Identifying usability aspects with digital pupil attendance registration in a low resource context:

A case study from the Gambia

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Abstract

This thesis identifies essential usability aspects for a pupil attendance application. Usability often determines a system's survival in operational use. Users may abandon a solution that is perceived as useless or difficult to use. In the context reported on here, the primary users are school staff and teachers in the Gambia that do not have the luxury of abandoning a solution with poor usability, as it is used for their daily work tasks. However, usability is still essential for them to perform their work as best possible.

This thesis draws on state of the art literature on usability and identifies usability aspects that are relevant to the context studied. In an exploratory search of essential usability aspects for a pupil attendance application in a low resource context, the study was conducted with qualitative data collection methods. The use of qualitative methods has allowed me to observe the actual use of the application in schools, and converse with the users of a pupil attendance application with open-ended questions.

The thesis identifies essential usability aspects for a pupil attendance application in a low resource public education setting. Importantly, ***communication*** between designers, users and other stakeholders can support the application to be more usable, as every actor of the system can share their opinions and be heard.

Acknowledgements

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Acronyms

ADR Action Design Research (ADR)

DHIS2 District Health Information Software 2

EMIS Education Management Information Systems

GDP Gross Domestic Product

GSM Global System for Mobile Communications

GUI Graphical User Interface

HISP Health Information Systems Programme

HMIS Health Management Information System

HISP Health Information Systems Programme

HISP UiO Health Information Systems Programme University in Oslo

HISP WCA Health Information Systems Programme West Central Africa

ICT Information and Communication Technology

ID Identification

IMF International Monetary Fund

ISP Internet Service Providers

IS Information System

IT Information Technology

LBS Lower Basic School

MoHERST Ministry of Higher Education Research Science and Technology

MIS Management Information System

MoBSE Ministry for Basic and Secondary Education

MoE Ministry of Education

NNGROUP Nielsen Norman Group

OOSC Out of school children

PWA Progressive Web Application

SDG Sustainable development goals

SMIS School Management Information System

SMS Short Message Services

SRN Student Registration Number

SSE Senior Secondary Education

UI User Interface

UiO University in Oslo

UNICEF United Nations International Children Emergency Fund

UX User Experience

WIFI Wireless Fidelity

Introduction

Globally, approximately 1.5 billion children and youths are enrolled in kindergartens, primary and secondary schools and universities [1]. The access to education in developing countries is steadily increasing, whereas enrolment in higher education is rising, adult education programmes and literacy rates are improving. Access to basic education can transform the lives of the disadvantaged [1].

Student absenteeism is a challenge for many developing countries. Absenteeism refers to a pupil that for some reason does not attend school. According to Unesco, 67 million children are out of school in primary age, 53 percent of this number consist of girls and 43 percent of them are in sub-Saharan Africa [1]. Many of them may not receive education in all of their lifetime. Enrolment rates are negatively impacted by dropout rates, armed conflicts and the consequences of political disarray. Countries with armed conflicts make out 40 percent of Out Of School Children (OOSC) [1]. Gender disparities are today a major issue that stagnate the progress in education. In the end, these limitations affect the basic literacy skills of the people, and make it difficult to combat or end poverty.

This master thesis focuses on usability aspects of a pupil attendance application that enables monitoring of pupil attendance. In this context, usability aspects constitute any function that allows a system or application to be usable for the end-users.

Motivation

Education has the power to improve livelihood and health that can contribute to social stability and long term economic growth [2]. Education plays a key role in human, social, and economic development, which makes basic education a vital human right.

With the present digital technologies and tools, we can create sustainable and efficient solutions for the education sector. There are many applications, but not all of them are usable for their intended purpose. Furthermore, many systems put in place in the education sector in developing countries are poor on usability simply because usability is not considered important, or just due to lack of awareness of usability issues. This affects the users of the application and their ability to monitor the attendance of pupils and take appropriate action.

Context

District Health Information Software 2 (DHIS2) is a web-based free and open-source platform that is being used as a Health Management Information System (HMIS) [3]. DHIS2 is governed and coordinated by the The Health Information Systems Programme within the Department of Informatics at the University of Oslo.The education sector is calling for a ***robust*** and ***flexible*** software platform. With the financial support from Norad, what they hope to achieve is a system that facilitates ***accessible***, ***timely***, ***quality data*** (***reliable data***) for EMIS decision-making in The Gambia.

The initiative for The Gambia project began back in the 2019, with a meeting between HISP UiO, HISP West Central Africa (HISP WCA) and the Ministry of Basic and Secondary Education (MoBSE) [3]. Their goal was to develop a long-term plan for the education sector. This plan consists of a configuration of DHIS2 for education. DHIS2 for Education is an extension from DHIS2 for Health. At the current moment, DHIS2 for Education includes a custom pupil attendance application used to collect pupil attendance and enrolment data. The pupil attendance application will in the future support many features like marks/grades, teacher attendance and so on.

The application has been tested by the Ministry of Basic Secondary Education (MoBSE). Because of the software's adaptability and flexibility, it was given positive feedback by the MoBSE. The application was described as being accessible, user-friendly, and with an efficient interface that "was just a few clicks away". This thesis explores further the usability of the application, from the perspective of the end users.

Research question and objectives

This thesis focuses on usability aspects for the users and the use of a pupil attendance application. The purpose is to explore how usability can enhance and ensure “ease of use” for the pupil attendance application. The research is guided by the question:

- What aspects of usability are essential for a pupil attendance application to be useful in a low resource public education setting?

The reason I chose this topic is because usability is essential to a product's survival and use. Jakob Nielsen is a user advocate and principal of the Nielsen Norman Group (NNGROUP). He has established the “discount usability engineering” movement for fast and cheap improvements of user interfaces and has developed several usability methods, including heuristic evaluation [4]. Jakob Nielsen argued that usability is a necessity for a website to survive on the Web. If the website is difficult to use, people leave [5]. In the context reported on here, the users are reliant on using the application system. In a worst case scenario, they have to endure the poor usability as part of their work system. This may undermine the production of **accessible**, **timely** and **quality data** for decision-making.

Thesis Structure

Chapter 2: Background

The chapter presents an overview of the education sector in the Gambia.

Chapter 3: Related Work / literature review

The chapter provides a review of relevant literature for the study.

Chapter 4: Methodology

The chapter reports on the methods used for data gathering and analysis.

Chapter 5: Empirical Findings

The chapter presents the findings from my observation in The Gambia.
The presentation consists of the network experience in the country,
the tools to collect information regarding pupils and the school visits.

Chapter 6: Result and analysis

In this chapter, I provide a presentation of the result derived from the data collection. This chapter also includes some of the literature review to assess the findings.

Chapter 7: Discussion

This chapter discussiones the study findings with state of the art research in the field. A summary of

discussion will present the important the essential
usability aspect for the study.

Chapter 8: Conclusion

Background

This section will give an overview of The Gambia education sector background information. The information consists of general facts about the country regarding geography, demography and especially the educational system.

UNs Sustainability Development Goals

This initiative was adopted by all the United Nations (UN) Member States back in 2015. The Sustainable Development Goals (SDG) provide a shared interest for peace and to achieve a better sustainable future for all. In addition, they embrace the global challenges alongside poverty, inequality, climate change, environmental degradation, peace and justice [6].

The SDG has an agenda in which its ambition is to fulfill these goals within 2030. There are 17 goals in this comprehensive plan, but in this thesis I will narrow it down and focus on the relevant goals to the educational sector. It is arguable that all 17 goals are to some degree relevant to education, but a selection of these goals land a bigger impact than the rest. Out of the 17 goals, the ones marked in bold beneath, are the ones I have chosen to explore [6]:

1. **Quality education**
2. **Gender Equality**
3. **Reduce inequalities**

The most relevant goal for this thesis is first of all the **Quality education (Goal 4)**. This goal will ensure inclusive and equitable quality education and promote lifelong learning opportunities for all [7]. The quality education has a motive to achieve their targets by 2030 and the relevant goals for this thesis is by following [8]:

1. Ensure that all girls and boys will complete their free, equitable and quality primary and secondary education.
2. Ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education.
3. Ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.

HISP

Health Information Systems Programme (HISP) is a global movement to strengthen Health Information Systems [9]. Their work began back in the ‘90s, and the HISP University of Oslo (UiO) is one of the leading organisations when it comes to contribution of design, implementation support, research and sustain Health information systems in the developing countries.

The goal of HISP is to enable and support countries to strengthen their health system and their capacity. The incentive is to govern the Health Information System in a sustainable way to improve the management and delivery of health systems [9].

DHIS2

District Health Information Software 2 (DHIS2) is an open source, web-based health management information system (HMIS) platform [10]. Nowadays, the DHIS2 is the world largest HMIS platform and the platform is being used by 72 low and middle-income countries. The core of DHIS2 software is developed and coordinated by the HISP UiO [10].

DHIS2 for Education

UN Sustainable Development Goal 4 (Quality education) aims at improving learning outcomes and equitable access to education [11]. DHIS2 for Education is an extension from DHIS2 for Health, and can collect data for analysis and visualization for the education sector [11]. The platform is open-source and offers a flexible solution which supports many use cases. DHIS2 for education is compatible with many devices such as desktop computers, mobile devices, creation of custom web and Android applications, and it supports integration with other software platforms [11].

The Gambia

The Republic of The Gambia is positioned in West Africa and is the smallest country within the mainland. The country itself is surrounded by Senegal, and the Atlantic Ocean is covering the western part of the country. This country has an area of 10 689 square kilometres which is almost the same size as a Norwegian former county, Rogaland, with 9326 square kilometres. According to Google, the population of The Gambia is currently 2,28 million and is almost corresponding to half of the population of Norway. The capital of The Gambia is Banjul, and the largest cities are Brikama and Serekunda.

Figure 1: Map of The Gambia [12]

As for the historical events, The Gambia shares roots with many West African countries in the slave trade. Because of the geographical location of the country, The Gambia became a key factor for many colonists, and they were first colonized by the Portoguese and thereafter became a part of the British Empire. During the colonial times, The Gambia was affected and

influenced by the colonists, and today the official language is English. The country hosts many ethnic groups from Western Africa, and therefore has other native languages like Mandinka, Wolof, Fula, Serer and many more.

Farming, fishing and tourism are the main pillars of The Gambia's economy. The poverty rate of the population is 48,6%, where 70% of the population is located in rural areas. These numbers are based in 2015 [12].

The Gross Domestic Product (GDP) is a monetary value of final goods and services—that is, those that are bought by the final user—produced in a country in a given period of time [13]. In 2018, The Gambia had a GDP of 1,624 billion dollar, while Norway had 434,2 billion in comparison [14]. There is a big gap between these two countries and the differential is almost at 267%. In terms of International Monetary Fund (IMF) within world basis ranking in 2020, The Gambia is ranked at 172th and the lowest rank is 194 [15]. This makes The Gambia one of the poorest based on IMF ranking.

Education in The Gambia

The United Nations International Children Emergency Fund (UNICEF) has been working to save children's lives in over 70 years. This organization is the largest internationally within promotion and protection of children’s rights. Nowadays, UNICEF has a known presence in more than 190 countries [16].

UNICEF is in cooperation with the Government of The Gambia to achieve the education policy goals [14]. This policy is aligned with the Sustainable Development Goal 4, and is done through communication with the Ministry of Basic and Secondary Education (MoBSE). The SDG 4 is focusing on accesible, equitable and inclusive education for all [14]. Due to the expanding of the educational sector annually, the country is facing a challenge to meet up with requirements to steady the growth in terms of resources. These resources are classrooms, learning materials and teachers. The goal is to realize his and her rights to educate, but due to low performance in learning outcomes, a strategic partnership and collaboration with the MoBSE is needed. Many factors are stagnating the progress of quality education in this country. These factors can be related to disability, access of education, family choice of education and social norms that drive child marriage [17].

The solution UNICEF propose is to support the MoBSE with a programme whilst the aim is to achieve an inclusive education system to provide comprehensive early childhood education to all children, in conjunction with health, nutrition and protection interventions, and to ensure the rights of all children to appropriate quality education [17].

The education in The Gambia should mandate free and compulsory primary education [12]. Achieving this constitution had been difficult due to lack of resources, and coupled with the current education infrastructure. Back in 2005, the net enrolment rate in primary education was at 71,5% of the children, and 74,8% in 2016 [18]. This ratio shows that it is steadily growing, and can impose a challenge for the educational sector if they cannot keep up with the resources.

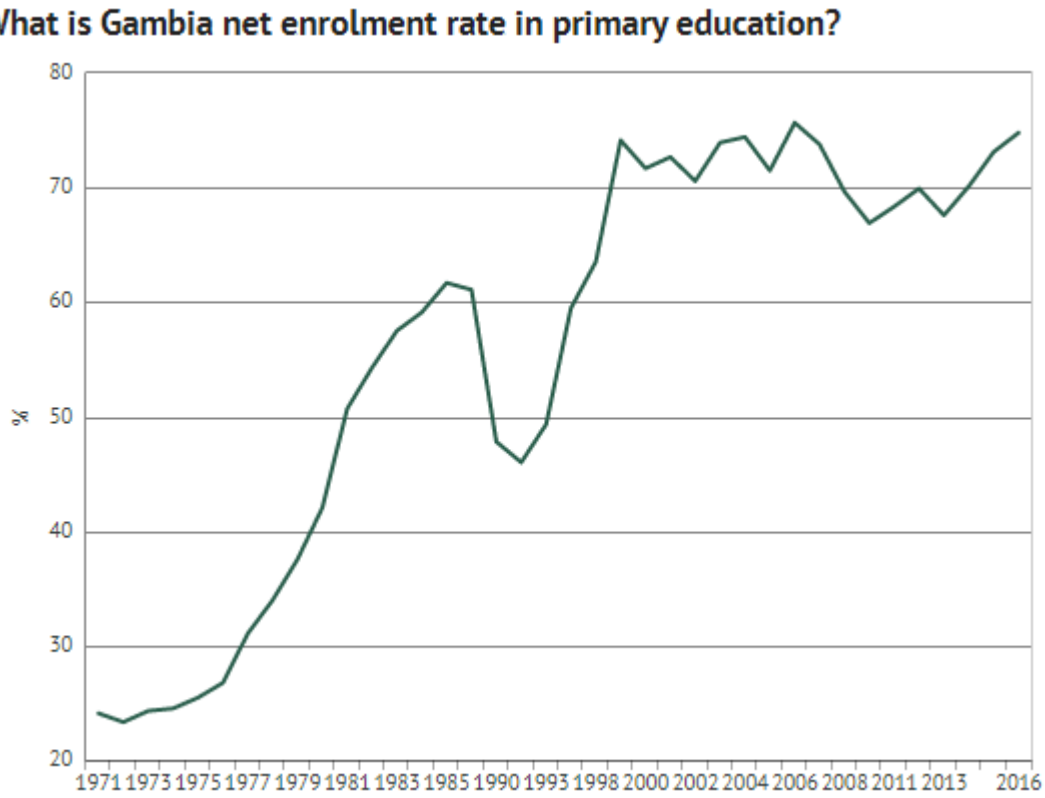


Figure 2: Enrolment rate in primary education in The Gambia [18]

The Gambia has divided the education ministries in two; The Ministry of Basic and Secondary Education (MoBSE) and Ministry of Higher Education Research Science and Technology (MoHERST) [19]. Whereas the MoBSE is responsible for the administration and coordination of public action regarding Basic Education [19]. The educational system is inspired and influenced by the British system. The academic year starts from September to July and is divided into three terms. The first term is from September to December (Christmas vacation), second term runs from January - March/April (Easter vacation) and the third is from March/April - July (summer vacation).

School level	Years of education	Age	Grades
Early Childhood Development(ECD)	3	3-6	1st-3rd
Lower Basic School(LBS)	6	7-12	1st-6th
Upper Basic School(UBS)	3	13-15	7th-9th
Senior Secondary Education(SSE)	3	16-18	10th-12th

Table 1: Table of educational system in The Gambia [19, pp. 30, Table 3.1]

Telecommunications, Internet and electricity

The Gambia has four main telecommunication companies. Africell and Comium are both foreign-owned, Gamtel is state-owned and Qcell is private-owned. According to Privacyshield, the penetration of the mobile phones is well over 100 percent [20]. The cellular subscriptions are at 119,6 per 100 habitants (est. 2018) [21].

There are four main Internet Service Providers (ISP) in the country; Gamtel, Africell, Netpage, and Qcell [20]. In 2011, the quality of connectivity was improved due to a launch with submarine cable in the African Coast to Europe. Even with the improved connectivity, the numbers of Internet users are quite low. Only 19,84% of the population are using the Internet (est July 2017) [22].

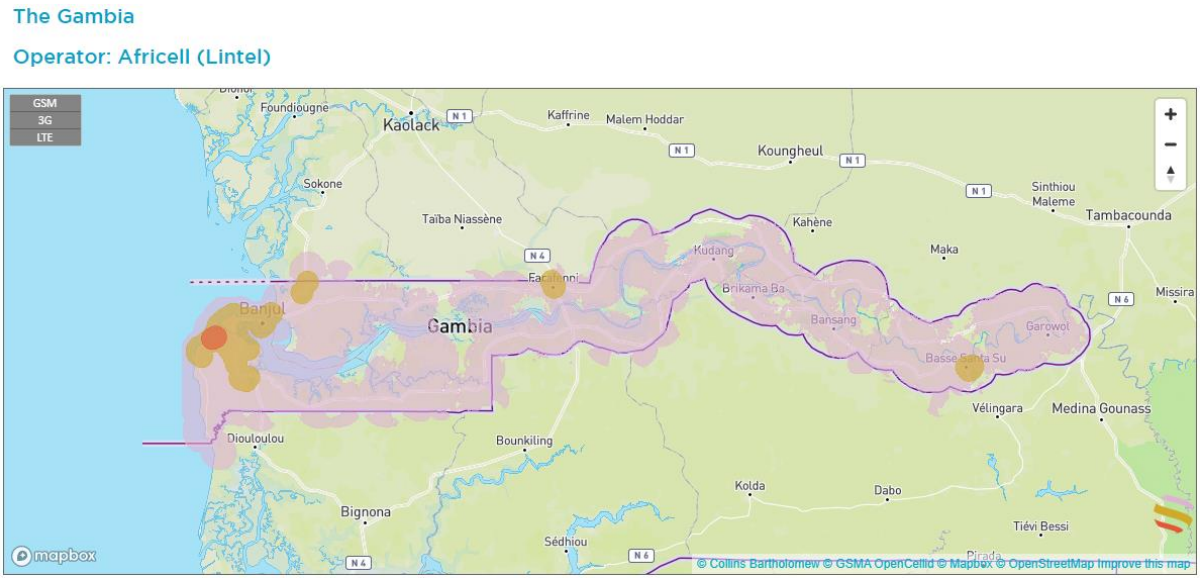


Figure 3: A map of cellphone coverage. 4G, 3G and GSM connection by Africell [50]

The map over shows the coverage with the particular type of signals. The purple indicates GSM connection, which covers most of the country. While the yellow displays 3G coverage which covers the capital and smaller parts of the country. Lastly, the orange indicates 4G or LTE, and covers Serekunda areas.

Approximately a half of the population have access to electricity [22]. Whereas urban areas have a higher access than rural areas, and the differential is 69% (urban) vs 19% (rural). Thus maintaining electricity in their home in rural areas can be costly for many people. The main source of electricity comes from fossil fuels [22]. The country also produces renewable electricity, but the numbers are scarce.

Related Work / literature review

Information System

An “Information systems (IS) are combinations of hardware, software, and telecommunications networks that people build and use to collect, create, and distribute useful data, typically in organizational settings” [23]. To further explain this, information systems are a combination of hardware, software, data, people and process. The first three combinations fall under the technology category and the rest are detaching the concept of information system from more technical fields. Furthermore, all these components together should bring value for an organization [23].

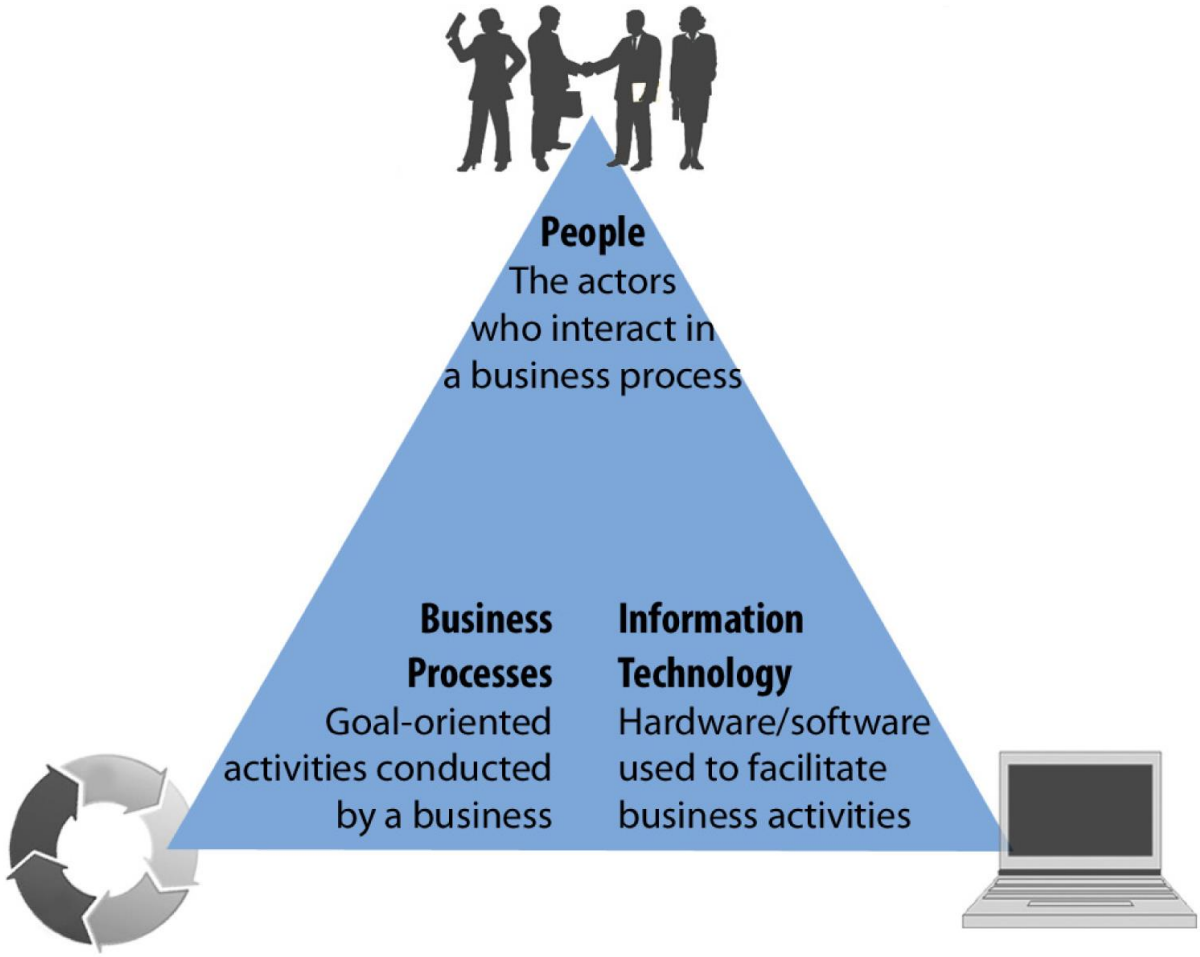


Figure 4: Three parts of an information system [52]

One of the roles of an information system is to capture data and transform into information, and use that for organizational knowledge. Information systems will change through time, and that is why this role has evolved into the backbone of the organization [24].

Management information system

A «Management Information Systems (MIS) is the study of people, technology, organizations, and the relationships among them. MIS professionals help firms realize maximum benefit from investment in personnel, equipment, and business processes. MIS is a people-oriented field with an emphasis on service through technology» [24].
A management information system is a subset of information system. As information systems is used to collect, process and store data. Then the management information system aggregates and disseminates this data for decision makings [24].

Education Management Information System

The acronym of Education Management Information System is commonly known as EMIS. Although, reviewing from an extant literature, finding a common definition proved challenging. Based on Cassidy, EMIS means different to different people [25]. It seems to be all about the perspective based on the author, or the present circumstances of the setting. There are many definitions that can be observed to complement each other, but some of them may not cover a comprehensive definition of EMIS. EMIS has existed for decades, but received more use after the ‘90s.

One of the definition of an EMIS provided by Wako [26, p. 3]:

> “The acronym EMIS stands for “Education Management Information System”. It is a system for organizing information base in a systemic way for the management of educational development. It is an information center in the ministry of education responsible for collection, processing, analyzing, publication, distribution, rendering information services for users of educational information.”.

The problem with Wako's definition of EMIS may leave some actors in the shadows. Considering that actors like humans play a huge role to constitute an EMIS, and in the present event, technology has been more frequently used as well. In this case, Cassidy's definition of EMIS shows to be more comprehensive, and has been widely referred to by others [27]. This is the following [25, p. 27]:

> "An Education Management Information System (EMIS) is a system for the collection, integration, processing, maintenance and dissemination of data and information to support decision making, policy-analysis and formulation, planning, monitoring and management at all levels of an education system. It is a system of people, technology, models, methods, processes, procedures, rules and regulations that function together to provide education leaders, decision makers and managers at all levels with a comprehensive, integrated set of relevant, reliable, unambiguous, and timely data and information to support them in completion of their responsibilities."

Cassidy's definition shows to include important actors, functions and properties which may constitute to be a more successful EMIS. Therefore, this definition will be adopted for this thesis because of its detailed description compared to Wako's.

The main purpose of an EMIS is to assimilate comprehensive information regarding the management of educational activities to make it available for a variety of users. These users are teachers, principals, curriculum planners, inspectorate officials, financial controllers, planners, policy, adviser and political leaders. The parents and pupils are included as well. The service provided by EMIS will benefit the entire community [28, p. 5]. The success of EMIS consist mainly of three key factors [27]:

1. Timely and reliable production
2. Data integration and data sharing among the departments
3. Effective use of data and information for educational policy decisions.

According to Wako [26, p. 47], the challenges facing EMIS is the following:

1. Getting dedicated workers to improve the situation, and to take away **control** and **command** type from the management in such a way it can lead to a continuous learning environment.

2. Awareness: The purpose of having a coordination unit is to mark a significant awareness among the actors in the ministry of education. Despite doing a good effort on substantive work, Sub-Saharan Africa is facing a challenge when it comes to using the educational statistics for decision making.

3. Budget Allotment: In addition to awareness among the decision makers and planners, allocate necessary budget to acquire new technology, mailing data collection instruments to schools, undertaking research and surveys will supplement statistical results.

4. Personnel shortage: There is an inadequate amount of professionals, both in quality and quantity. The resources required to train long term professionals in EMIS is lacking, due to allocation of budget.

5. Overrating of the capacity of EMIS: Due to rapid change of technology and coordination of information systems for education, has led to a need for short and long term training of personnel. The EMIS personnel need to train themselves before they can produce. This is somehow overlooked by the decision makers within the ministry.

6. Training: Due to rapid change of technology, adapting to these circumstances takes time for the professional EMIS worker. It requires time to gain this knowledge, and is often overlooked by the decision makers.

SMIS

School Management Information System (SMIS) is an application for managing school and pupil information [29, p. 37]. According to UNESCO, SMIS refers to the school-side information system and can be established as a web-based extension for EMIS. The SMIS is an alternative system which is installed as a software on a computer and coupled with EMIS. Through this system, the school staff can enter information, and the application administrators should secure the determined information to be regularly reported to the national EMIS.

SMIS aids data on individual pupils accessible at the national level and the data accessible through the web. The web-based SMIS ensures the data to be up-to-date to provide EMIS to reflect on the current situation based on the records. Practically, the SMIS allows monitoring

individual pupils and following them up. Likewise, moving from school to school or supporting them based on their needs. The pupil attendance application used in this thesis is by definition a SMIS.

Conceptual Framework

User Experience

User Experience (UX) is described as the name says, the experience from the user. UX concerns all the aspects of the user's experience when interacting with the product, service or facility [30]. To illustrate the UX, we can use a website as a term. The UX will concentrate on how the user is feeling happy before, during and after using the website. To elaborate even further, we can try phrase UX as a question [31]:

- Did the user have a pleasant experience with the visit of the website?

UX is a consequence of the presentation, functionality, system performance, interactive behaviour and assistive capabilities of the interactive system [31]. To further explain the definition easier, the UX deals with interaction between the design and the user.

User Interface

User Interface (UI) is what the user sees, hear, touch, talk to or control and direct [32]. Shihong also explains that UI is often "the product" and further allows the user to see and may make their decision on. The UI can be described as interaction or communication between human (user) and device. Objects like display screen, keyboards, a mouse and the appearance of a desktop are parts of the UI.

Usability

There are many definitions of the term, "Usability". The definition could be either technical or general described. Usability refers to, "Ease of the product, and includes Graphical User Interface (GUI) but everything else that touches the user" [32]. Another definition refers to, "Usability extent to which a system, product or service can be used by specified users to

achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [33]. These two definitions can be used interchangeably because both refers to give the users satisfaction and to accomplish the desired goal. Usability is commonly known as "ease-of-use" or "user-friendliness", but it is broader than that.

Jakob Nielsen explained usability more as a framework, which is: "Usability is a quality attribute that assesses how easy user interfaces are to use. The word "usability" also refers to methods for improving ease-of-use during the design process" [5]. The quality attributes are learnability, satisfaction, effectiveness, efficiency, memorability, and errors. Nielsen further explained usability as a part of usefulness and includes utility for the explanation. Utility is a quality attribute likewise usability, but the utility refers to the functionality of the design. While usability concerns how easy and pleasant these functions are [5]. To explain furthermore, the utility will ask whether the product provides the features you need, and usability refers to how easy and pleasant these features are to use. Utility and usability together will determine how useful the product is.

To illustrate them together with mathematical language and for the sake of simplicity [5]:

$$\text{Useful} = \text{Usability} + \text{Utility}$$

The calculation tells that usability and utility are equally important, and therefore required both to determine Useful [5].

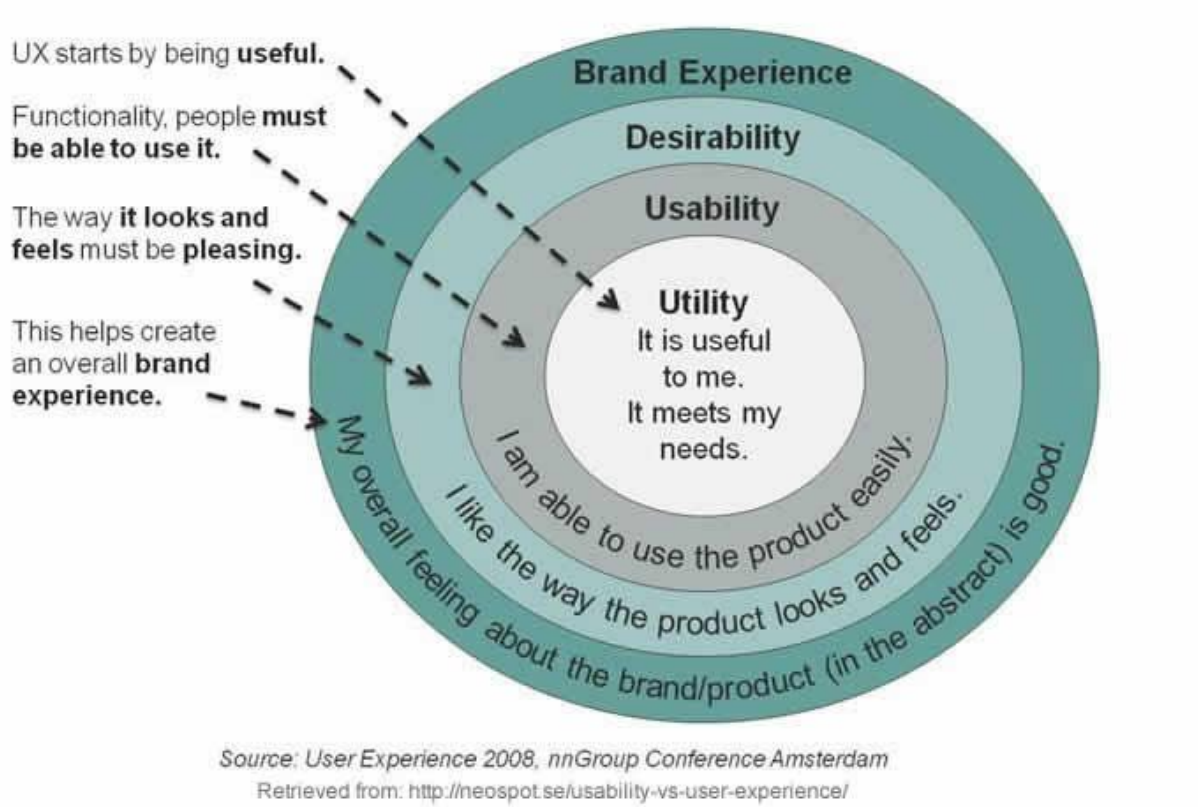


Figure 5: Illustration of UX [31]

The whole concentric circle explains user experience in a bigger picture and to further see which role usability has in the concept of user experience. Usability is first of all a narrower concept than user experience, because usability only concentrates on the achievement of the goal and not the overall feeling from the user [31]. To define usability as a question phrase:

- Can the user accomplish their goal?

According to Nielsen, the usability has 5 quality components, and they are explained in a quite intuitive way:

Learnability: How easy is it for the users to accomplish basic tasks the first time they encounter the design?

Efficiency: Once users have learned the design, how quickly can they perform the tasks?

Memorability: When users return to the design after a period of not using it, how easily can they recover from the errors?

Errors: How many errors do users make, how severe are these errors, and how easily can they recover from the errors?

Satisfaction: How pleasant is it to use the design?

Jakob Nielsen 10 Usability Heuristic for User Interface Design:

Jakob Nielsen has developed 10 usability heuristics in cooperation with Rolf Molich. These heuristics are based on factors of 249 usability problems and the 10 usability heuristics are behaving as rules of thumb rather than guidelines [34].

1. Visibility of system status
    - The system should always keep users informed about current state and actions through appropriate visual cues and feedback within reasonable time.

2. Match between system and the real world
    - The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

3. User control and freedom
    - Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

4. Consistency and standards
    - Users should not have to wonder whether different words, situations, or actions mean the same thing.

5. Error prevention
    - Even better than good error messages is a careful design which prevents a problem occurring in the first place. Either eliminate error-prone conditions or

check for them and present users with a confirmation option before they commit to the action.

6. Recognition rather than recall
    - Minimize the user's memory load by making objects, actions, and options visible.

7. Flexibility and efficiency of use
    - Accelerators - unseen by the novice user - may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

8. Aesthetic and minimalist design
    - Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

9. Help user recognize, diagnose, and recover from errors
    - Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

10. Help and documentation

In connection with answering the research question, the research of Nielsen Norman Group has been adopted to identify the essential usability aspects for the application. Since the research question empathizes with the essential usability aspects, one needs to understand what usability is. In terms of explaining usability, I had to include user interface and user experience to see the whole picture. The five usability quality components will be used to measure and research the application. In addition to including the 10 usability heuristic to see the relevance with the encountered issues.

Methodology

This section will cover methodology and procedure within my master thesis. The choice of methods will be presented, as well as a clarification as to why the method is a suitable choice for the purpose. Project summary will be presented first before I describe the use of methodology. The section will also outline methods used during observation in the field.

Project Summary

As I explained earlier in the Research Question chapter; The main focus of this thesis is to explore and observe the pupil attendance for EMIS to further uncover essential usability aspects for the application.

The project started in the beginning of 2019 with meetings with the supervisor and his team. During this time of period, it was essential for me to join meetings and workshops with the supervisor's team, since a clarification and an insight of the project is needed for me to understand the domain. The following year, I had a meeting with two girls from NTNU to present us the current EMIS system in The Gambia. During the DHIS2 Annual Conference, the leader of MoBSE met me to further discuss the project and when I could commence an observation in The Gambia.

As the project was during the pre-pilot phase, factors like limitations were to be expected. I had to switch from my first approach with Action Design Research (ADR) to a Case study. Because the first study was to research a **Progressive Web Application (PWA)** that could benefit the context of study. I could not contribute to this study since they had an application going, and it made more sense to observe this instead of reinventing it. Therefore it was more appealing for me to change the research method to a **Case Study**, to explore for the essential usability aspect with the current pupil attendance application. This application was ready to test with the user, and I could observe the design and how it works.

Primarily, the visit to The Gambia was planned to be on several trips, but I ended taking one trip and it lasted for three weeks. Because we thought three weeks should be sufficient for the study, but it was shown to limitate the study in a later time. The importance during the field study was to collect data regarding usability aspects in terms of Nielsen Norman Groups

definition of usability. Usability refers to “ease-of-use” within the system and I had to observe the users of the system to see how they behave during data entry.

Research Method

Qualitative research

According to Robert K. Yin, there is a challenge to arrive at a singular definition of qualitative research. Many disciplines will be left in the shadow, given the definition is too short. Supposing the definition is too broad, it may be useless globally [35, p. 7]. Yin furthermore compares the qualitative research in line with **sociological research, psychological research, or education research.**

Based on Robert K. Yin, one should consider what features are involved in qualitative research [35, p. 7]. First of all, qualitative research is used to study the **meaning of people’s lives, under real-world conditions**. Secondly, to represent the **views** and **perspectives** of the participants in a study. This means that qualitative research can capture the people's perspectives who live in the context to further represent the real-life events. Lastly, sources of evidence like **observations**, **interviews** and **inspections of documents and artifacts** are part of a qualitative research. These sources of evidence are used to study real world settings and the participants within it.

Case study

Case study is a research methodology, typically in social and life sciences. There is no one definition of case study research. Depending on the field of interest, the case study gives the investigators the opportunity to focus on a “case” and retain a holistic and real-world perspective such as managerial processes, school performance, international relations and maturation of industries [36, p. 2].

The first definition provided by Yin, can be simply explained as a study of the meaning of people’s lives, under real-world conditions. What people perform in their everyday roles and express them is individual based on the setting and circumstances they are in. The qualitative

research has an ability to capture their perspective and represent the real-life conditions. Furthermore, qualitative research has an impact to cover contextual conditions when it comes to people's social, institutional, and environment conditions [35, pp. 7-8].

A case study can be either descriptive, exploratory and explanatory. It can further be designed such as a single or multiple case, depending on the research. The case study is applicable to answer “How” and “Why” questions [36, p. 22].
Yin explained that the choice of these types of research strategy are based on the focus or the aim on the research question. Because the Five W’s can determine which strategy is suitable for the case. These Five W’s are referred as [37]:

1. **Who**
2. **What**
3. When
4. **Where**
5. **Why**

Many authors also adds the sixth question as well [37]:

6. **How**

The highlighted Ws and in addition to How, are the ones that are mentioned by Robert K Yin’s book and he also explains which one is suitable for which method.

METHOD	Form of Research Question	Requires Control of Behavioral Events?	Focuses on Contemporary Events?
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival Analysis	Who, what, where, how may, how much?	No	Yes / No
History	How, why?	No	No
Case Study	How, why?	No	Yes

Source: Case Study Research: Design and Methods - Fourth Edition, 2009, Robert K. Yin

Figure 6: Relevant Situation for Different Research Strategies [36, p. 5]

However, my research questions are mainly focusing on **"What"**, and Yin explains that some **"What"** can be justifiable rationale to be conducted as an exploratory case study, as long as the goal is to develop pertinent hypothesis and proposition to further inquiry [36, p. 5]. My study will in the best effort give propositions to further be inquired or to be used for future research.

As mentioned, the case study can be designed as singular or multiple (multiple methods), and the singular was the suitable choice for me. Since multiple case studies concentrate on a larger study, which include quantitative data, and my data collection does not provide any quantitative data [36, p. 150]. Thus, creating a multiple would be difficult for my case.

The study is focusing on the social interaction between humans and computers, in addition to some degree, a study of individuals and groups [36, p. 1]. A case study will then be a suitable choice for this study.

According to Robert K. Yin [36, p. 13]:

A case study is an empirical inquiry that…

> "...investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.".

For my thesis, an exploratory case study is a fitting choice to help me answer the proposal research question. Because I do not know much about the domain and therefore exploring the field is essential for me to get a clearer picture of the study. I am exploring the essential usability aspects for a pupil attendance application, and being in the field to observe social phenomenon and the behavior between the user and the interaction with the application is needed to understand more of the domain. Even more so to achieve better evidence to which aspect of usability is important for the pupil application.

Data collection methods

There are six sources of evidence according to Robert Yin, and some of them were mentioned in the **Qualitative Research** section. A case study would benefit by including as many sources of evidence as possible. Because the sources of evidence encompass their own strength and weakness, in fact, combining the various sources will balance the strength and weakness together.

The six evidence consist of documentation, archival records, interviews, direct observations, and physical artifacts. The list is also extensive by including films, photographs, and videotapes [36, p. 85].

I used pictures, interviews, observation and some documentations for the thesis. The following section will elaborate the evidence and findings, and justification of why I chose the methods and data gathering methods.

Pictures

I used pictures to document or analyze in connection with the application. Oral consent was followed before the pictures were taken. These images are mainly for recreating a memory of the situation and to document them as evidence. The camera was used at the MoBSE and at the school visits. I avoided taking pictures with peoples faces since it requires a formal written agreement and an oral agreement would not be sufficient. The pictures were taken by mobile phones and the device was a Samsung S8. In conclusion, these pictures are used to document my observation and for the readers to see what I saw.

Unstructured/ Open-ended Interviews

Rober K. Yin explains that interviews are one of the most important sources of a case study. He further elaborated that the interviews behave as guided conversations rather than structured queries [36, p. 89]. The researcher should pursue this type of data gathering method by having a consistent line of inquiry, following this will lead the streams of questions to be fluid rather than rigid [36, p. 89]. This means firstly the researcher has to follow their own line of inquiry. Secondly, reflect their case study protocol, then lastly carry out the questions in an unbiased manner. Note that the questions must serve the line of the inquiry.

The way I conducted the interview was unstructured interview/open-ended and the reason is quite simple; the direction of the interview should be as freely as possible. It was utmost important for me to safeguard the person's integrity during and after the interview. Thus, I distanced from taking sensitive information and anonymized people that were involved. Due to my knowledge of the domain and being inexperienced as a researcher, the design of the questions did not fully conventionally follow the guidance provided by Robert K. Yin. He even suggested the question to be designed to answer "why". Thus the nature of a "why" has a relevance to might impose a friendly and non-threatening approach as the researcher converse with the participants [36, p. 90]. However, many of my conversations did in the best effort to give the participants a feeling of openness and thereby could elaborate more freely.

Collections from observations gave me a wide variety of data, and the interviews I conducted will provide a deeper understanding of the domain for the research. In addition, the interviews allowed me to gain more insight about our research topic and to see a relevance with my observations. Unstructured interviews are flexible as the question can be adapted, based on how the responder answers. The unstructured interviews can be seen as "guided conversations" in preference to strict structured interviews [38]. Thus, when conducting an unstructured interview, the interviewer does not have any predetermined set of questions. Instead the interviewer asks more open-ended questions and changes adaptively depending on the participants' answers in addition to preserving the topic. At first glance, designing predetermined queries was not feasible due to my insufficient knowledge of the domain. For this reason, unstructured interviews were a suitable choice since I had to explore and try to gain more insight to better understand the field of study.

Observation

The main data gathering I used in this study was observation. The observation method used for this thesis was Direct Observation. Robert K. Yin explained the direct observation as a passive observation [36, pp. 92-93]. He also stated that this form can be used during observing meetings, sidewalk activities, factory work, classrooms, and the like [36, p. 92]. Since the definition was less clear, I had to include an addition definition [39]:

> "Direct observation is distinguished from participant observation in a number of ways. First, a direct observer does not typically try to become a participant in the

> context. However, the direct observer does strive to be as unobtrusive as possible so as not to bias the observations. Second, direct observation suggests a more detached perspective. The researcher is watching rather than taking part…"

This method was conducted because I want to set "a wall" between me and the participants. Reasonably, I wanted the some involvation to be as neutral as possible and to give a space for the participants to behave naturally. In some situation, I had to be involved to understand more about the users during data entries, and factors involved within the application. One has to put themselves "in their shoes" and at the best effort try to experience events in the way they experience them.

During the stay in the Gambia, I observed following to potentially find the essential usability aspects:

- The internet capabilities
- The pupil attendance application, DHIS2 for education
- Data entries during school visits.
- Questionnaires

The observation generated most of the data collection, and the main source of data is from school visits and the meetings. Because the data entry was being used in the schools, and it makes sense to conduct an observation here. As foretold, I was involved in some situation because I had to participate with the participants to uncover the advantages and disadvantages with the application. It was reasonable for me to be in their shoes to understand their perspective when using the application. Because it is different how we perceive and solve the task. Therefore, it was important for me to collect the data from the available users to further see the bigger picture.

Albion was the first school I visited, and MoBSE had some preliminary work before involving me. During meetings without my involvation, I made sure to not interrupt in any way between the accountable from MoBSE and the headteachers. It was inevitable for me to

be unseen by the participants, in consequence of that, the direction of the meeting may be less natural. Despite the consequence, the accountables from MoBSE introduced me before and during the meeting, to ensure the headteacher that accompaniment was to be expected. I felt that the outcome of the meetings was natural because of the initiative by the accountable from MoBSE. Subsequently, I documented as much as possible during these types of meetings and wrote down questions if I found some parts being misleading. The goal from these meetings was to gather data regarding the pupil attendance.

I had a master student from UiO that accompanied me during the stay in The Gambia. He contributed to the same research, and we cooperated with the data collection. We were two when the observation went on, and it allowed us to discuss our individual perceptions and to further compare our findings. Generally, the first visit to the school was more or less just meetings and distributing questionnaires for the pupils to fill. Usually, the pupils get a couple days to fill the questionnaires with their parents, but one must expect some delays. The observation was noticeable during the second visit to Kabafita SSE. It was an initiative suggested by the headmaster of this school and he decided to use ninth grade for the pilot. He requested us to be present while the pupils were filling the questionnaires, supposing that some terminologies could be misunderstood and we could elaborate to them. We had a conversation with the leader of MoBSE at the end of the trip. In this conversation, we delivered him our thoughts with the encountered issues. In a later time, we also sent him and his team a comprehensive report regarding our observation with the application.

Data sources/ Involved Actors

Interviews and observations served as my main sources for data collection. Both sources came from MoBSE and urban schools.

Documentation

In addition to observation, interview and pictures, the MoBSE provided me with presentation and documentation regarding pupil enrolment and attendance. The MoBSE distributed me with questionnaires (See Figure 9 & 10) and presented their current - and - shift of EMIS. I will use some of their documentation to answer my assumptions of which aspects of usability are essentials for the pupil attendance.

Triangulation

According to Robert K. Yin, turning to only one source of evidence is not recommended for a case study. He stated that using many different sources of evidence is a major strength for a case study. The multiple sources should also aim for the same fact or phenomenon. By using multiple sources or methods will give the investigator a broader view to address historical, attitudinal and behavioral issues. The use of multiple sources or methods can overcome or counterbalance the insufficient evidence and biases that may appear from a single methodology [36, pp. 97-98].

As Robert K. Yin stated, it would be insufficient for me to stick to only one type of data gathering method. For the cause of my study, I indeed agree with Robert K. Yin to show evidence through multiple sources. For my thesis, a combination of observations, interviews and documents has been my sources of evidence. In the best effort, I will use triangulation for my thesis to increase the credibility for my study.

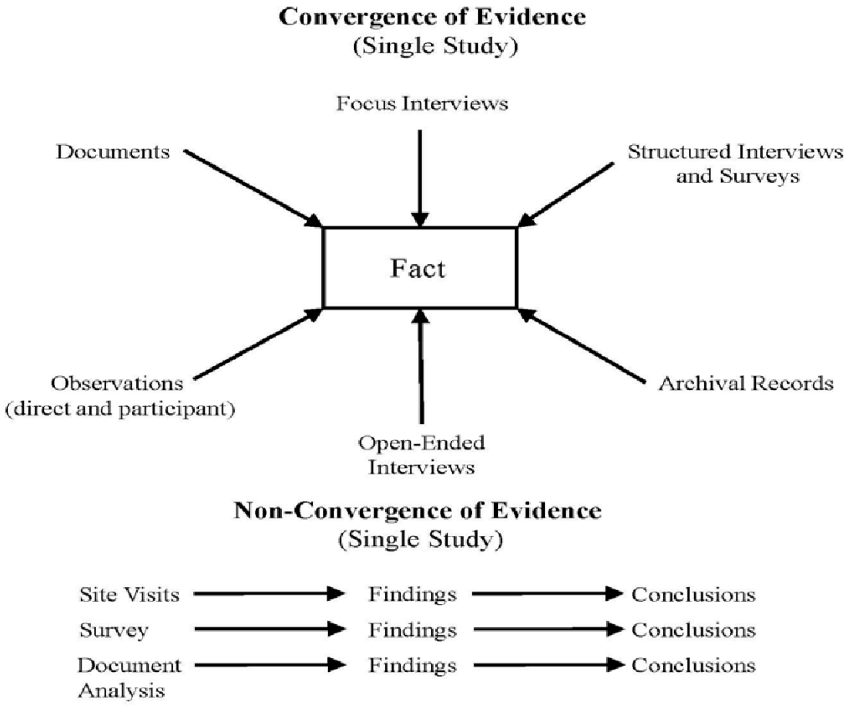


Figure 7: Convergence of Evidence [36, p. 100]

As presented in the figure and for my thesis, every collected data will be combined to explain the fact. Robert K Yin explained that relying on individual sources is not recommended for a case study [36, p. 97]. To illustrate this, take for example relying only on observation without conducting an interview. Can consequently impose a biased manner since it relies on the

researcher's subjective judgement. Therefore, my analysis will in the best effort keep the convergence of evidence.

Data analysis

This section will outline how I performed the analysis. The data collection has been qualitative which consist of interviews, observations and field notes. Data analysis can be summarized by using examination, categorizing, tabulating, testing [36, p. 109]. In addition to combining qualitative and quantitative evidence(triangulation) to address evidence in the study. It is noteworthy to mention that the edition I used for this thesis is threatened to be outdated, and therefore I would attempt another analysis method than proposed by Robert K Yin. Due to my data collections' insufficiency, and my inexperience as a researcher, I had to choose an analysis method that will fit my data and correspond to my ability as well.

Initially, these collected data are raw information thus needed to be processed to further make sense. There is a lot of raw information which needs to be narrowed down and finding patterns within the data, and to further identify the themes of these data. Firstly, I transcribed interview notes, compiled the field notes and photos, and from this point it was possible for me to try out coding. Secondly, there was no record of audio during the interview, because I felt without it could make the conversation more free. Lastly, the analysis method chosen for my thesis is ***Thematic Analysis***.

What is Thematic Analysis?

Thematic Analysis was originally developed by Virginia Braun and Victoria Clarke for psychology research [40]. This method is used for analyzing qualitative data, and due to its flexibility, it can be adapted to many different kinds of research. Thematic analysis allows the researchers to find out something about people's views, opinions, knowledge, experiences or values from a set of qualitative data [40].

There are two approaches when conducting ***Thematic analysis***:

1. Inductive involves allowing the data to determine your themes

2. Deductive involves coming to the data with some preconceived themes you expect to find reflected there, based on theory or existing knowledge.

I had some preconceived themes developed by Nielsen Norman Group during my research. These themes involve using the usability attributes from ***Conceptual Framework***. Subsequently, after choosing between inductive and deductive, the researcher should decide between semantic and latent approaches.

1. Semantic approach will focus on people's stated opinion
2. while Latent approach tends to in revealing their statements about their assumptions and social context.

I focused on the users' opinions during field study in The Gambia to uncover the essential usability aspects. In summary, this thesis will use deductive with semantic approach to analyze the data collections.

NVivo 12 is a tool for organizing, storing and analyzing the data collection. The tool is specialized for qualitative research, thus the structure from qualitative is less structured compared to quantifiable research. The interviews, video tapes, surveys with open answers and so on, are categorized to be less structured data [41]. I chose to use NVivo 12 to analyze my qualitative data and to categorize the codes.

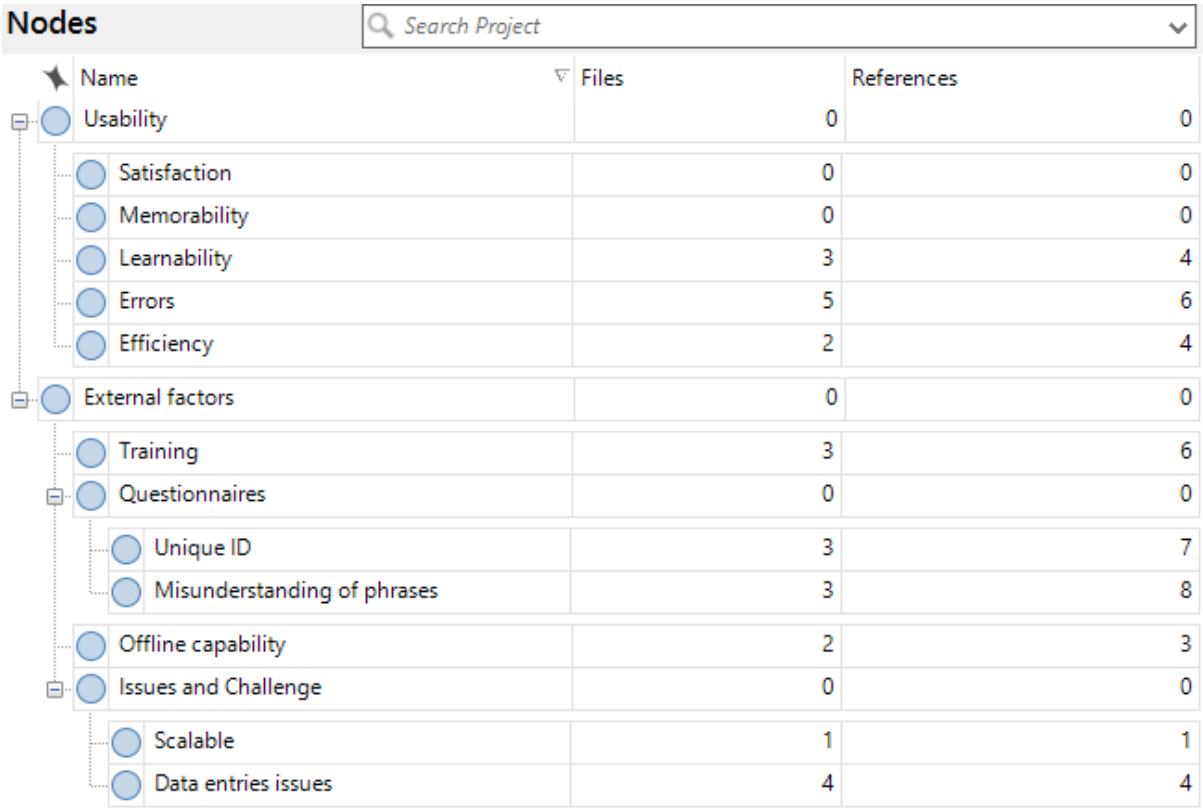


Figure 8: Categories made from NVivo

Usability category is the preconceived theme as shown in the pictures. This was determined before I conducted analysis of the data collection I gathered. The external factors were made to make sense, and in addition to categorize the data better.

Reflections of data collection

This section will reflect my data collection and to justify the chosen methodologies.

The Gambia has a cultural and social difference compared to Norway. Thereby, remaining flexible and adaptable during field study in the Gambia was ideal for me. Sometimes, unfortunate situations can occur and it can lead to plans being adjusted. The circumstances may be under effect of change and political conditioning may result in the absence of relevant actors. I was aware that changing my intended plans may occur and by any means, adapting to the situation was necessary. The original plan was to travel to the Gambia on several occasions, thus reassessment of plans had to occur whereas delays and limitation factors became a part of the picture. Despite being able to travel several times, I ended up with one trip in three weeks. Then again, this inflicted my data collection and constrained my understanding to the field. Based on my knowledge and the experience of the domain, it was difficult for me to take the advantage of the timeframe given to me. By reflecting on the timeframe, it would be beneficial for me to collect data in several trips to the Gambia. As a consequence of collecting the data in one trip, I lost the opportunity to reflect over the data collections and to plan for the next approach for data collection purposes.

The outcome of results depends on my data collection and how I proceed with the research. The methods I use would affect the result and the evidence of the study. Qualitative research cannot generalize populations at large by itself. The reason being that qualitative research majorly focuses on a small population in contrast to quantitative with a wider population. Assumptions cannot be made from data collection beyond a small population [35, p. 226]. Following, by combining qualitative and quantitative will increase the validity and reliability of the research and to further generalize the study. Due to the fact that quantitative data provides a macro view with larger samples and in addition to enable the conclusion to be generalized by combining those two research methods. This in fact will comply with triangulation, hence multiple sources can overcome and counterbalance the weakness of qualitative and quantitative by itself.

Empirical Findings

This chapter concerns the practical use of DHIS2 application with the users from the chosen schools. The chapter will start with an introduction of network capabilities in The Gambia, followed by how I prepared the training for the users. Subsequently, a description of what went wrong during observation and a comparison with the issues I experienced and how the users felt. This chapter will concern every part that is necessary for the application to be useful.

Network capabilities

The network access is very poor compared to Norway. However, The Gambia have access to 4G network, but we can discuss if the price is efficient for a long term strategy for a low resource school. During the visitation, I subscribed to a monthly subscription by Africell with 4mb/s speed for internet access. The 4G was working fine in the area I spent the night (Bijilo) and in Banjul (MoBSE office and Albion School). I observed that the internet connection was unstable, seeing that when I crossed the transition from town to town. Even so, the school I visited had neither WIFI or 4G dongles to access the internet.

Online/Offline feature:

The application lets the users perform daily tasks without internet connections. As long as there is no internet access, the laptop will stay offline and the user can do the task without being dependent on the internet for the functions to work. The online function was only used when the MoBSE needed to collect data. The data from Chromebooks will synchronize to the web and will be available in the browser for the MoBSE. To synchronize the data, the accountable from MoBSE must bring a 4G dongle to access the internet since the schools don't have WIFI. This feature was founded to be very essential for The Gambia and it could be the same for the corresponding countries.

I knew from my prior preparations that accessing the internet could be a challenge to some degree. I wanted to follow up the fact by experiencing the access and even more to confirm the expectation. The lack of resources to access the internet could be a challenge for the data collection to be timely and efficient for the educational sector. Online/offline function for pupil attendance is one of the solutions used in the Gambia to support against poor internet

access. I also had the opportunity to test and document the online/offline feature. The Chromebook will stay in offline mode until they get connected to an internet source. Online function was used when MoBSE came for data collection and they had to bring a 4G dongle to transmit the data to the internet.

Preparations and Training

I did preparation in University in Oslo (UiO) before I travelled to The Gambia. I attended a workshop with the HISP/EMIS team to understand more of the domain. My supervisor made sure that I got the relevant information before the visit. It was not possible for me to explore the application during my time in UiO.

I got access to the application through the first day at the MoBSE office. A demonstration of the application was provided by the MoBSE. The purpose of the preparation was to retrieve data regarding usability. I evaluated the application through 5 quality components based on the definition of usability provided by NNGroup. It was to some degree sufficient for me to evaluate learnability, errors, efficiency and satisfaction during the first time encountering the application. Evaluation of memorability was not feasible since I had to be absent from using the application. Because memorability is based on how easy it is to re-establish the use when encountering it after a while.

The data of the most interest to me, was to register the pupil attendance and enrolment. Reason being that usability deals with whether the goal is achieved. The goal in this case was if I could register the pupil. Secondly, I gather data related to misunderstanding of phrases and features that I did not understand. I wanted to see if other users experienced the same as I did. The last objective in preparation was to test how the error handling behaved. This was tested through checking of duplicate data and to provoke an error. I left some questionnaire fields empty, wrote the same pupil twice and so on in an attempt to provoke an error.

I kept the preparation quite simple because I needed to reflect over my assumptions with other users and to see if I can encounter other issues. My intention was to approach cautiously and in my best effort try not to miss any important data as I visit the schools.

Questionnaires

NOTE: See Figure 9 & 10.

The questionnaire was used to gather data regarding the pupil biological and socio information. These questionnaires are paper based and we distributed the papers to each school to collect data from pupils. They had a couple of days to fill in the papers and deliver the forms for data entries.

To begin with, these questionnaires had been a main tool to collect data from pupils regarding their socio-economics and biological information. The old system is all paper based while the new one deals with a combination of paper-based and digital solution. They transfer the provided data from questionnaires(paper-based) to the Application(Digital solution). While the old solution was transferring the questionnaires to the books provided by MoBSE.

The books collected the following information:

School admission register:

School admission register is for enrolment data.

The school admission register is known as The Exercise book

Pupil attendance register

Pupil attendance register is for daily attendance data.

The form within the application in Chromebooks is a mimic of the questionnaires. As I mentioned earlier about the function of the questionnaires, the teacher had to transfer the data from paper to a computer. The report from an earlier visit conducted by two master students says that the teacher felt transferring data from paper to data was time consuming with the prior system. This demand made by the Ministry showed in a later time that the teachers ended up only using the exercise book.

Unique identification of Pupils

Unlike in Norway, The Gambia does not have a national ID for the population, thus the teachers/users had to manually generate an ID for each pupil. These Identification numbers are unique, and will follow the pupil throughout the entire education.

The enrolment is divided in two cases: New student/existence and transfer students. According to the Student Admission Profile paper and the information MoBSE provided to me; Old Student registration numbers are used for transition pupils, then School admission numbers and Unique Student registration numbers are for New and existing students. Even if the enrolment is divided in two cases, the MoBSE are determined to keep one of them for future related registration. Since the system is under changing and existing students are already enrolled, thus they had to keep the old registration for that purpose.

Enrolment:
Re-admission(Old registration method)
Contains indicator:

- Old SRN(Old Student Registration Number)
- Name of previous School
- School code
- Last class attended
- Date of leaving

New admission fields(New registration method)
Contains indicator:

- School admission number
- Unique SRN(Student Registration Number, generated by EMIS)

It was discussing how they should generate the unique Student ID, either as manual filling by the users or for the application to generate automatically. Either way, there were some quick solutions since the project was under a pre-pilot phase. The MoBSE suggested that we format the Student ID as followed:

1: Five numbers for school code

2: Four numbers for the enrolment year

3: Three numbers for the Student ID

These numbers are combined/merged and will be the unique ID for the pupil. The first five numbers will identify the school the pupils are enrolled in. Subsequently, the next four numbers are to identify the enrolment year. Lastly, the final three numbers will be the pupils ID numbers. The Student ID numbers are generated based on their position in the registration queue, by meaning, the first pupil will get number 001 and the next 002 and this will go ascending.

(11111)(2222)(333) ⇒ 200102016001

Once again, generating the Student ID is manual work for the users (Teacher, IT accountable).

School observation

This section will describe the pupil attendance application during observation. What went well and issues within the application throughout the observation. As mentioned in Chapter 5, two schools were chosen as pilots and I observed them on two occasions. The objective on the first visit was to clarify the purpose of the pilot and to train the staff. The second time was to collect data regarding accomplishment of registration and collect data regarding incoming issues. Both schools were urban and not rural.

Albyon

This school is located in Banjul and in the neighbourhood of MoBSE. Since Albyon was close, it was more convenient to prioritize this school before the other schools. The MoBSE had already started their work before involving me. Usually, the first visits were more or less just for introductory purposes. Since MoBSE already launched the pre-pilot in Albyon, there was not much new information to be gained on the first visit. Despite the current situation, it

was attainable for me to collect data regarding user interaction and usability terms during this visitation.

During the first attempt with the application, I found adding a new pupil was not quite intuitive and I felt a need to verify this issue with the users. The accountables for daily and enrolment registration in Albyon could verify my assumption. In contrast with this issue, once we knew how the add function worked, it was intuitive for us to use it.

The second approach of Albyon

Albyon experienced a delay on gathering the questionnaires from the pupils. However, we did a synchronization with the current data to inspect for further issues. It was registered duplication on some pupils and the accountable from MoBSE had to do some quick fix to ensure the synchronization went through. The synchronization will not allow any transmission of daily attendance and enrolment if the data entry is wrong.

I asked the IT accountable from this school whether they had experienced any issues that could stagnate their workflows. They explained to me that navigation with only a trackpad was not very efficient, and they felt using **cursors** and **TAB** to navigate to the next field could make the work more efficient. Despite that issue, they told me that they believed the system would be of aid.

Kabafita

The Kabafita is an urban school and is located south of Banjul. The school is divided in two parts, Lower Basic School and Secondary School Education. Both schools were next to each other and there were only walls separating the two schools. This school had not had data collected by MoBSE previously, which was an opportunity for me to collect the data from scratch. The accompaniment from MoBSE suggested that I took control and tried in my best effort to direct the introduction of the pre pilot to the Kabafita schools.

Kabafita LBS

The lower basic school consists of 1-7 grade and is somewhat similar to the Norwegian grade school system. The headteacher of the school was absent during my visitation, but had been

notified in advance of our presence there. The deputy headteacher was the stand in and helped me arrange a meeting with other accountables of the school. A young teacher was chosen by the deputy headteacher to be responsible of the application training. There were also two teacher pupils from the Netherlands during this meeting. The purpose of this meeting was to train the users to be capable of entering the data to the application. I distributed 45 questionnaires to this school among the fifth grade pupils.

Kabafita SSE

The secondary school education consists of 8-12 grades and I visited them right after Kabafita LBS. The headteacher and a teacher were present during this meeting. In similarity with the recent visit, I introduced to them the intention of the pre-pilot. Kabafita SSE chose the ninth grade for the pre-pilot. Usually during these meetings, I provide the questionnaires and then leave, because the pupils need time to fill these questionnaires with their parents or guardians. Despite the usual routine, the headteacher suggested that the pupils should fill the questionnaires while I was present. He argued that I could elaborate to them in case of misunderstanding. Accordingly, the headteacher ensured that I had a teacher to accompany me.

This suggestion was unique in comparison with the method MoBSE suggested. I found the suggestion from the headteacher reasonable, since I could collect data regarding timeliness, misinterpretation of concepts and how these questionnaires worked in practice. It turns out that the questionnaire was confusing for some pupils. Fieldnames like “Distance from School (in KM)”, “Mentally Challenged?” and “How long did it take you to get to school(minutes) were a recurring confusion during the observation.

The second approach in Kabafita

The Kabafita LBS was delayed and we could not gather any data from this school. On the other hand, Kabafita SSE finished their data entry and was ready for synchronization. There was registered duplication of data during synchronization and some invalid data entries. Again, the accountable from MoBSE had to do some quick fix to get rid of duplication of data. Duplication of data occurred usually when the user is registering the pupil’s Unique ID,

and this occurred in Albyon as well. Subsequently, we had a problem with another data field. The problem started first from the questionnaire field. I will discuss this issue in **Result,** section **Errors during data entry, case 1.**

Conclusion from visit

I wanted to observe the use and collect data regarding usability from the users. These users are working in the schools, their thoughts and perceptions are relevant data as well. Since these users are entering the data to the application, would it be natural for me to focus on them. I sympathize that errors are to be expected during pre-pilot and the application is not fully developed yet. However, I learned a lot during these visits, and I could observe where the users misinterpreted the application. Subsequently, a visit to a rural school would benefit my study to map essential usability for them as well.

There is a weakness with the suggestion provided by the headteacher of Kabafita SSE, besides for being quite efficient. Many of these fields are not sufficient to be filled by the pupil themselves. For example, the health data should be filled by their parents/guardians or with a certified health personnel because it is mostly unlikely that a young pupil knows every detail.

Result and analysis

This chapter presents the result derived from the outcome of Empirical Findings and data analysis. My contribution and evaluation of the pupil attendance application was during pre-pilot. The following section will also present the essential usability aspect that is found from the analysis. Many essential usability aspects are still left uncovered.

Offline capability

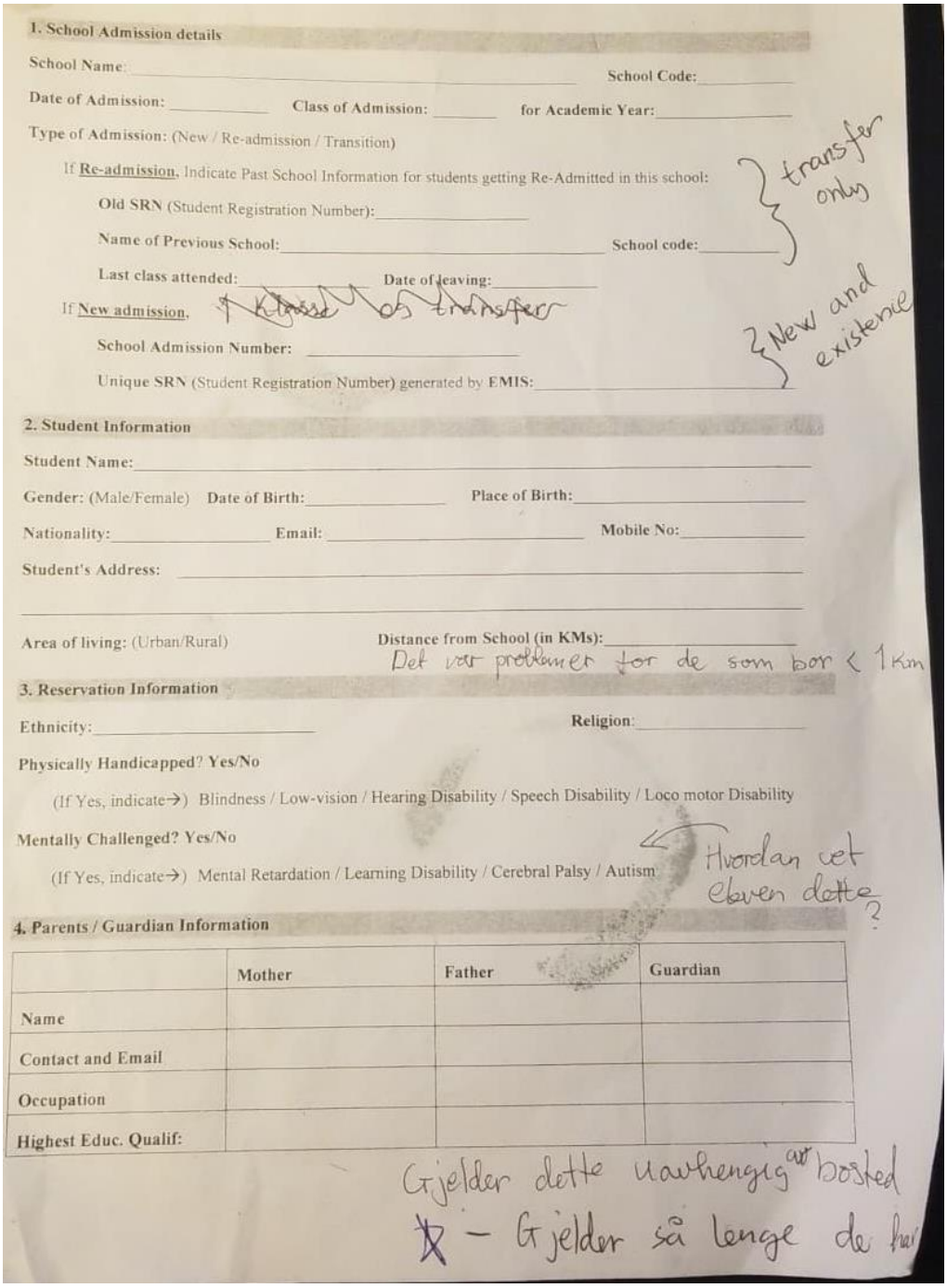
I described in the previous chapter the lack of continuous access to the internet, and the fact remains the same. The school does not have access to WIFI. The lack of resources is limiting the schools from reporting attendance daily and they strive to utilize the very few resources they have. Due to a strict budget, adding an additional cost by having Internet access in every school may be costly for them in the long term. In addition, some areas may not gain access to WIFI or 4G due to poor Internet infrastructure. The ministry has a solution to support them with a 4G dongle for that purpose. The schools can connect through the dongle to transfer the collected data. This solution did capture my attention as it solves the connectivity problem for the schools. The offline mode is a very important function for a pupil application to be useful with the same context as The Gambia. The offline function lets the user complete entry of enrolment and attendance data, and the collected data will be stored locally until they transmit to the web. This solution showed me that the application can somehow simulate a "real time" daily attendance, despite the data not being transmitted on the same day.

Questionnaires

I explained in the earlier chapter the content of the questionnaires, and how they were used during field study. The questionnaires have purposes and goals, which means there is usability within these questionnaires. These papers are for enrolment data, biological data and socio-economic data about the pupils, and these data are considered to be useful for the ministry to ensure quality education for the pupils. Because the data provided by these questionnaires will be used to monitor the pupils. As the questionnaire informs the pupils physically or mentally challenges, their contact information, what communication equipment they have access to, and so on… However, the questionnaire had not been easy to utilize.

As the content from these questionnaires should be designed for the intended users. This implies that the questions should be answerable for the pupil and their parents/guardian. Whereas, the field names like **Physically** and **Mentally** from **section 3: Reserved information** should be discussed if these should be answered by their parents or by a health responsible like doctors. Another discussion will be if an integration between Health Management Information Systems and Education Management Information System would be beneficial for this situation. I discussed this with my supervisor and to achieve this, an unique ID for both systems must be created to be able to communicate.

Some questions and examples should be rephrased to a degree that the pupils and their parents/guardian can understand. For instance, **field 5.8: How long did it take you to get to school** was a concurrent question from the pupils(Kabafita SSE) because converting hours to minutes shows to be a struggle. The teacher assisted them, but he showed the wrong format. Even though the paper specifies that minutes is the format. This is because the entry point from the questionnaires has three boxes, which the teacher interprets to be **Hours/Minutes/Seconds**. In addition to the example(middle column from the questionnaire) did not support them either. Whereas the example provided: **[What time did you leave home today? What time did you arrive at school? on time?]** does not help them to understand the intended question: **How long did it take you to get to school(minutes)?**. In overall, these questionnaires can make the data entry challenging, and consequently cause poor quality data.



1. School Admission details

School Name: _____ School Code: _____

Date of Admission: _____ Class of Admission: _____ for Academic Year: _____

Type of Admission: (New / Re-admission / Transition)

If Re-admission, Indicate Past School Information for students getting Re-Admitted in this school:

Old SRN (Student Registration Number): _____

Name of Previous School: _____ School code: _____

Last class attended: _____ Date of leaving: _____

If New admission, Klasse ved transfer

School Admission Number: _____

Unique SRN (Student Registration Number) generated by EMIS: _____

transfer only

New and existing

2. Student Information

Student Name: _____

Gender: (Male/Female) Date of Birth: _____ Place of Birth: _____

Nationality: _____ Email: _____ Mobile No: _____

Student's Address: _____

_____

Area of living: (Urban/Rural) Distance from School (in KMs): _____

Det var problemer for de som bor < 1 Km

3. Reservation Information

Ethnicity: _____ Religion: _____

Physically Handicapped? Yes/No

(If Yes, indicate→) Blindness / Low-vision / Hearing Disability / Speech Disability / Loco motor Disability

Mentally Challenged? Yes/No

(If Yes, indicate→) Mental Retardation / Learning Disability / Cerebral Palsy / Autism

Hvordan vet ebven dette?

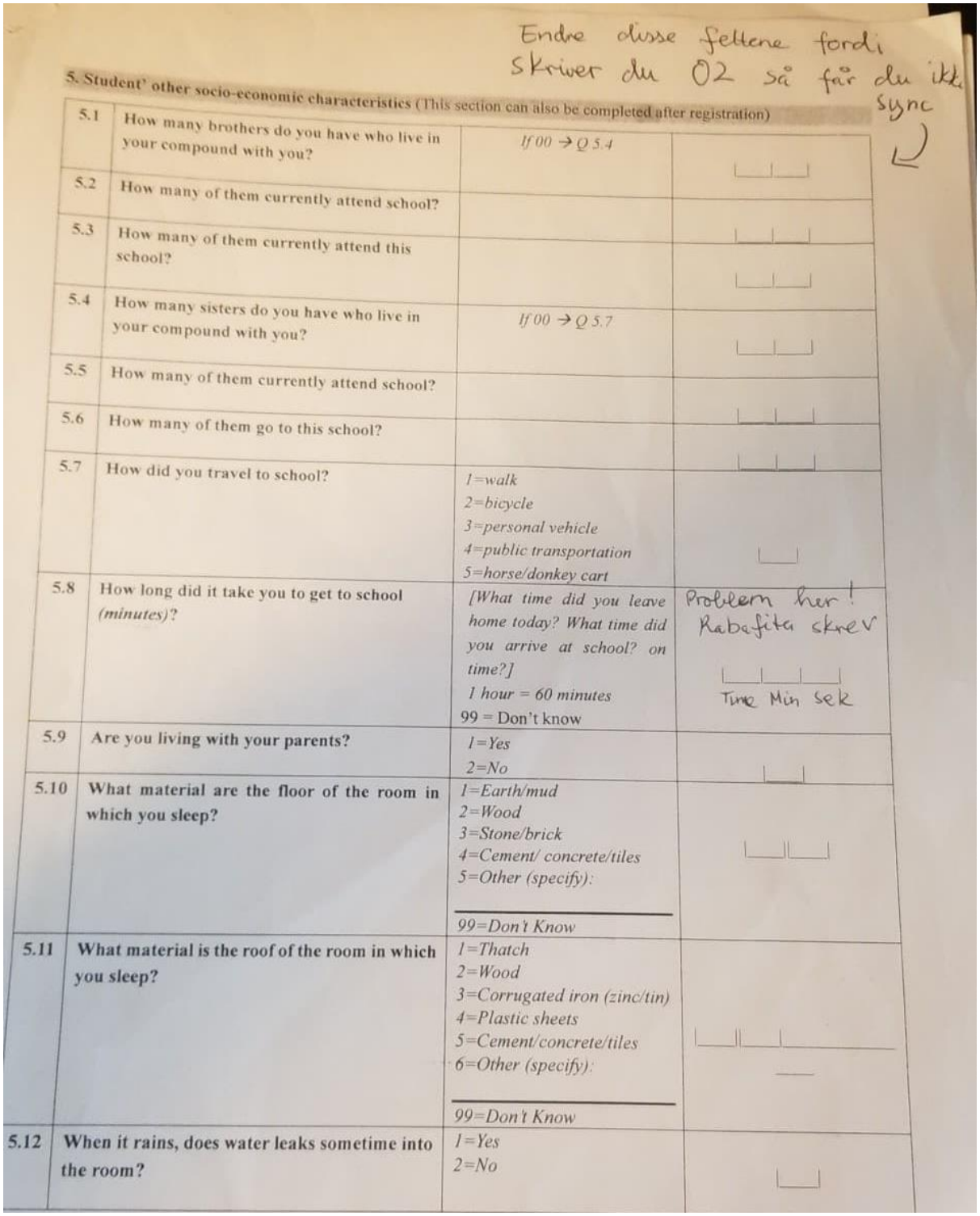
4. Parents / Guardian Information

	Mother	Father	Guardian
Name			
Contact and Email			
Occupation			
Highest Educ. Qualif:			

Gjelder dette uavhengig av bosted

X – Gjelder så lenge de har

Figure 9: Questionnaire page 1



Endre disse feltene fordi skriver du 02 så får du ikke sync

5. Student' other socio-economic characteristics (This section can also be completed after registration)

5.1	How many brothers do you have who live in your compound with you?	*If 00 → Q 5.4*	___
5.2	How many of them currently attend school?		___
5.3	How many of them currently attend this school?		___
5.4	How many sisters do you have who live in your compound with you?	*If 00 → Q 5.7*	___
5.5	How many of them currently attend school?		___
5.6	How many of them go to this school?		___
5.7	How did you travel to school?	*1=walk* *2=bicycle* *3=personal vehicle* *4=public transportation* *5=horse/donkey cart*	___
5.8	How long did it take you to get to school *(minutes)*?	*[What time did you leave home today? What time did you arrive at school? on time?]* *1 hour = 60 minutes* 99 = Don't know	Problem her! Rabefita skrev ___ ___ ___ Time Min Sek
5.9	Are you living with your parents?	*1=Yes* *2=No*	___
5.10	What material are the floor of the room in which you sleep?	*1=Earth/mud* *2=Wood* *3=Stone/brick* *4=Cement/ concrete/tiles* *5=Other (specify):* _____ *99=Don't Know*	___
5.11	What material is the roof of the room in which you sleep?	*1=Thatch* *2=Wood* *3=Corrugated iron (zinc/tin)* *4=Plastic sheets* *5=Cement/concrete/tiles* *6=Other (specify):* _____ *99=Don't Know*	___
5.12	When it rains, does water leaks sometime into the room?	*1=Yes* *2=No*	___

Figure 10: Questionnaire page 2

Errors

Errors were to be expected since the application was not fully developed yet. I did however, not experience any severe or critical errors throughout using the application. The same corresponds to the other users of the application. The error messages were not triggered during data entry, but only when synchronization happens. The following section will show and explain the errors.

Errors during data entry

The errors that encountered will be described as cases underneath:

> Case 1: Wrong entry of numbers:
> value_not_zero_or_positive_integer
>
> Case 2: Duplication of data:
> ERROR: Some of your data failed to sync. Check their sync status: programs with error are marked as "icon", TEI's and events as "icon"(Duplication)

Wrong entry of numbers

The forms from the application should in practice mimic the questionnaire. My observation has shown that not every field corresponds to this. The questionnaire field 5.1(See Figure: questionnaire page 2) from the questionnaire expects the user to write 00 if the pupil doesn’t have brothers or sisters. If the user writes 00 in the application, the system does not render any error, but if the user writes 01 then an error message will appear during synchronization. This is because 00 is a zero value and 01 is not zero or a positive number.

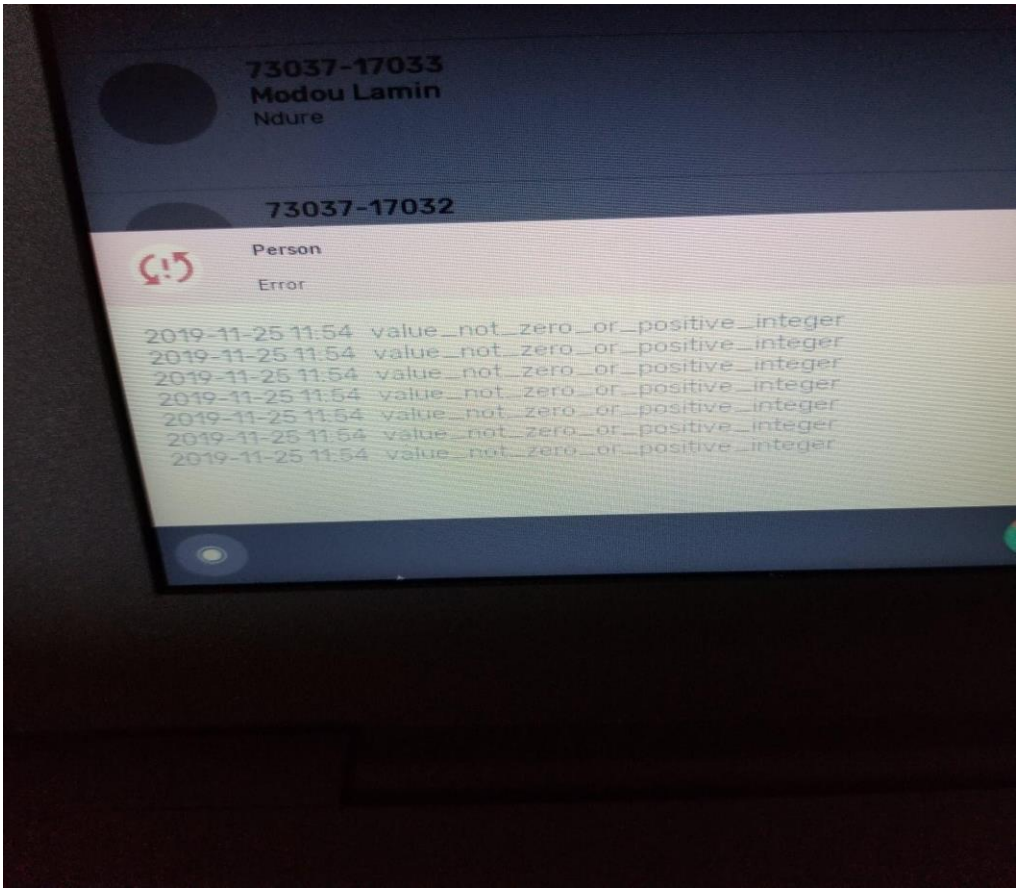


Figure 11: Error message for wrong entry of numbers

Duplication of data

The application should in practice mitigate the users from duplication of data according to their leader. However, I could observe occurrences of duplication of data. The question is how this is possible, and when the application captures it? First, there is no data validation during entering the pupil's unique ID(OLD SRN/ SRN). Many of the users experienced struggle with manually inputting these IDs. Lastly, the application captures the duplication when the data is synchronizing, thus none of the users would notice.

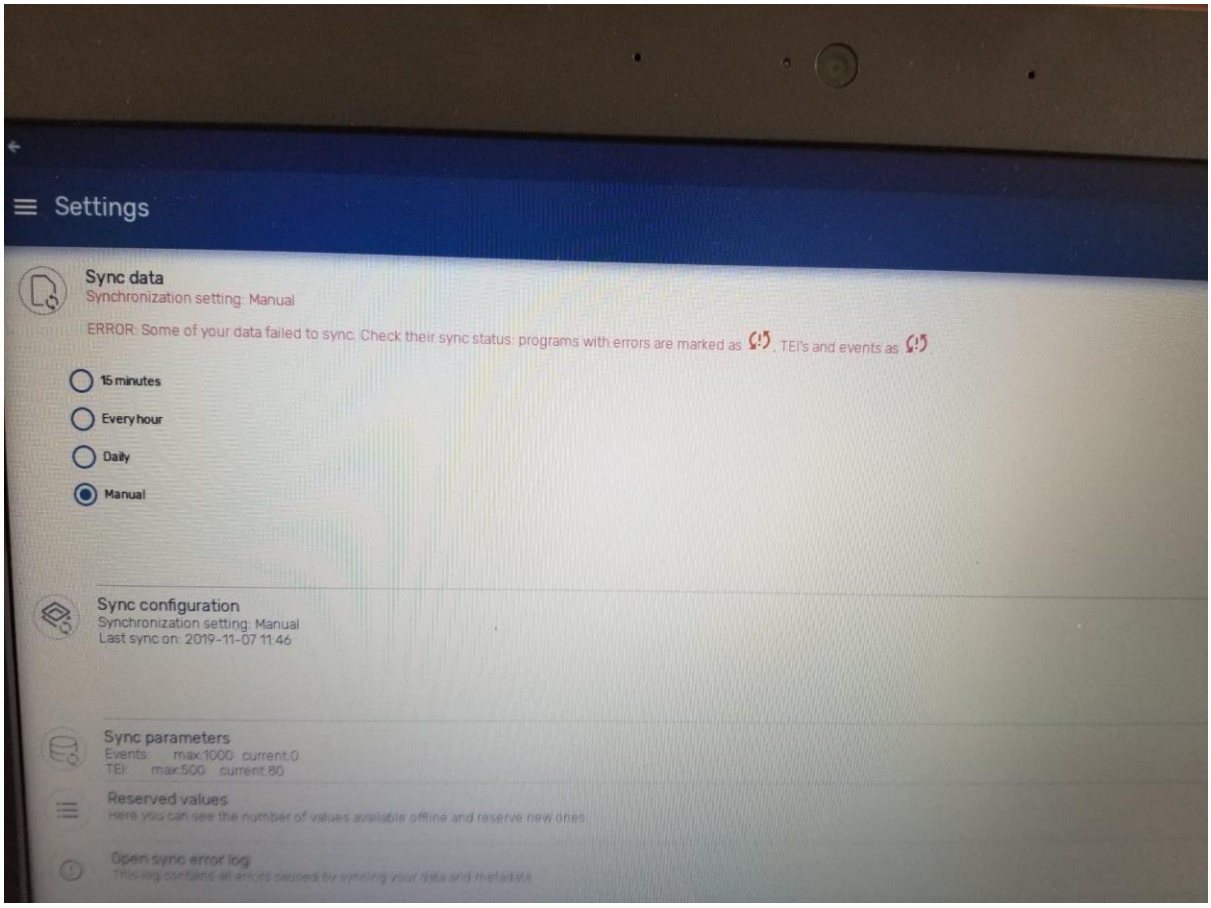


Figure 12: Error message for duplication of data

Training and support

The training and demonstration are essential for the users to be able to use the application. The users in this context were the teachers or ICT accountable for the schools. I observed that the training on the field was more or less too short. Because in a later time showed that the users had questions regarding the data entries and utilization in the application. Transferring the data from the questionnaire was explained to be “very easy”. However, my analysis showed that the users did experience issues. Nevertheless, the trainer explained that once the users (Teacher/ICT accountable) acquire the questionnaires from the pupils, they should transfer the questionnaire data to the computer right away. This was shown not to be easy for Kabafita LBS, considering that the young teacher kept calling the trainer to ask questions regarding the transfer and the utilization of the application.

Knowledge of use of hardware devices

Google Chromebooks were used during my observation. The Android Tablets were demonstrated to me but were not used in the pre-pilot. The observation shows that some users lacked information on how to use the Chromebooks. Simple user interaction like writing capital letters was not intuitive for them. I had to show the user to press **Shift+"letter"**, and this finding may correspond for other users.

Assessment of Nielsen's Usability Quality Attribute

In terms of Nielsen's definition of usability, I will use the five quality components defined by Nielsen Norman Group to analyze my findings. The analysis was based on the data collected from the users, and coupled with my subjective judgement of the pupil attendance application during observation. There will be a description of each quality component as an introduction before I discuss each component.

As usability deals with a goal, the goal for this assessment involves registration of the pupil attendance and enrolment.

Learnability

Definition provided by NNGroup:
How easy is it for users to accomplish basic tasks the first time they encounter the design? [5]

This component is about how easy it is for you to use the application and still accomplish your daily task. To illustrate this component for my study, I will connect this component with my observation.

My first encounter with the application was during the first day at the MoBSE. The ministry provided me with a demonstration of how it worked. The question is whether the demonstration somehow violates or hurts the evaluation of learnability? But if I compare this with the real-world convention, it would be natural to have a demonstration for the new users anyway. Because how much information you gain from the demonstration may be subjective, and it may not be quite intuitive when you use it on your own. Subsequently, based on my

experience, I encountered an issue when registering the pupils. Adding the new pupil was an experience challenge, because the add-button does not display until the user presses the search button first. The function is quite understandable, because this function can be one of the factors to mitigate against duplication of data since the user has to check if the pupil already exists before adding. In practice, this function misled me and commonly the users from each school.

Efficiency

Definition provided by NNGroup:

- Once users have learned the design, how quickly can they perform tasks? [5]

This component talks about how quick and easy they can perform the daily task after learning the application. Now that the users know how it works, then the next step is to evaluate how quick the user can utilize it.

After I understood the use, it was possible for me to evaluate efficiency. Efficiency in this context will be how fast can I register a pupil's enrolment and daily attendance. Beside the add-button issue, I encountered a navigation problem that will reduce the efficiency. Basically, the form in the laptop should be mimicking the questionnaire. Which means every field name in the questionnaire is to be found in the application. Transferring the information from the questionnaire to the application was not a challenge for me and the users. Rather, the explanation provided in the middle column from the questionnaire led to an error.

Subsequently, moving from field to field using the laptop was not convenient, because navigation was possible only through a trackpad. Navigation with TAB or cursors was not implemented during pre-pilot and this issue was picked up on by myself and other users. We can argue that the user may be proficient after every iteration of use, but in the end, the efficiency was hindered by the use of trackpad navigation. Another aspect to improve the efficiency is to connect with a mouse. Either way, adding extra equipment to improve the workflow should not be necessary for the users. The application should be efficient as possible, and support the option to add equipment based on the users preference of work.

It took me three steps to finish an attendance. First, the user has to press “Add New” and then it navigates the user to the next screen. Secondly, the user must choose the date and the school. Lastly, they can now choose the attendance and finish and complete. I will argue that this process can be done in two steps, by combining the second and the last step together. Whereas the application will improve efficiency and still maintain a minimalistic design for the users. I think that removing this type of redundancy can speed up this process.

Memorability

Definition provided by NNGroup:
When users return to the design after a period of not using it, how easily can they reestablish proficiency? [5]

This component is about after a period of not using the application, will it still be natural for the user to come back and accomplish daily tasks?

Consistency is an important aspect to apprehend the memorability. If the user knows the design after they are returning to it, then they will not struggle cognitively and furthermore having an easy reestablishment. The study lasted for three weeks and I do not think it was sufficient time for me to determine the memorability of the application. In addition to my data collection does not provide any information to this attribute. Another consideration is that the application was under development, thus the application is not consistent enough, since it will get new features later on. This consideration limits me from fully evaluating the memorability.

Errors

Definition provided by NNGroup:
How many errors do users make, how severe are these errors, and how easily can they recover from the errors? [5]

The definition provided from NNGroup is already explained in directness, but this component is concerning if one encounters an error, is a critical error? Is it easy for the users to recover from it?

The pre-pilot version of DHIS2 pupil attendance application was flexible during this stage. It was possible to “close and finish” the registration of attendance or enrolment and still be able to edit later on. The system was not complex during pre-pilot and the intended goal is to register the pupil enrolment and daily attendance which is not a complex operation in the first place. Of course, I did encounter some errors and these error messages did not show up until synchronization. The errors I experienced were not that severe or critical, but rather common issues that led to more work for the users. These common issues were usually duplicated data, and this could be mitigated if a data validation was implemented. The data validation will check if the OLD SRN or SRN already existed, and the quality check should do the same for every unique variable.

To illustrate the quality check, take for example a registration of email; You have the option to choose which username you want to use, and the website validates right after you filled the username to check for whether it exists or not. Basically, you are free to move on to the next step if the username does not exist. The same could be essential for a general pupil attendance application as well. Because each time the users encountered duplication of data, they had to fix this by themselves or get support from an accountant from MoBSE. It was possible to recover from errors, but only if you had technical background. The error messages were not intended for the regular user, but rather for the developers.

Satisfaction

Definition provided by NNGroup:
How pleasant is it to use the design? [5]

Do the service meet the users expectations and needs by using the application?

It was not sufficient for me to evaluate this attribute due to inadequate data collections.

Conclusion of Nielsen’s usability analyzation

Using the quality attribute provided by Nielsen’s group to analyze my findings has shown pros and cons of the pupil attendance application, and its perceived ability to be useful. The application was at an early development, thus it has room for improvement. These improvements may construct the system to be more efficient and more usable for the users.

Conclusion and reflection of Result and Analysis

The purpose of this thesis was to research essential usability aspects that will serve for a pupil's attendance in a low resource public education setting. The data was collected during pre-pilot, and the analysis was conducted on that collection of data. The analysis shows in a later time that I could have been missing some essential data during my observation. I reasoned this in the chapter **Method: Reflection of data collection**, due to my knowledge on the domain during that time. Missing the opportunity to reflect over my data collection, and prepare for a new approach to collect the data has shown to be a disadvantage when fully analyzing the quality attributes.

I will discuss this further in the **Discussion** chapter. I see the derivation of results from the analysis has appeared to miss some essential data. As collecting data to analyse memorability and satisfaction required more time and the proper method. I see in a later perspective that conducting a comprehensive **Usability Testing** could be the proper method. As I could capture more of the user’s behaviours, and their interpretation while using the application to strengthen my evidence. I will discuss this further in **Discussion** and **Future work**.

Discussion

This section concerns a discussion about my findings, results and analysis. I will discuss with other researchers, and use Nielsen's Ten heuristics from the literature review to discuss as well.

My findings show that involving users is essential to uncover usability issues.
In **Chapter 3: Methods**, it was mentioned that I tested the application before I was involved with the users. This was specifically because I wanted to compare my thoughts with theirs to observe the differences in how we perceived the use of the application. Once again, my findings show that we shared to some degree a common ground with the difficulties. I think involving the users to test the application was essential, because I learned to understand their interpretation and they provided me a confirmation to what I felt could be an issue. In conclusion, Nielsen's usability heuristics are based on experience from a different context. This could lead to usability evaluation being more challenging, as the user may lack ICT knowledge. Therefore they provided me with insufficient data. This will be discussed under **Limitations on data collection.**

Speak the same language

From Background: Literature review, the usability quality attribute "Match between system and the real world", says the system should speak the same language as the user, with words, phrases and concepts familiar to the user is an important usability aspect. Nielsen Group stated that designers/programmers should never assume that their interpretations and understanding of words or objects match those of their users [42]. How we perceive and interpret the world around us varies from individual to individual. To illustrate this furthermore, take for instance the questionnaire from the result; The designer of the questionnaire meant it was "very easy" and straightforward. However, the observation during Kabafita SSE turned out to be different from the anticipation by the designer. First of all, it is arguably to say that it is not sufficient to let the pupil answer these questionnaires by themselves, and should have support from their parents or guardians. However, due to some parents'- or guardians' illiteracy, it is not unlikely that some of the pupils may have to explain

or read for their parents and guardians. Based on my findings, I will argue that these questionnaires should be discussed whether the ministry should rephrase it or discuss for which data is necessary, and be more answerable for the pupils/parents/guardians.

The next section, **Developing for rural users**, will continue the discussion with the same use of heuristic. This is a presentation of a concern that I think may implicate a challenge, and including this **Usability Heuristic** may support the case. Although, this needs to be studied.

Case: Developing for rural users

Chapter: Empirical findings stated that a rural visit was not possible due to the constraints. From the chapter**: Background, ICT and Technology** confirms a distinction of network capabilities between rural and urban areas, whereas 4G and 3G are accessible in the western part of The Gambia. As we go further to the east, GSM-signal is dominating these areas, but only two areas have access to 3G. A tablet with an extension of the prior SMS solution was provided to support these rural areas for attendance of pupils and teachers. The design of the tablet showed me to be easier than using old phones with no touch interfaces. Because the application formats the input from the users which in theory will serve to reduce the errors, and then send the daily attendance through SMS. The reason I said in theory, is because I had no opportunity to explore the tablet solution during my field trip and therefore it needs further study to conclude.

The literature review explains that developing for the rural can be challenging for the software engineers and for the other stakeholders [43, p. 1]. Thus, the software developers must respect the challenges with the limitations of the infrastructures, the cultural differences and different languages. I cannot comply to this case since I had not visited the rural areas, but from the chapter **Background: The Gambia** and the literature review, stated that The Gambia hosts many languages and therefore the software developers and stakeholders should also consider **mediations** or **agents** to support the different languages in The Gambia [43, p. 1]. The applications should speak the same language as the users, as it can support them to handle the application.

Pruitt and Grudin argue that the users do not always know what they want until they get it [43, p. 3]. They explained that good design comes from the designer, rather than from the users. First of all, by involving the users for testing had allowed me to uncover a few usability issues with the current version of the application. But it required the users to try the application first, which complies to the first argument of Pruitt and Grudin. During my interviews with some of the users, I observed that some of them did not have any opinions regarding the application.

The other argument was shown to be inaccurate to some degree, since navigation with **"Cursors"** and **"TAB"** through the application was not implemented. This was mentioned by the users from Albyon. By leaving this function outside, it can lead to a disadvantage for the experienced users in a later time. This function is defined as an "accelerator" which will speed up the user interaction according to Nielsen Norman Group [44]. Furthermore, this function can allow the experienced users to complete common daily tasks faster and more efficient. Based on my findings, I recommend that the designers/programmers together with some representative users try to determine the accelerators. This in fact requires the users to know what they want first. The designer/developer should also know what to determine as an accelerator, and it could be done by focusing on the feature that is repeatedly used by the users. This aspect will comply with one of Nielsen Norman Group's Ten heuristic of user interface, **Flexibility and efficiency of use**, in addition to enhancing the **Efficiency** usability attribute as well.

Another function that could be handy in the future is batch operation, as the current application does not support it yet. This implies that the user cannot insert values for several tracked entities concerning the pupils at the same time. The batch operation can enhance the inserting speed for the teachers/data enters. The user can expect a lot of repetitive work with the current application. Another aspect is that the application does not provide auto filling. Auto filling may increase the speed during inserting enrolment data. These aspects will potentially be **accelerators** that need to be studied and discussed to further conclude.

Cooper argues that designers/programmers have too much influence over the human interface [43, p. 3]. He also stated that the programmers lack skills in this area, leading to doing a poor

job out of it. If this is a case in The Gambia, I would recommend the designers/programmers to involve the users despite their knowledge. The data collected may be a potential benefit to understand the users' point of view more in depth. You could argue that this process requires a lot of time and resources, and consequently not worth it. However, strengthening the designers/programmers knowledge for the domain, and giving more power to the users opinions is more beneficial than bad, as far as I can tell. I will also argue that this may help the case of **command-and-control** type, since the collaboration between developers/programmers and users together have more impact versus one person. That is why the developers/programmers for this field should consider evaluating together with the representative users to assign these **accelerators**.

The relationship between learnability and efficiency

Based on Nielsen Norman Group study, there is a difference between **learnability** and **efficiency**, despite being related [45]. To understand them, we must introduce two users: New user and experienced user. We know that learnability concerns how quickly you can perform basic tasks during the first encounter of the system. A highly learnability system will be beneficial for the new users because new users want to learn the system quickly and achieve the **optimum** performance. The problem with a highly learnability system is when the user becomes more advanced. Considering the experienced users strives to complete the task in a time as short as possible. Therefore, a highly learnable system will be a disadvantage for an experienced user.

The point is a highly learnable system is not always efficient [45]. A highly learnable pupil application will provide a lot of instructions and explanations for every process, which ensures the user to complete the task with the right input. But in the long term, a highly learnability system will be inefficient for repeated use. Thus, the designer should consider a balance between learnable and efficient systems so neither the new users nor experienced users will be left outside of the scope. The key is to maintain a balance between learnable and efficiency.

Involve 5 users to test the application:

Usability test was introduced during **Conclusion of Result and Analysis**, and if the resource does not allow that, then *Testing with five users* can be sufficient to use instead. Nielsen Norman Group stated that testing with five users is sufficient to gain the best results. I will explain the Usability Test in **Future work**.

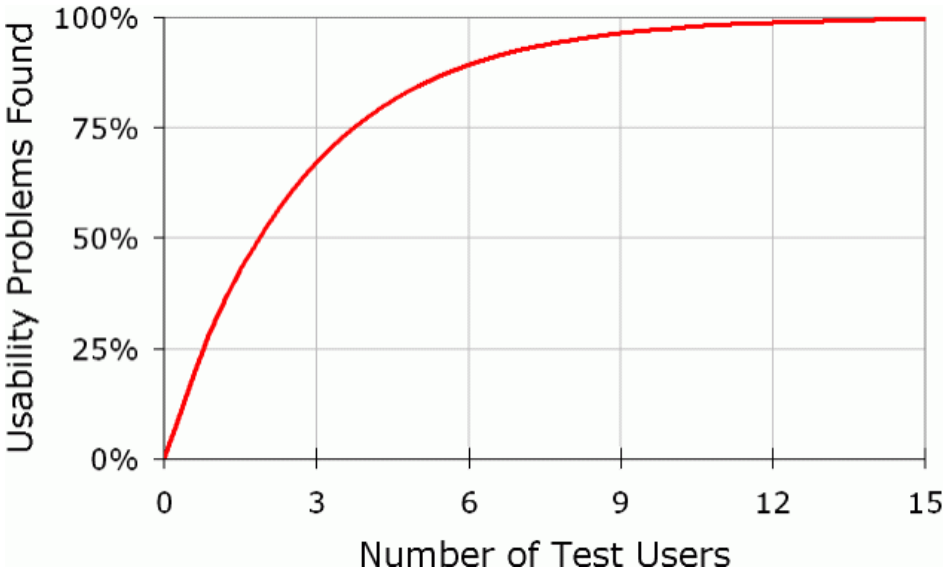


Figure 13: Why testing with 5 users is sufficient [46]

Initially, testing with zero users gives zero insights! The **first single test** with a user will give the programmers/developers a good collection of data. The insights gained from the first single test uncovers almost *a third* of what is known about the usability of the design [46]. The **second test** with another user will uncover many of the same as the first user, but you may uncover new data for new insights. The third user will generate a small amount of new data, but supposedly the same as the first or the second user.

As the designers/programmers add more and more, they will learn less [46]. Reasonably, they will observe the same again, and this can be illustrated as seen on the Figure: 13. The curve begins to flatten out as one examines after the fifth user, although the figure shows that testing 15 users is needed to discover all the usability problems in a design. In the long run, testing with 15 users each time may cause waste of resources and time. Instead of focusing all resources on one single study, divide it into three studies with five participants in each study [46].

However, this is based on a Nielsen Norman Group's study, and this can impose a challenge for the Sub-African context and therefore need to be examined to further conclude. The intent of this proposal is to collect data to find a balance between learnability and efficiency, that in the end will benefit the users. As the users know how to handle the application, they can provide better reports for EMIS statistics. This statistic can be used to facilitate better decisions in such a degree that will benefit quality education.

Errors

In this section I will divide the *Errors* in two parts, whereas the first part will be about the **Error messages**, and the other will be **Error prevention**.

Error Messages

Help users recognize, diagnose, and recover from errors is one of the Ten usability heuristics. This heuristic addresses that the error message should use the same language as the user, and not in code [47]. In addition to providing suggestions for a solution. The results derived from my data collection showed that the error messages were not intended for the users, but rather for the developers. This was not observed as a problem, because the user did not know at all when an error occurred. Because the errors were shown during synchronization and the accountability from MoBSE aided the user with solutions. However, the accountability will not always be present, and the solutions provided were more or less repetitive work for the users. Then this can be unpleasant for the users to handle without any **indications** or visible **messages** during data entries.

Error Prevention

The best scenario is to prevent the errors from happening in the first place. Although, errors may occur even if we want to or not. **Error Prevention** is one of the ten usability heuristics, which implies a careful design that prevents errors from occurring will be a better alternative than providing good error messages in the first place [48].

In some occasions of errors, the term **Blaming** may be assigned to accuse the victim. The victim in this case is either the **user** or the **developer/programmers**. If the fault lies in the

user's mistakes then the term **"user error"** will describe this phenomenon [48]. On the contrary, the designers/programmers can be at fault, thus they could make it easier for the user to commit **user errors** [48].

Two types of user errors:

Slips: This type of error occurs when the user performs one action, and the outcome becomes another action. According to Nielsen, typing "i" instead of "o" counts as a slip [48]. **Slips** are common in daily life as well, like using salt instead of sugar during cooking. In most cases, the slip occurs when the user does not devote their attention to their intended task.

Mistake: **Mistakes** are made when users have goals that are inappropriate for the current problem or task; even if they take the right steps to complete their goals, the steps will result in an error [48]. This occurs when the user has incomplete or incorrect information about the task. For instance, the user's task was to register a pupil attendance, but ending up with registering an enrolment instead. Regardless of following the step correctly, the user's attempt was inappropriate for the task.

Both slips and mistakes occurred during my observation. As stated in Chapter: **Result and Analysis - section Errors**, errors were found during data entry and when the user transferred from the questionnaire to the Application. In respect of the developers and the user, I will devoid any blaming for these errors. But rather support the current situation by giving input.

Case 1: Wrong entry of data from **Result and Analysis** shows to be a mistake that can be fixed by the developers, given that the user did every step correctly and it still resulted in an error.

Case 2: Duplication of data shows to be a slip made by the user, reason being that generating a unique ID manually appeared to be less accurate and efficient. Slips can occur with none being at fault to blame, but manually controlling twelve numbers for a Unique ID for an entire class is not unlikely to cause the user to miss sometimes. It would likely be more dependable to let the application generate the Unique ID instead of the users.

Training and Support

The desire of the application to be usable without documentation requires a lot of effort. It is necessary for the current situation to provide documentations or manuals for the use of application, and for the hardware device as well. The findings show that one user did not know how to write capital letters with the current hardware device, and another user had difficulty with using the application. Despite having training, it was shown to be difficult to complete for some.

There will be cases when the users will miss either training, receive errors during use, and so on. Having access to these manuals can benefit these cases in such a manner the users can handle it by themselves. **Help and documentation** is one of the ten usability heuristics, and recommends to include information that is focusing on the user's task, easy to search, list concrete steps to be carried out, and not being too large [34].

Summary of discussion

Many functions were not implemented during pre-pilot since it makes sense to prioritize other functions or aspects first. Due to the limited network access, the **offline mode** for the application is a high priority. Thereafter, involving registration of enrolment and attendance data is essential to further test the application during pre-pilot. The pre-pilot was tested among a small group, which made the current implementation of the application doable. Occurrence of errors were to be expected, but I am concerned that this will scale up with more pupils and users. Subsequently, more users and pupils will also require the system to support many functions to operate the data.

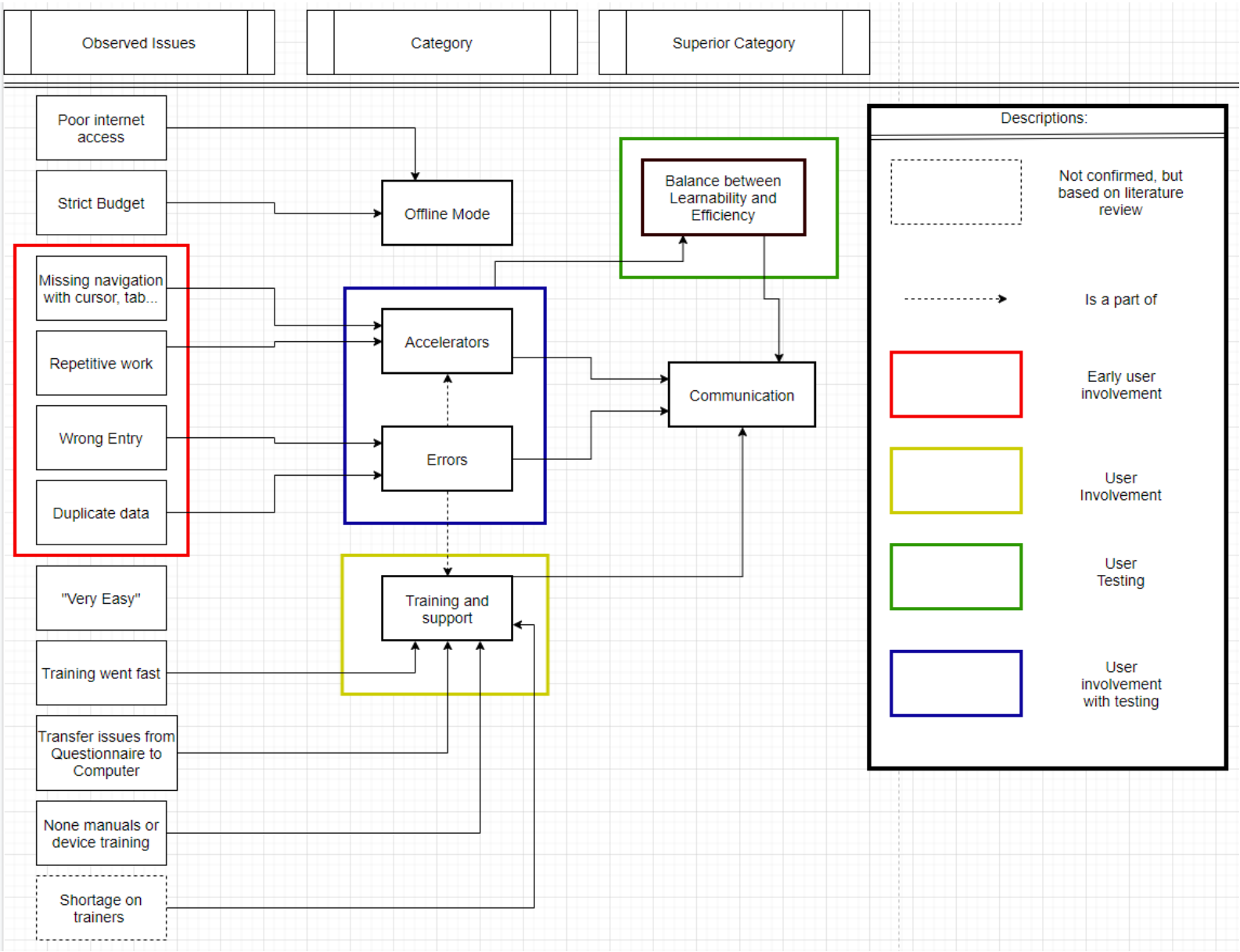


Figure 14: A categorization of observed issues

The figure presents a connection between the observed issues and which category it belongs to. This is all based on my analysis of the observation. With the current data collection, it was possible to derive some essential usability aspects for the thesis. In total four categories and 2 superior categories. The superior category was made because it has a relation with the categories. Whilst the **offline mode** can stand by itself.

The following section will present the essential usability aspects that fit for the current study:

Offline mode: Offline mode is no doubt the most essential aspect, due to its functionality against poor network capabilities and strict budget. Distributing information through the Internet is more efficient than on the road. An application which is depending on network access will not be sufficient for a low resource country. Given that the poor availability of the Internet and the application should not limitate the users from performing their daily task force. This function should be considered first when the developers are designing an application for a low resource country with the same context as The Gambia.

Accelerators: Functions that lets the users accomplish their daily task fast and efficiently is essential for the cause. The outcome should be timely and reliable as well. To achieve this, one has to consider ***accelerators*** to reduce the repetitive work. In addition to automating some of the manual work force likewise generating Unique ID's. These accelerators should consider user involvement and testing. Firstly, some of the end-users gave me valuable information to make the application more efficient. Secondly, the end-users will perform the daily task force (enrolment and attendance registration), thus listening to their opinions and seeking for a solution can ease their daily task force. Lastly, the developer should search for confirmation with the end-user by testing the accelerators. See if it actually works.

Communication: Communication is overall one of the most essential usability aspects. Despite not being a function of the application, communication is still a part of it. Wasting resources and time is not desirable for a low-resource country, thus guidelines and principles from NNGroup may have a minimal impact on the resources and correspond can save time. Considering the observation uncovers many faults that can be reflected based on Nielsen Norman Group's study. One can learn from others, but some must be solved locally.

Communication is then a key for an application to be usable in this context. Communication will ensure understanding between the actors of the system. Try to involve the end-users early as possible, as the experienced users can share their opinion about **accelerators** to make the application more efficient. New users can show their opinion regarding difficulty within the system and so on. Considering every actor of the application can share their opinions to support the application to achieve the **optimum performance**. Listen to each other and try to solve issues locally if possible.

Training and support: Training and support will have a big impact for an application to be usable to the context. Due to rapid change of technology, the personnel need to learn first before they can train others. With the shortage of personnel in mind, it was not unpredictable that the schools would face issues with the implementation of the application. Nevertheless, giving adequate training and support is a necessary action which helps. Investing more time on training can impact on the long term, as the user can train other users.

Error handling: The occurrence of errors had many factors, either being a slip or a mistake made by the users or developers. Based on my view and coupled with the derivation of the analysis, the **Error handling** can somehow be reduced by giving proper **Training and support**. In addition to implementing **accelerators** to reduce the repetitive work, and let the application generate some of the indicators (likewise Unique ID). In summary, **Error handling** has a relevance to **Training and support**, **Accelerator** and **Communication**.

Balance between Learnability and Efficiency: Finding a balance between learnability and efficiency is not an easy task for the developer. The developer should treat these attributes as a scale. Because as the developer focused too much on one attribute, it will affect the other. In the context of The Gambia, a little more highly learnability application will be more beneficial for the time being. Since some of the users have shown lack of device knowledge, thus the application should support them with more explanations and descriptions. As the users become more advanced, the developer should counterbalance the scale, which means reduce the learnability. With all due respect, I empathize that this requires more resources and time. But if one wants the developer and the end-users to be better at their field, they need to support each other. The developers need to know who their end-users are, as well as the end-users should understand what they do. Therefore, test the new implementation in the application with the end-users to ensure that they really understand it.

Limitations

The significant limitations of my thesis are adjustment of study, time, and inexperience. The research was first initiated as developing an innovative application with *Progressive Web Application.* Due to adjustment of research and plans, it was founded to be challenging, and difficult for me to adapt. Secondly, I could not make the best use of the time frame given to me. As the collected data was not sufficient for me to use for the new adaption of the research. I will further explain the data collection in the next section, **Limitations regarding the data collection**. It will be an advantage for me to travel to The Gambia on several occasions, since then I would be able to reflect over my approach between visits. If I had more time, a new visit to The Gambia would benefit my research in such a manner that I can strengthen my evidence. Lastly, I have tried to minimize the weakness in my data collection by reading and seeking answers in different research articles.

Limitations regarding the data collection

It is notable to know that qualitative research has weakness, due to its nature. First of all, I used only unstructured interviews (Open-ended questions) to impose an unbiased manner in such a manner that I collected the user's subjective opinions. Subsequently, I found in a late time that the interviews I conducted were more or less too thin. The period I conducted data collection, turns out to be less matured. Since some of the users had little knowledge about the device during that period, in addition they began to try the application. Thus, they need more time to understand the device and the application, to further know what they really want. Maintaining the chain of evidence may suffer from not having quantitative data, such as conducting a structured interview may help the future researcher to use the result to generate quantitative metrics. These metrics could also support generalizing the study.

As a result, I had more observation than interviews for this thesis. Due to involvation in some situation during observation, it can lead me to be potentially influenced the users. Because not all the users did not know what they wanted, and therefore led me to use my subjective judgment and opinions. I had to search and explore for essential usability aspects, then I could seek for the users' confirmation. In consequence of that, it may influence their opinions.

All things considered, this study would benefit from having a new round of data collection with more parameters involved. Thus, the users may progress their knowledge of using the devices and the application, to further gaining more data to determine more essential usability aspects for the study.

Conclusion and future works

The main focus of this thesis is on usability and user involvement in low resource context. Usability is a key factor for an application to survive and be useful in a low resource context. There are many factors that need to be involved to make a product usable. ***Communication*** has shown to be the factor that can enhance usability, and even more to uncover many other usability issues. This thesis has demonstrated that developers and the users are imperfect, but communication and working together as a team can be better for the good.

The research project has used *An Exploratory Case Study* to uncover usability aspects for an pupil attendance to be useful in a low resource context. The research methodology has been beneficial for the cause, since it led me to conduct a study on social behavior in a small group of individuals. Thus, the strategy gave me more insight to understand the interaction between humans and technologies. Even more, it led me to uncover usability issues with the current application and to propose strategies to help the future related issues.

Practical implication

The practical implication of the project is the interaction between the users and the application. The initiative of this project began first in Uganda, and sourced to The Gambia on request. Tracking the pupils with pen and paper had not been efficient over the past decades, and therefore digitalization was thought to solve the issue. Although, the transition from pen and paper to digital means had not been straightforward.

Humans and technology have been the main factors to obstruct the progress. ***Communication*** has shown to be the main key to support the current situation between the developers and the users. In this context, ***Communication*** has the effect of understanding the underlying problem within the use of the application. ***Communication*** can also be used to seek for further improvements with the current application to uncover other usability issues.

The pupil attendance application will serve its purpose by supporting reliable and timely data for the EMIS statistical. Additionally, gathering these statistics will support the decision makers to further provide a better quality education for the pupils.

Theoretical implication

This thesis aims to answer the research question:

- *What aspects of usability are essential for a pupil attendance application to be useful in a low resource public education setting?*

An exploratory case study had been adopted in attempt to answer this research question. Alongside with observation and interviews has guided this thesis to further answer the research question. Gathering feedback from the end-users, aligned with observing the application, supported this thesis to generate the end result.

With regards to the limitations during the study, many usability aspects are still left uncovered. Although, this thesis can answer the question to some degree with some essential usability aspects that is core for the current situation. With the derivation of analysis presented from **summary of discussion**, the essential usability aspects will be by following:

1. **Offline mode**
2. **Communication**
3. **Balance between learnability and efficiency**
4. **Training and support**
5. **Accelerators**

For the time being, the responsibility weighs more on the developer's shoulders. As they need to design an application with high usability, since some of the end-users lack basic computer literacy. This may change in the future if one considers involving the end-users more often. As the end-users will progress by knowing their involvement has an impact on the end interface. By giving them the opportunity to reflect over their thoughts for what is possible or

not with support from the developers. The keyword is “Sharing is power”, and to achieve this; One must communicate with each other through involvement.

By using the literature review from Nielsen Norman Group to study the context has shown to be feasible. However, as described in **summary of discussion**; Some of the issues must be solved locally through communication between the representative actors. A **Usability testing** or **Testing with five users** may benefit as a new implementation of the application appears. In addition to when repeated errors occur too often, as the developer should seek the occurrence by observing what the users really do. Overall, involving the users in early stages or during development of new implementation can benefit the application to be more usable.

Future work

For the future related study, I would recommend **Usability testing** to gather more essential usability aspects. The method can provide more insight about the users while they are using the application. I would recommend the conductor to give daily work tasks to the users, and see what they do. Collect these data to understand how they perceive and interpret the tasks. The goal is to understand the users behaviours, goals, thoughts, and motivations [49].

Usability testing is an observational methodology used to test a product or a service. This is done by observing a representative user while they use the product. According to Nielsen, the usability testing is used to uncover problems and opportunities in designs. The ICT expertise may differ between the users, therefore, try to seek for the representative users.
The designers/programmers cannot design a perfect or a sufficient user experience without observing the real user when they interact with the design [49]. Therefore, a cooperation between the designers/programmers and the users can enhance the usability. Thus the users know better how to handle the application and the designers/programmers will gain more knowledge.

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