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Understanding the Impact of Location-Based Learning on Pupils' Attitudes

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ABSTRACT

This project has investigated the effects of location-based learning on pupils' satisfaction, motivation and engagement in educational situations. A mobile application utilizing beacon technology has been constructed, alongside a web portal for teachers to update curriculum content to be shown at each location.

The mobile application has been evaluated with a time series design experiment, where pupils have been asked to evaluate a course before and after utilizing the mobile application. 58 pupils have presented feedback, both quantitatively and qualitatively, through questionnaires and semi-structured interviews. The pupils were recruited from three different classes and two schools. They were in their eighth and twelfth school year.

The results of the research show a significant increase in pupils' satisfaction, $t(57) = 4.682$, $p < 0.001$, with the course and their motivation, $t(57) = 5.503$, $p < 0.001$, towards it. No significant positive effect was found for engagement. Evaluating the use of the mobile application for a longer timeframe is suggested as further work in order to reveal the effects of longtime use of the mobile application. Additionally, experiments testing for increased learning outcome are applicable.

SAMMENDRAG

Dette prosjektet har undersøkt lokasjonsbasert læring og dets innvirkning på elevers tilfredshet, motivasjon og engasjement i utdanningssituasjoner. En mobilapplikasjon som benytter beacon-teknologi har blitt konstruert, i tillegg til en web-portal hvor lærere kan oppdatere innholdet som vises ved hver lokasjon.

Mobilapplikasjonen har blitt evaluert ved et tidsseriedesign-eksperiment (*eng: time series design experiment*) hvor elevene har vurdert et skolefag før og etter bruken av mobilapplikasjonen. Totalt har 58 elever gitt tilbakemelding, både kvantitativt og kvalitativt, i form av besvarelse av spørreundersøkelse og gjennom semi-strukturerte intervjuer. Elevene var fordelt på tre forskjellige fag og to forskjellige skoler. Aldersmessig var elevene fra klassetrinnene 9.klasse og 2.klasse på videregående skole.

Resultatene fra studien viser en signifikant økning i elevers tilfredshet med, $t(57) = 4,682$, $p < 0,001$, og motivasjon for, $t(57) = 5,503$, $p < 0,001$, faget. Det ble ikke avdekket en signifikant økning i engasjement for faget. Utprøving av mobilapplikasjonen over en lengre tidsperiode er foreslått som fremtidig forskning for å avdekke effekter av langtidsbruk av mobilapplikasjonen. I tillegg er forskning rettet mot testing av økt læringsutbytte aktuelt.

PREFACE

A warm thank is sent to everyone who have contributed to this project. I would like to express my gratitude to my supervisor John Krogstie for his invaluable contribution throughout this project. A particular thank is sent to Isabel Øren and Ståle Tømmerås, teachers at Rosenberg Skole and Charlottenlund Skole whose participations were essential for the project. A special mention is given to Michail N. Giannakos for his guidance in research approach and quantitative data analysis theory. Finally, I would like to thank Inger Dagrund Langseth for her contribution that exceeded what was expected of a participating teacher.

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ABBREVIATIONS

BLE	–	Bluetooth Low Energy
CPU	–	Central Processing Unit
CSCCL	–	Computer-Supported Collaborative Learning
CSS	–	Cascading Style Sheets
GHz	–	Gigahertz
GPS	–	Global Positioning System
HTML	–	HyperText Markup Language
NTNU	–	Norwegian University of Science and Technology
PDF	–	Portable Document Format
SUS	–	System Usability Scale
WLAN	–	Wireless Local Area Network
3G	–	Third generation mobile telecommunications technology
4G	–	Fourth generation mobile telecommunications technology

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CHAPTER 1 – INTRODUCTION

1.1 Motivation

Technological progress continues to offer usable tools that can aid teachers in creating interactive learning experiences for pupils in all ages. Educational institutions adopt more and more technology in their classrooms and there seems to be a willingness to use digital tools. Examples of such tools are digital quizzes, electronic blackboards and various forms of multimedia. Even though digital tools are increasingly used, educational institutions still base their teaching on a format where pupils passively listen to a lecturer explaining the curriculum. Therefore, the motivation of this project was to activate pupils in their learning endeavors by utilizing technological tools.

1.2 Project Description

The goal of the project was to investigate the use of positioning technology to create *learning zones* for educational purposes. In this project, a learning zone was defined as a spatial area where specific information, quizzes, tasks and multimedia are displayed on a digital device. The idea was to make content automatically appear on various locations at educational institutions, giving teachers the opportunity to involve pupils actively in the learning process. Figure 1 illustrates the concept, where different content are displayed on iPads on separate locations within a room. A possible area of usage is station-based education where pupils in small groups walk from station to station. Another example is an outdoor treasure hunt with clues at various locations, where puzzles must be solved to unlock the next location.

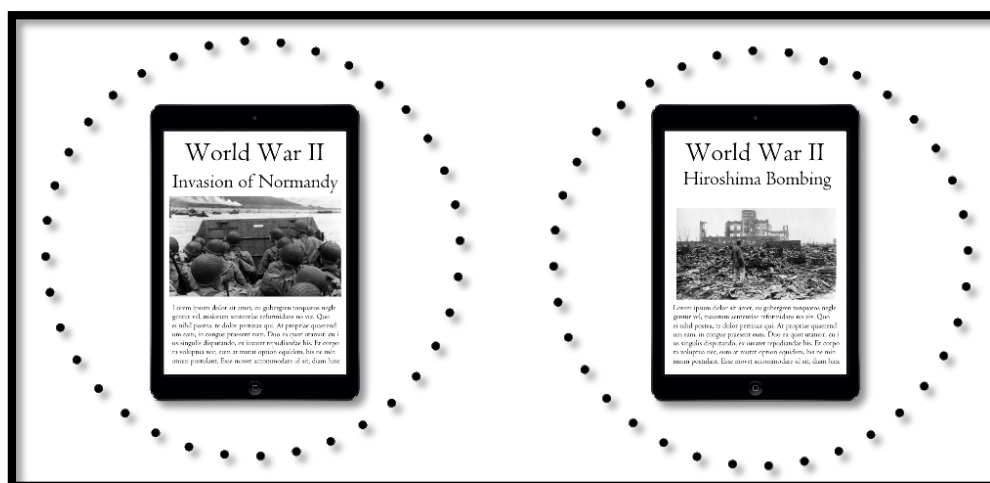


FIGURE 1 - LEARNING ZONES

This Master's thesis serves as a continuation of the computer science specialization project conducted by the author during the fall of 2015. In that project, a location-aware mobile application prototype was implemented and usability tested by pupils and teachers. Additionally, several interviews with teachers were performed in order to collect feedback on the prototype and to receive input on technology usage in schools today. A summary of the project is given in section 2.5 - Summary of Computer Science Specialization Project.

The Master's thesis has been conducted with a design science research approach, with two artefacts as outcomes. A mobile application has been implemented for pupils to utilize in learning situations. Secondly, a web portal is created in order to present teachers with the option of changing content shown at each learning zone. The system has been named Edigi.

In total, 58 pupils have tested the application as the main program of a learning session. The testing has been conducted for three different school classes, with pupils in their eighth and twelfth school year. The pupils have presented feedback through questionnaires and semi-structured interview, which was used to investigate changes in pupils' attitudes. More precisely, detecting changes in pupils' satisfaction, motivation and engagement has been the focus of the research. Results and findings are presented in this report.

The project has been conducted in connection to work in Wireless Trondheim Living Lab [1].

1.3 Report Outline

Chapter 2 – Background serves as a preliminary study for this project. It introduces the field of context-aware computing, before a section on beacon technology, the location determination technique used in the mobile application, is presented. Further, the chapter discusses pedagogical theory in regards to technological aids. A section on related work is given, while a summary of the computer science specialization project conducted last fall concludes the chapter.

Chapter 3 – Research Methodology explains the research methodology utilized in this project, alongside the research goal and the hypotheses which have guided the research. Following, a discussion of the experimental approach for evaluating the mobile application is given. A section on data collection methods, and reasoning for utilizing them, is presented, before the quantitative data analysis approach is introduced.

Chapter 4 – Edigi Implementation presents the various parts of the system and how they cooperate. Requirements for the system as a whole are presented alongside specific requirements for the mobile application and the web portal. Additionally, views of both the mobile application and the web portal are displayed in order to demonstrate the system.

Chapter 5 – Evaluation & Results evaluates the application utilizing the results acquired during experiments. Additionally, the chapter explains how the experiments were conducted. A

section on implemented improvements of the mobile application based on quantitative and qualitative results concludes the chapter.

Chapter 6 – Discussion summarizes the results of the project. In addition, threats to validity of results are discussed.

Chapter 7 – Conclusion & Further Work concludes the project by answering the hypotheses. Suggestions to further work are given at the end of the chapter.

CHAPTER 2 – BACKGROUND

This chapter starts with a section on context-aware computing, before an overview of beacon technology is presented alongside an elaboration of why it was the preferred positioning technology for this project. Continued, pedagogical aspects concerning computer based and active learning methods are introduced. Additionally, cognitive aspects are included to offer an insight into memory development theory. A section on related work is included to present findings from comparable research. Finally, a summary of the computer science specialization project conducted by the author during the fall of 2015 is presented.

2.1 Context-Aware Computing

In 1991, Mark Weiser famously introduced the vision of ubiquitous computing [2], which is also referred to as pervasive computing. In his paper, Weiser states

«The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.» – Mark Weiser [2].

Weiser envisioned numerous computers per person, all interconnected, that behaved unobtrusively. Devices would acquire knowledge regarding their surroundings, utilizing this information to offer context-aware behavior and functionality. At the time, hardware and communicational infrastructure did not exist in order to achieve Weiser’s vision. With the vast technological achievements during the nineties and the beginning of the twenty-first century, all components are present to achieve the vision. The last twenty years have introduced smart phones, tablets, laptops and large digital surfaces, as well as communicational infrastructure in the form of the World Wide Web. However, most devices are still blind to aspects of its location, such as number of people in close proximity and the intended usage of its location [3].

A pervasive computing system that strives to be unobtrusive must be context-aware. In line with Weiser’s vision, a context-aware application is cognizant of its environment and behaves accordingly. Context applies to various dimensions, such as physical location and user’s state of mind, personal history and behavioral patterns [4]. The issue of handling overwhelming amounts of data for context-determination is arising, marking a key change in the field of context-aware applications [5]. This is in contrast to the previous challenge of acquiring enough data for context support.

2.2 Beacon technology

This section introduces beacon technology, which was utilized in this project for location determination. A technological overview is presented, before a discussion of why beacon technology was applied for this project concludes the section.

2.2.1 Technical Overview

The source of this section is [6]. It is written by Estimote, the company behind the beacons utilized in this project.

Beacons are devices that broadcast Bluetooth signals containing a small data package. The maximum data payload size is 257 bytes, which is not sufficient to transfer media content. Therefore, a beacon only transfers their ID's and information regarding signal power. The underlying software on a receiving device is responsible for reacting to the data sent from a beacon. Examples of reactions can be notifying a user of a sale in a nearby store or showing timetables for a bus stop where the device is located. The Bluetooth signals transmitted are 2.4 GHz radio waves.

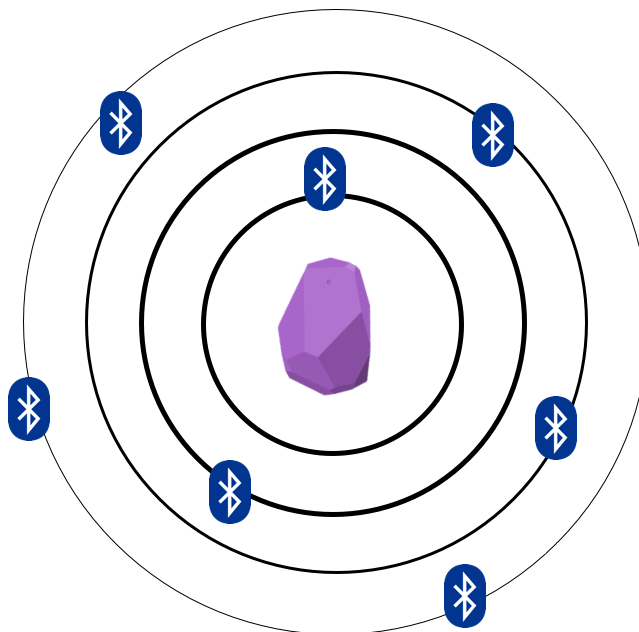


FIGURE 2 - BEACON ILLUSTRATION

Beacons utilize Bluetooth Low Energy (BLE), which consumes only a fraction of the power of classic Bluetooth. This enables beacons to be powered for years by a single coin-cell battery [7]. BLE also offers lower implementation cost and enhanced range, making it preferred for simple applications that only require small data transfers [8].

The two main factors determining the range and stability of a beacon signal are advertising interval and broadcasting power. Firstly, it is important to emphasize that a beacon do not range continuously. It broadcast signals at a certain advertising interval, which is the same concept a smart phone utilizes when ranging for Bluetooth signals. Therefore, it is possible for a smart phone to miss a Bluetooth signal due to noisy environment or poorly synchronized advertising/ranging intervals. The higher advertising frequency, the higher the chance of detecting the signal. Secondly, broadcasting power plays an important role on signal quality. The broadcasting power is directly correlated to how far away a beacon is detectable. Both advertising interval and broadcasting power are adjustable, but higher intensity will lower the capacity of the battery used to power a beacon.

The signal strength of a beacon is utilized to estimate the distance from a beacon to a receiving device. In turn, this can be used in an application to determine functionality based on distance. The estimate of the distance will more accurate for shorter distances due to higher signal density. For longer distances the signal will be increasingly distorted and scattered, eventually making it undistinguishable from background noise. Additionally, as beacons broadcast radio signals, they are vulnerable to multipath propagation, wave diffraction, absorption and interference, which can all affect the distance estimation. Therefore, it is impossible to measure the exact distance to a beacon due the nature of a radio signal.

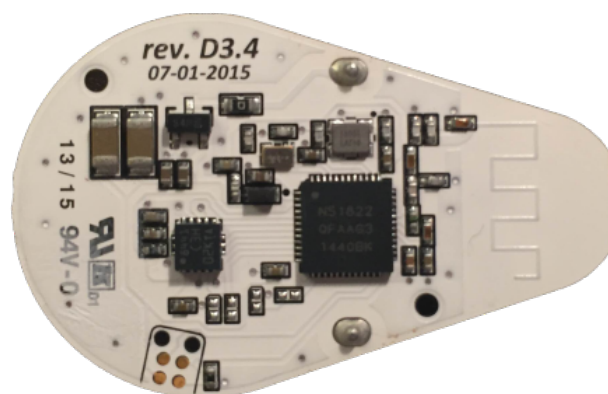


FIGURE 3 - BEACON CIRCUIT BOARD

Figure 3 illustrates the beacon circuit board with CPU, antenna and sensors. The antenna is twisted, considering that the electromagnetic field around a straight wire is not spherical. In other words, the waves do not propagate with the same strength in every direction. Even though the antenna has a shape resembling a zigzag, the desired outcome of a perfect spherical electromagnetic field is not achievable in a real-life setting. Due to this property, both the orientation of a beacon and the receiving device can influence the distance estimate.

Additionally, the estimate can vary even for fixed distances. For instance, the distance estimate can alternate between 10 meters and 12 meters in situations where the distance between a beacon and receiving device is fixed and stable. Beacons are therefore more applicable in

situations where proximity zones are adequate, which holds for many location-based applications.

In 2015, ABI Research released a report on the future of beacon technology, estimating that shipment of beacon devices will exceed 400 million units by 2020 [9]. Their research indicates that beacon technology has grown from a market with focus on retail, to a market with several application areas such as connected homes, smart cities, connected cars and vending machines.

2.2.2 Reasoning for Utilization

The computer science specialization project involved a comparison of advantages and disadvantages of various location-determination techniques applicable for this project. The reasoning for utilizing beacon technology is summarized in the following section, which requires the reader to have insight into positioning technologies. Please refer to the computer science specialization project report for the full discussion.

Beacon technology was utilized in this project for several reasons, the first being its simplicity. Compared with WLAN positioning, no large-scale infrastructure was required. In addition, moving beacons was not an issue as the mobile application did not need the exact location of several beacons to calculate distance estimates. Proximity to only one nearby beacon was sufficient for a mobile phone to display information relevant to a learning zone

Secondly, the mobile application had to be usable both indoors and outdoors. This excluded usage of GPS, as this was only a viable option for outdoor learning zones. A combination of GPS and WLAN would be usable, but it would be more complex than with beacon technology. Cell Network Localization was not precise enough to be used in either case.

The third factor for utilizing beacon technology was that beacons are powered by batteries. As beacons do not require a power outlet to operate, they could be placed anywhere. Additionally, compared to older Bluetooth standards, Bluetooth Low Energy offers lower battery usage on mobile phones, as well as increasing the time a beacon can run on one battery.

In combination, these three factors were clear indicators that beacon technology was the most suited choice for this project.

2.2.3 Estimote Beacons

Estimote is the manufacturer of the beacons utilized in this project. Their beacon is a 32-bit ARM® Cortex MO CPU equipped with an accelerometer and a temperature sensor, in addition to the 2.4 GHz radio transmitting the Bluetooth Low Energy signals. Powered by a CR2477 battery, an Estimote beacon can last more than three years on a single battery [7]. Estimote beacons are wrapped in waterproof silicone, making them usable outdoors. Figure 4 displays three beacons as consumers perceive them.

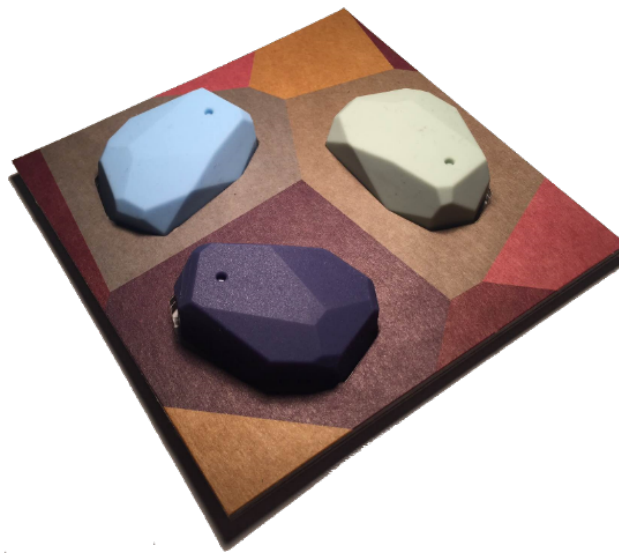


FIGURE 4 - ESTIMOTE BEACONS

The maximum range of an Estimote beacon signal is 70 meters [7], although Estimote states that this is highly dependent on location, given that radio signals can be absorbed. For real world conditions, a range of 40 - 50 meters is expected. As water absorbs radio signals, rain will possibly reduce a beacon's signal strength outdoors during poor weather conditions.

Estimote beacons have an average measurement error of 20-30% of the actual distance [10], which can be improved by increasing broadcasting range and reducing the advertising interval. Broadcasting range of an Estimote beacon is configurable from 3 - 70 meters [11], while the advertising interval is adjustable from 100 milliseconds to 2000 milliseconds. The default values for Estimote beacons are 15 meters for broadcasting range [11] and 950 milliseconds for advertising interval [6].

2.3 Pedagogical Theory

This section aims to offer a foundation of pedagogical aspects regarding technology usage and movement in a learning process. First, the roles of active and collaborative learning activities are introduced. To cover all the pedagogical advantages of utilizing technology for learning, three different aspects are discussed. These aspects are computer-supported collaborative learning, resource-based learning and cognitive aspects. The research on pedagogical theory was conducted during the computer science specialization project and was included in this Master's thesis to provide necessary background information.

2.3.1 Learning Methods: Active and Collaborative Learning

In contrast to traditional learning methods where pupils passively receive information, active learning methods engage pupils in the learning process [12]. These methods require pupils to actively participate and reflect on why they are doing it. Active learning methods often refer to learning methods introduced inside the classroom, but it also covers other methods such as homework.

Collaborative learning refers to any learning method that requires pupils to collaborate. The emphasis is on pupils' interactions, where a group works towards a common goal [13]. Collaborative learning classifies as an active learning method, as it requires interaction with classmates.

There exists a range of active learning techniques including debates, peer reviews and game-based learning. Table 1 highlights two learning methods that are suitable for location-based systems.

TABLE 1 - LEARNING METHODS [14]

Method	Explanation
Gallery Walk	Gallery Walk is intended to aid pupils promote interactions and cooperative learning. The method divides the class into small groups, which rotates between stations, where a new task is presented at each station. The method is often concluded with the groups summarizing one task each. The major benefits of this method involves team-building, practice in discussion and that it interrupts lethargy of sitting for long periods. Presenting the tasks digitally adds the option of utilizing multimedia.
Field Lab	Fields labs are conducted with the aim of observing, collecting and recording data. An example is collecting plants in a local forest. This method can demonstrate the material more realistically than classroom-based methods, especially within subjects such as geology and history. Aided by positioning technology, relevant information can be displayed at digital devices.

In 2004, Michael Prince performed a study that examined the effectiveness of active and collaborative learning [15]. The study discovered support for active learning methods, but that results varied in strength. More precisely, Prince reported benefits for pupil engagement. In addition, pupils recalled more of the curriculum when brief activating methods were performed during lectures. Similarly, the study showed support for collaborative learning, given that individual responsibility was present. Continued, the paper stated that academic institutions should promote collaborative learning environments.

2.3.2 Computer-Supported Collaborative Learning

Computer-Supported Collaborative Learning (CSCL) is a research field concerning how information technology can support learning in groups, both located together and distributed. The research questions in this field include how individuals learn with specific tools, how institutions change and create new conditions for teaching and learning and how society adopts to new models of education [16]. Shared space for messages, documents, pictures and videos online is an example of a technical advancement that has influenced CSCL, as it allows teachers and learners to communicate in a new manner.

The field emerged, in part, as the contemporary knowledge-based society required a new set of skills. For example, the labor market requires both specialized skills within a certain area of expertise and the ability to work in teams. This has made the teaching of communication, information sharing and collaboration an important factor in the educational system.

In CSCL, the role of the teacher is to explain the framework and emphasize goals, in addition to monitoring and guiding pupils during the process. This technique relates to scaffolding, a technique where the teacher models the learning task, before shifting the responsibility of learning to pupils. These types of exercises often have discussions or collaborative problem solving as a starting point and it requires the pupils to be active participants.

2.3.3 Resource-Based Learning

Resource-based learning is a learning activity surrounding the ability to effectively access a range of different information resources [17]. The access to several forms of information offers pupils the possibility of learning a topic with various studying techniques, which can be customized to each pupil's interests and abilities.

With the advancement of information technology, how resources are used to support learning has changed dramatically. Resources are now easier available, in a range of different forms. New types of resources have arrived, for example wikis, podcasts and blogs. Although this shift has improved the availability of information, it has simultaneously introduced issues such as misinterpretation, propaganda and copyright infringements [18]. Therefore, training in information selection, resource validity evaluation and selection criteria are critical.

2.3.4 Cognitive Aspects

2.3.4.1 IMPLICIT MEMORY VERSUS EXPLICIT MEMORY

Research on human memory has shown a clear distinction between implicit and explicit memory. Implicit memory is memory that helps humans successfully perform tasks without full conscious awareness. Brushing one’s teeth or reading are examples of tasks performed without focusing on how to perform the action. Explicit memory, on the other hand, requires conscious awareness. Examples of such tasks are recalling an event from last year or reciting the last page one reads. Table 2 lists differences [19].

TABLE 2 - DISTINCTIONS BETWEEN IMPLICIT AND EXPLICIT MEMORY

Implicit Memory	Explicit Memory
Early maturing	Late maturing
Spared in amnesia	Impaired in amnesia
Unconscious	Conscious
Automatic	Controlled
Involuntary	Voluntary
All-or-none-retrieval	Partial retrieval
Incidental	Intentional
Know	Remember

Priming is an implicit memory effect where small, often unconscious, sensations from one stimuli influences the response to other stimuli. Sensations from pictures, gestures, smells and actions are all examples of such stimuli. For instance, a subject is presented an incomplete sketch of a word one is unable to identify. Being shown an increasingly more detailed sketch, the subject is able to recognize the word. Completing the process for a second time, the subject will identify the sketch at an earlier stage than before. Figure 5 shows two examples.

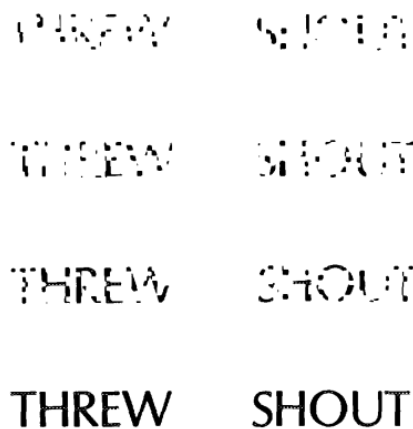


FIGURE 5 - PRIMING EXAMPLES [20]

Interestingly, Naito's research [21] has shown that implicit memory is equally developed in children and in adults. A recognition priming experiment of words involving seven year olds, nine year olds, eleven year olds and adults showed no difference in implicit memory capabilities between the different age groups. This is opposed to explicit memory, where a test showed higher word recall for adults. The experiment indicates that implicit memory and explicit memory develop differently. The work of Meulemans, Van der Linden and Perruchet [22] presented similar results. After an initial learning phase, they tested the serial reaction time to stimulus of six year olds, ten year olds and adults. Their results showed no age-related difference in the reaction time performance, which is consistent with Naito's work.

2.3.4.2 METHOD OF LOCI

The method of loci is a memorizing technique described in *The Art of Memory* by Yates [23]. The basic idea of the technique is that a subject remembers places where one is familiar. By linking an item to a familiar place, that place will serve as a clue. To remember several items, a subject can memorize the layout of a building or the arrangement of shops in a street. A subject completes an imaginary walk in his mind through various sub-locations and connects each place to a particular item. By walking the same path for a secondary time the subject recalls items based on the clues associated with each place. A simple example of grocery shopping in a familiar store illuminates the concept: Instead of remembering a set of groceries, a subject visualizes the path he will take through the shop to acquire all the desired items. At each location within the store the subject will have a reference in his mind to what should be acquired at this location. When the subject arrives at each location the desired item will be collected due to the reference in the subject's mind.

In [24], changes in brain activity before and after instructions of the method of loci was examined. Their results showed significantly improved memory recall when the method of loci was applied. Similarly, [25] compared the memory related brain activity of ten excellent memory performers to brain activity of members of a control group. Their results indicated that superior memory did not originate from exceptional intellectual ability or any structural brain differences. Instead, the research showed that the excellent memory performers utilized a spatial learning technique that increased brain activity in parts of the brain critical to memory.

2.3.4.3 ACTIVITY WHILE LEARNING

In [26], Mia Keinänen studied the impact of walking-for-thinking. The research was based on in-depth semi-structured interviews of nine Norwegian academics who utilize walking-for-thinking as an explicit practice. Walking-for-thinking has a steady individual speed, where the rhythm of the body correlates with the rhythm of walking. The subjects experience that this practice offers feeling of enhanced memory and creativity. Keinänen discussed that subjects implicitly utilize spatial space to enhance memory, which relates to the method of loci.

2.4 Related Work

In [27], the authors analyzed the use of a mobile city game to teach pupils aged twelve to fourteen about medieval Amsterdam. The project was conducted with 458 pupils from twenty different classes from five different schools, where pupils from ten of the classes learned the curriculum by playing the game. The game was location-based, meaning that pupils travelled within Amsterdam in order to receive assignments relevant to their position in the city. Their research showed that pupils learning using the game acquired significantly more knowledge than pupils engaged in a traditional teaching approach. No significant differences were found in terms of motivation for either History or Middle ages.

Location-aware devices were used in [28] to present multimedia information to pupils in an outdoor environment utilizing GPS-receivers. Opposed to the research done in Amsterdam, the information presented on the devices was unrelated to the area. The researchers superimposed digital information regarding the River Thames on a school ground, with the source of the river on one side and the mouth of the river on the other. Pupils participating in the experiment revealed that they could associate specific features of the river course to specific locations on the school ground, indicating that the experiment had provided mental markers at each location. As a reference to the method of loci introduced in section 2.3.4.2, the mental markers helped pupils recall information. Pre and post tests confirmed this result. In addition, pupils reported that they enjoyed the new form of teaching.

2.5 Summary of Computer Science Specialization Project

The computer science specialization project conducted during the fall of 2015 focused on investigating usage of technological aids for educational purposes. It aimed to identify how a location-aware application needed to be implemented in order to be suitable for educational institutions. Simultaneously, detecting existing usage of technology in schools was an important aspect of the research. This section summarizes the findings of the project as they serve as important background information for this Master's thesis.

2.5.1 Research Approach

To answer the research questions listed in Table 3, semi-structured interviews with teachers were performed. Five interviews with five different teachers were conducted during the project. To achieve interview subject diversity, teachers from four different schools were recruited. To cover all age groups, teachers for first to seventh grade, eight to tenth grade and eleventh to thirteenth grade participated.

TABLE 3 – COMPUTER SCIENCE SPECIALIZATION PROJECT RESEARCH QUESTIONS

RQ1	How do teachers rate the location-based learning application?
RQ2	What characterizes a technical aid that teachers find useful?
RQ3	How is technology used in schools today?

During the project a location-aware mobile application that utilized Bluetooth technology for location determination was developed. The prototype was implemented as an aid to demonstrate location-based learning during the semi-structured interviews with teachers. Additionally, the teachers were able to evaluate the prototype and elaborate on possible areas of usage. Finally, the application was tested by both pupils and teachers to report on the application's usability and how they reacted to the idea of location-based learning.

2.5.2 Edigi: A Location-Aware Application for Educational Purposes

In this section, a brief introduction to the prototype is given to establish context for the following parts of the summary of the computer science specialization project.

The prototype utilized its proximity to nearby beacons to display information of a specific topic. The main view of the prototype can be seen in Figure 6. For the prototype, information regarding places in Trondheim was chosen as the location specific information. The prototype had support for textual information, video and images which updated automatically based on the nearest beacon. This effect can be seen in Figure 7 where different content are displayed on the mobile phones due to the fact they are not closest to the same beacon.

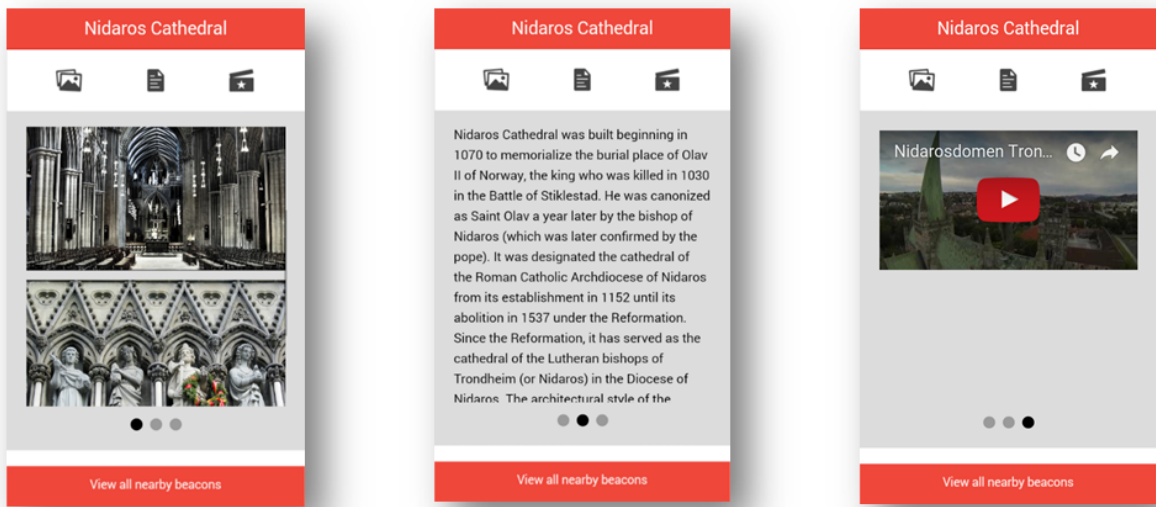


FIGURE 6 - PROTOTYPE MAIN VIEW

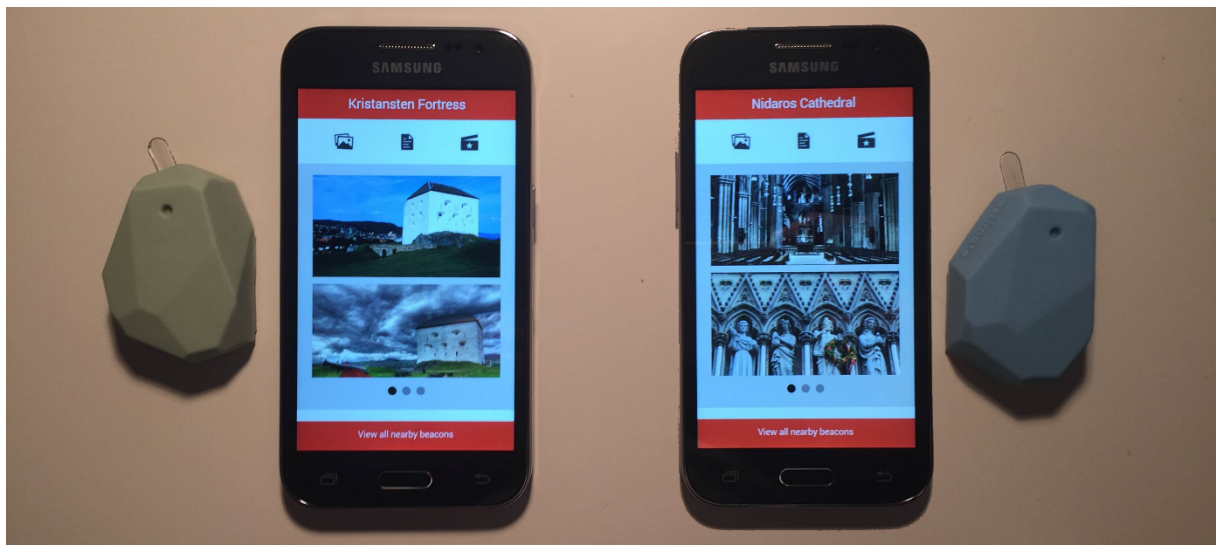


FIGURE 7 - BEACON INFORMATION CHANGE

2.5.3 Results from Semi-Structured Interviews

This section highlights the findings acquired during semi-structured interviews with teachers. There were four focus areas for the interviews, which are presented in Table 4.

TABLE 4 – COMPUTER SCIENCE SPECIALIZATION PROJECT INTERVIEW TOPICS

Topics
Assessment of Technology in Schools
Passivity of Pupils
Assessment of Requirements of Technological Aids
Application-Specific Feedback

2.5.3.1 ASSESSMENT OF TECHNOLOGY IN SCHOOLS

The teachers revealed high level of technology usage within schools. All schools visited utilize Smart Boards [29] (interactive whiteboards) and computers. In addition, administrative tools, such as It's Learning [30], are applied for assessment and project delivery. Some schools also utilize iPads, for example as a tool to aid dyslexic pupils and during gallery walks (see section 2.3.1). One teacher experienced positive results with the use of adaptive learning software for language courses. In the future, schools planned to offer cloud-based services to pupils.

Simultaneously, teachers divulged that pupils react positively to the use of technology. One teacher stated that pupils expect the use of technology within schools, as technology is an integrated part of their leisure time. Consequently, it makes the curriculum more relevant. The major benefits of technology usage were declared as higher motivation, higher eagerness and that it offers pupils tools to create products on their own. Additionally, it presents pupils with a number of options on how to solve a particular task. Some may choose to hold a presentation, while others may choose to construct a graphical product. The option of choosing how one solves a particular task is regarded to have a highly positive pedagogical effect. As a drawback, pupils can be distracted by technology as it offers easy access to online newspapers and social media.

Teachers acknowledged that there exist vast differences in technological utilization, both between and within schools. School management, teachers and the age of school buildings were introduced as major factors in varying technological adoption. In addition, teachers utilize technology differently, dependent on their technological skill level. Further, it was stated that older pupils are more exposed to technology than younger ones.

Finally, it was referred to The Norwegian Directorate for Education and Training's reference document for developing and revising the Norwegian national curriculum. This document identifies digital skills as one of five focus areas for the Norwegian education system, alongside reading, writing, oral skills and numeracy [31].

2.5.3.2 PASSIVITY OF PUPILS

The teachers informed that lectures are the most used teaching method in schools, but that they rarely last for more than 20 minutes. Only in special cases, for example during the derivation of a mathematical proof, are longer timeframes necessary. Even for these short lectures, teachers acknowledged that pupils lose focus. As a benchmark, a teacher of thirteen to fifteen year olds stated that pupils usually keep focus for five to ten minutes.

All teachers unanimously agreed that learning outcome increases when pupils actively participate in the learning process. Additionally, it has positive effects on motivation and mood. Consequently, this leads to a better school experience. Especially, tasks where pupils have to explain a topic to their classmates is deemed as a highly effective learning method. In general, all learning methods where pupils experience the topic for themselves have a positive effect.

2.5.3.3 ASSESSMENT OF REQUIREMENTS OF TECHNICAL AIDS

For adoption of technical aids, teachers declared key aspects. Firstly, the usage of technology must be closely related to helping pupils learn better. Simultaneously, it was explained that technology serves two purposes. Technology can play the role as a tool for something else, for instance using Microsoft Excel to perform calculations. In addition, it can be used to familiarize pupils with technology in general. By making pupils comfortable using various forms of technology, pupils acquire technological competence that is essential for the labor market and everyday life. Secondly, the teachers expressed the importance of ease of use. This requires a simple user interface without distractions. Additionally, an application must be easily maintainable concerning tasks such as connecting to Wi-Fi and updating to newer versions. Finally, technology should be usable on various platforms and financial cost must be justifiable.

2.5.3.4 APPLICATION-SPECIFIC FEEDBACK

Teachers were given the opportunity to test the application during the interviews and subsequently present feedback. They appreciated the simplicity of the application, as pupils would understand the area of usage quickly. Consequently, they stated that it would require little time to initiate a learning activity utilizing the prototype once the teacher had prepared the system.

All subjects anticipated that use of the system would have a motivational effect for pupils. The fact that pupils had to move was evaluated as positive. Earlier experiences from language courses had shown that it was easier for pupils to engage in conversations in a foreign language while standing. Using the system as a station based learning activity, similar to gallery walk, was suggested. Compared to gallery walk using pen and paper, teachers emphasized that the option of video and audio gave additional value. In addition, they assessed that interactivity, for example in the form of tasks at each location, would enhance the application by rewarding a higher learning outcome. Along the same lines, teachers saw potential area of usage outside the classroom. They envisioned using the system all over the school grounds, both indoors and

outdoors. Treasure hunts or quizzes at each location were suggested as ways to utilize the system.

For field trips, a valuable aspect was identified which is best explained with an example: For a natural science class exploring tree types in the area, the system would give pupils the option of exploring the forest on their own. Previously, pupils would follow the teacher as the teacher was required to present information of each tree type. Additionally, beacons can be left at the location for a time span making it possible for pupils to return if they want to clarify information. On occasions where it is unfeasible to leave beacons a miniature version of the field trip could be assembled at school grounds.

During the interviews, one teacher suggested that pupils could create educational routes themselves. This is seen in contrast to a situation where teachers would prepare a route, making the pupils the recipient of the information. Furthermore, it was suggested that pupils could prepare routes for particular happenings, for example a school year ending ceremony with parents present.

A teacher for younger pupils (six to twelve year olds) speculated that it would require too much preparation time for teachers to use the system frequently. This is seen in contrast to statements made by teachers for older pupils, which stated that this would not be an issue. An explanation might be that for older pupils, teachers are in charge of particular subjects. Having less subjects to teach, teachers have more time to prepare. Simultaneously, teachers acknowledged that they would not use the system every day. They evaluated the system as more suitable when introducing a new topic or as a way to vary teaching.

2.5.4 Usability Testing

Both teachers and pupils were recruited in order to evaluate the application. In total, ten pupils and six teachers rated the application. After they had completed a series of tasks, they were asked to score the system using the System Usability Scale (SUS) [32]. The overall SUS-score of the system was, 84.2. A study of 500 evaluations using SUS presented an average SUS-score of 68 [33], which indicated that the prototype was easy to use.

Although the system received a relatively high SUS-score, observations during the usability test revealed possible improvements, which are listed in Table 5. Figure 8 shows the relevant elements in the view using the corresponding ID. The suggested improvements were used as a basis when developing the mobile application during the Master's thesis. Implementation of the mobile application is presented in Chapter 4 – Edigi Implementation.

TABLE 5 - SUGGESTED IMPROVEMENTS

ID	Issue	Solution
1	Participants did not use the sliding-buttons.	Remove the buttons in order to free more space for information.
2	One user had trouble finding the View All Nearby Beacons-button.	Add an icon to the button in order to make the button more visible.
3	Users are unfamiliar with automatically changing views.	Add a view that explains how the application reacts to beacon signals' strength. An icon linking to this view will be placed at the right side of the header.
4	Bluetooth signal turned off.	When opening the application with Bluetooth turned off, a popup-alert indicating that Bluetooth must be turned on will be presented to the user.

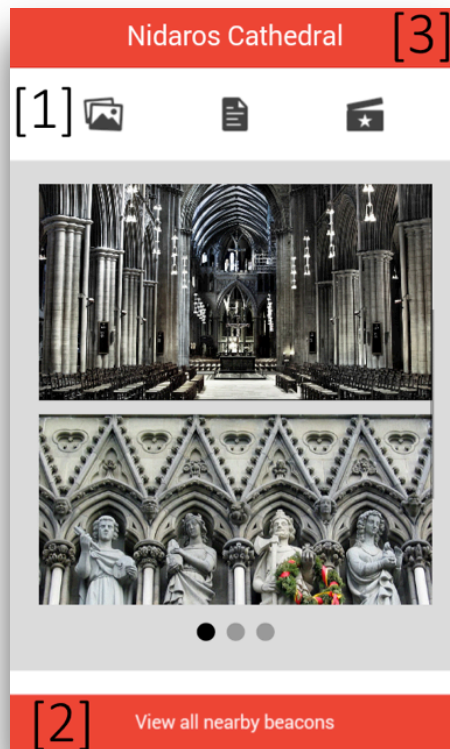


FIGURE 8 - SUGGESTED IMPROVEMENTS

2.5.5 Conclusion & Further Work

The positive results from both semi-structured interviews and usability testing inspired the author to continue with this research. It was identified that a real-life test was required to determine the application's worth. During semi-structured interviews teachers stated their interest in participating in further research. Consequently, further work was planned in close collaboration with these teachers, especially in regards to what type of information that should be presented to pupils at each location.

CHAPTER 3 – RESEARCH METHODOLOGY

This chapter opens with the introduction of the research goal and hypotheses of this project, before the design science research approach applied is elaborated on. Continuing, the experimental research method utilized for evaluating the mobile application is introduced. A section on data collection methods used during the evaluation phase concludes the chapter.

3.1 Goal & Research Questions

The aim of this Master’s thesis was to investigate how the use of a location-based mobile application would affect pupils’ attitudes. This introduced the following research goal:

Goal: How are pupils’ attitudes affected by using location to present learning material?

Early in the project it was evaluated that the term attitude was too broad to be researched as one term. Consequently, the term attitude was divided into three dimensions in this project. These three dimensions are listed alongside an explanation in Table 6.

TABLE 6 - DIMENSIONS

Dimension	Explanation
Satisfaction	This dimension relates to how pupils rate the teaching approach, how the pupils compare a subject to other subjects and whether they feel frustrated when working with this subject.
Motivation	Motivation relates to how eager pupils are to learn the curriculum and whether the subject inspires them.
Engagement	Engagement was defined as how active pupils are and to what degree they want to participate actively.

Adhering to the three attitude dimensions, the hypotheses listed in Table 7 were investigated during this project. All hypotheses have a corresponding null hypothesis of no positive effect for the relevant attitude dimension. Significance level for the research is 0.05.

TABLE 7 - HYPOTHESES

ID	Hypothesis
H1	The use of the location-based application has a positive effect on pupils’ satisfaction.
H2	The use of the location-based application has a positive effect on pupils’ motivation.
H3	The use of the location-based application has a positive effect on pupils’ engagement.

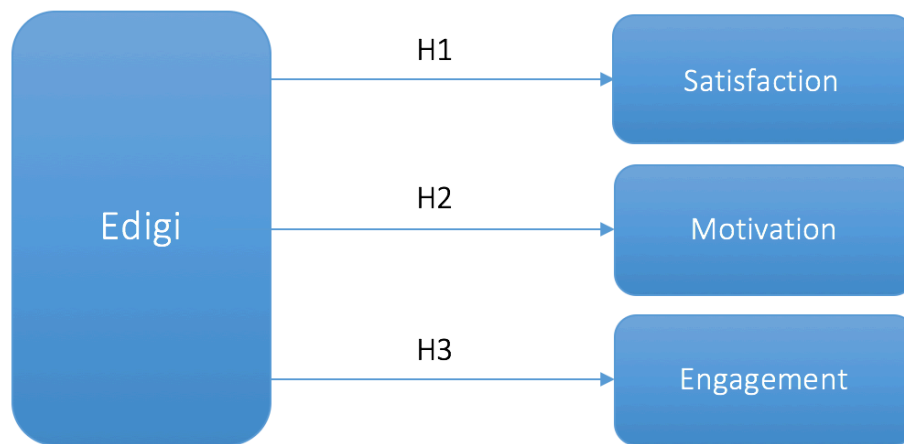


FIGURE 9 - HYPOTHESES

3.2 Research Approach: Design Science Research

The design science research methodology was chosen as the research approach for this project. As the idea of this methodology is to learn through making, it focuses on creating new products labeled *artefacts*. An artefact can for example be a developing methodology or a prototype that implements an idea. An artefact can have one of three roles in a design science research, illustrated in Table 8.

TABLE 8 - ARTEFACT TYPES [34]

Type	Explanation
Focus of research	This occurs when the artefact itself contributes to knowledge, for example by automating a previously analog process.
Tool for evaluation	This occurs when the research is mostly interested in how the artefact is adopted in a real-life setting. For a computer-aided learning system, the contribution to knowledge is how pupils and teachers adopt the system.
Process	The artefact is a product, but the focus of the research is on the development process. An artefact is used to analyze a particular diagramming notation or process model for computer-based systems.

The artefact creation involves five steps, structured sequentially [35]. However, as new knowledge is acquired, it is possible for researchers to jump between the steps. For example, the evaluation phase of the process may lead to higher awareness, which in turn can start a new cycle with a different perspective. Upon completion of a cycle, researchers evaluate whether the results have inspired them to start a new cycle or not. If not, the process concludes with researchers communicating their findings and suggesting further work. Table 9 explains the process steps.

TABLE 9 - DESIGN SCIENCE PROCESS STEPS

Step	Explanation
1. Awareness	This step involves the recognition and articulation of a problem. The recognition of a problem can come from many sources such as studying literature, clients expressing needs or technical development.
2. Suggestion	This is a creative step, intended to produce a tentative idea of how the problem can be solved.
3. Development	The tentative idea is implemented to create an artefact. How and what is done in this step is highly dependent on the type of artefact.
4. Evaluation	In this step, an evaluation of the artefact is conducted to determine its worth and whether it deviated from expectations or not. The evaluation criteria should be matched with the reason for doing the research.
5. Conclusion	During the conclusion-step the knowledge gain of the research is identified, possible loose ends are accounted for and suggestions of possible further work is introduced. This can be the end of one research cycle or the end of the research effort completely.

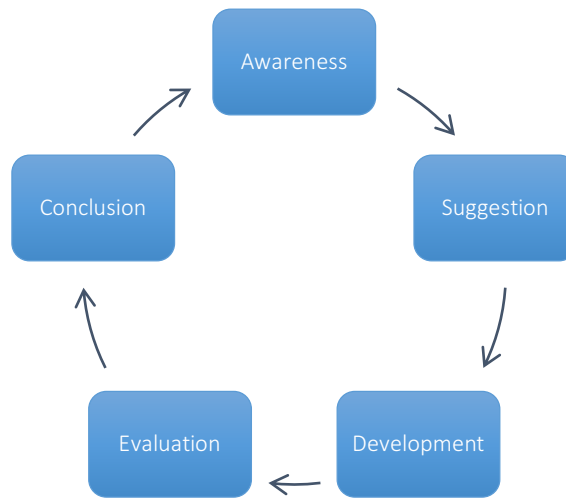


FIGURE 10 - DESIGN SCIENCE RESEARCH CYCLE

For this Master’s thesis, the computer science specialization project served as an initial cycle. The positive results inspired the author to start a new cycle. For both these projects, the artefacts were used as tools for evaluation. Adopting the research process, the awareness step of the project initiated through the author’s personal observations of passivity among pupils, ranging from lower grades to higher education. A research study of technology usage in schools and pedagogical effects of movement while learning motivated the research. Additionally, findings from projects utilizing location-aware systems revealed positive results. However, they utilized GPS-technology, making them unsuited for indoor activity. This bred the idea of creating a location-aware learning application for both indoor and outdoor usage.

3.3 Experimental Research

In order to classify a technological project as research, it must express more than technical qualities [34]. Academic aspects such as analysis, argument and critical evaluation need to be integrated parts of the project. Dependent on the reason for developing an artefact, different evaluation criteria are relevant. Examples are functionality, accuracy, performance, usability, entertainment and fit with organization. Adopting the design science research methodology, this section presents how the evaluation step of the method was conducted.

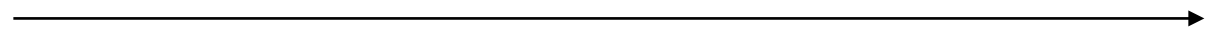
Experimental methods has been used extensively to conduct research in education [36]. In these methods, researchers investigate the effects of an environmental change. The environmental change is referred to as a “treatment.” To achieve viable results, there is essential that all variables expect the experimental variable are held constant. By achieving this, the experiment has acquired a high internal validity and experimental control.

This section continues with an introduction of true experiments and quasi-experiments, two types of experimental researches. The section is concluded with a discussion of the applied experimental research and the reasoning for utilizing it.

3.3.1 True Experiments

True experiments make use of an experimental group and a control group to acquire high experimental control [37]. Traditionally, true experiments are regarded to be the experimental approach that maximizes internal validity. The selection of participants into the two groups are performed randomly, eliminating any bias that might be present when using already intact groups. The two groups are then required to be in identical environmental conditions, while they are offered different treatments. For educational purposes, an example of a treatment may be varying instructional methods. The timeline of a true experiment is as follows:

$$R \quad \begin{matrix} X_1 & O \\ X_2 & O \end{matrix}$$

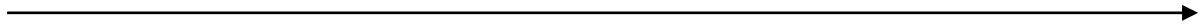


where R is random selection, X_1 and X_2 are two different treatments and O is observation.

3.3.2 Quasi-Experiments

The main difference between quasi-experiments and true experiments is that subjects are not randomly assigned to different treatments. In [36], the authors argue that for school-based research it is often unpractical to assign subjects randomly. For instance, usage of different teaching methods for different parts of the class may be upsetting for pupils and teacher. In these situations, quasi-experiments would be more suitable, although it introduces sampling bias, which can prejudice the findings of a research. Due to the introduction of sampling bias, pre-testing of groups to achieve group equivalence is recommended. The timeline of a quasi-experiment is as follows:

$$\begin{array}{cc} X_1 & O \\ X_2 & O \end{array}$$



where X_1 and X_2 are two different treatments and O is observation.

3.3.3 Chosen Approach: Time Series Design

For this project, time series design was applied as the experimental research approach. Time series design is a quasi-experiment where the same group undergoes repeated measures. Between two of the measures, the group is exposed to a treatment, and the individual group's changes in results from pre to post treatment are identified. Although a change may occur, without a control group present it is uncertain whether this result is achieved due to the treatment or to an external event. Consequently, results should be reported with caution. The timeline of the time series design is as follows:

$$G \quad O_1-O_p \quad X \quad O_{p+1}-O_N$$



where G is the group, X is treatment and O_x are multiple observations.

The time series design experiment was chosen due to the selection size available. For this project, three school classes with 58 pupils in total were the sample size. Utilizing a control and experimental group design would half the group sizes. Therefore, in order to achieve larger group size, the group were held as one unit. Unfortunately, this approach provided statistically weaker results. To address this issue, both quantitative and qualitative data collection methods, in the form of questionnaires and semi-structured interviews, were used as data collection methods. The next section explains the theory behind the methods.

3.4 Data Collection

3.4.1 Methods

One of the main challenges when researching pupils' attitudes is the vast variation of measurements being used by researchers, which has made it challenging to compare results from different studies. In [38], the authors argue that one of the main reasons behind this is that there exists varying definitions of terms such as pupil motivation. Additionally, the focus of researchers within this field is varying, as some focus on effort, homework and attendance, while others address emotional issues such as relationship with classmates and teachers. The authors of [38] continue by recommending multiple methods to assess pupils' attitudes. Especially, supplementary qualitative methods are suggested as tools to detect contextual factors and reasons behind answers. Adhering to this approach, two data collection methods have been utilized in this project, which are presented below.

3.4.1.1 QUESTIONNAIRE

In [38], the authors offer a comparative analysis of various measurements of pupils' engagement used in educational research. They report that self-report questionnaire measures are the most used method for assessing pupils' engagement. The paper identifies that it is critical to collect subjective perceptions from pupils, as emotion and motivation are not directly observable. This makes self-report survey a suitable data collection method for this project. In addition, questionnaires are easily administrated and practical when addressing a large group. As a drawback, questionnaires are vulnerable to effects such as respondents answering carelessly or dishonestly.

An extensive research of various self-report measures did not provide a measurement directly applicable to this project. Instead, the author developed a custom measure which was inspired by measures such as Learning Process Questionnaire and Study Process Questionnaire by John Biggs [39] and Motivated Strategies for Learning Questionnaire [40]. These measures are statement-based, where respondents are asked to answer their agreement to a statement on a Likert scale [41]. The custom-constructed self-report survey followed a similar approach as statements were required to be answered on a 7-point Likert-*type* scale. Likert-*type* scales are variations to the traditional Likert-scales that keeps the characteristics of ordered continuum of response levels and a balanced number of positive and negative options. In this project, questionnaire items were Likert-*type* items as only the endpoints of the response levels were anchored with verbal labels. The verbal labels of a traditional Likert-scale are anchored for each response categories and the categories ranges from "strongly disagree" to "strongly agree." Although Likert-*type* scales can have other category labels, the response categories in this project copied the wording of the traditional Likert-scale.

Following a time series research design, pupils were asked to score the questionnaire before and after using the mobile application. Subsequently, the answers were compared to detect possible changes. In the questionnaire, statements were grouped by the attitude dimensions:

satisfaction, motivation and engagement. The statements of the questionnaire are listed in Table 10, while the complete questionnaire can found in the appendices.

TABLE 10 - QUESTIONNAIRE STATEMENTS

Satisfaction	
Q1	I like this subject.
Q2	I like the teaching methods utilized in this subject.
Q3	I am often frustrated when working with this subject.
Q4	This subject contributes positively to my overall school experience.
Q5	This subject is more fun than the average of all subjects.
Motivation	
Q6	I find this subject motivating.
Q7	It is important to me to finish all tasks given in this subject.
Q8	I am quickly bored when working with this subject.
Q9	This subject inspires me.
Q10	I get a boost of energy when working with this subject.
Engagement	
Q11	This subject is one of the subjects where I am most active.
Q12	I do things I am not supposed to be doing in this subject (e.g. social media).
Q13	I want to participate actively in this subject.
Q14	I keep my focus when working with this subject.
Q15	I only do what I have to do in this subject.

3.4.1.2 SEMI-STRUCTURED INTERVIEWS

Semi-structured interviews are performed with an open framework of questions, which allows for two-way communication [42]. Compared to other frameworks, semi-structured interviews are conducted with more general questions and topics. The major benefit of the method is that information obtained often provides the reasoning of an answer, not solely the answer itself. In addition, it allows for follow-up questions in response to answers that provided interesting insight. Still, semi-structured interviews require interviewers to prepare properly as there exists challenges. These include asking leading or repeating questions and failure to listen closely. Therefore, the interviewer needs to prepare a list of topics and questions that should be covered during the interview in advance.

In this project, semi-structured interviews were applied in order to present pupils with the change of elaborating on the application's advantages and disadvantages. This was regarded as highly valuable by the author, as the questionnaire alone did not have the power to reveal the reasons behind pupils' answers. Additionally, as semi-structured interviews were performed after the questionnaire, they were used to address the reasons behind findings from the questionnaire results.

3.5 Quantitative Data Analysis

Three attitude dimensions were the focus of this research. The data analysis was therefore conducted for each of these dimensions separately. For stronger statistical results, it was desired to create aggregated variables for each dimension based on the corresponding five questionnaire items. Consequently, the quantitative data analysis could be performed on one variable for each dimension instead of a per item based analysis.

For aggregated variables to be constructed it had to be evaluated that the items measured the same construct. To evaluate this, data reliability tests were performed. Cronbach's Alpha test [43] and Spearman's Rank Order Correlation test [44] were suited for this purpose. If the data passed these tests, aggregated variables were constructed.

Quantitative data collected on an ordinal scale is not normally distributed, which implies that a non-parametric test, such as Wilcoxon-Signed Rank test [45], should be applied for item based analysis. A drawback of using non-parametric tests is that they are deemed weaker than parametric test. Parametric tests are stronger as they utilize more information in their analysis such as mean and deviation. Non-parametric tests analyze the ordinal position of the pairs of scores.

Aggregated variables, on the other hand, may be normally distributed. For the aggregated variables, the Shapiro-Wilk Normality test [46] was be performed in order to validate that they were normally distributed. The results of the test was used to determine whether the non-parametric Wilcoxon-Signed Rank test or the parametric dependent samples t-test [47] should be used as a significance test for aggregated variables.

The quantitative data analysis, including the results of these test presented above, are given in 5.2 - Quantitative Data Analysis.

CHAPTER 4 – EDIGI IMPLEMENTATION

The following chapter explains the Edigi system as it was during experiments. After requirements of the system are introduced, the chapter presents the components of Edigi and how they interact at system level. Following the system overview, each component is explained in more detail. The mobile application utilized by pupils is presented, before a section demonstrating the web portal used for managing content concludes the chapter.

4.1 Edigi Requirements

During the computer science specialization project a functional prototype was implemented on the Android mobile operating system. The requirements in Table 11 were identified and used as guidelines for implementing the prototype. The requirements had testing criteria in order to determine requirement fulfillment. The criteria were mostly usability benchmarks compared to System Usability Scale [32] results scored by teachers and pupils after a usability test. In total, 16 subjects tested the prototype and the results showed that all the requirements were met. For the Master’s thesis, additional requirements were identified to make the Edigi system applicable by educational institutions. They are listed in Table 12.

TABLE 11 - MOBILE APPLICATION REQUIREMENTS

ID	Description
MR1	The application should present location-aware information.
MR2	Current location should be easily readable for users.
MR3	No training is required to use the system.
MR4	Users must feel that the system is easy to use.
MR5	The application must be free.
MR6	In case of signal interference, the user must be able to list all beacons and determine what content to be displayed.
MR7	Intended for educational purposes, the application must not offer unnecessary functionality that can distract pupils.

TABLE 12 - ADDITIONAL REQUIREMENTS

ID	Description
MR8	Teachers must have the possibility of updating content at each beacon.
MR9	The mobile application must have a functioning version on Android and iOS.

MR8 is included as a requirement as there is essential for teachers to be able to update content at each location. The prototype was a stand-alone application where the content of each beacon was stored locally in the mobile application code. An infrastructural update, turning Edigi into an information system, was needed for it to be usable as a teaching tool. Additionally, a web portal for teachers to be able to update content was needed. A section on the web portal is found in 4.4 - Edigi Web Portal.

For a system to be adopted in schools, it must be available for all pupils. Therefore, the mobile application had to be working on the two major mobile phone operating systems, Android and iOS. The prototype was only created for Android, as this was deemed sufficient during a testing phase. **MR9** was included as a requirement for this project as the fully implemented mobile application had to be functioning on both Android and iOS.

4.2 Edigi Overview

It was apparent that Edigi, to be applicable for educational institutions, needed to be an information system, not just a mobile application. Adhering to requirement **MR8** in Table 12, the Edigi system is an information system composed of four parts. These parts are the Edigi mobile application, the Edigi web portal, beacons and the cloud based data storage unit. Figure 11 gives an overview of the system and how the components interact.

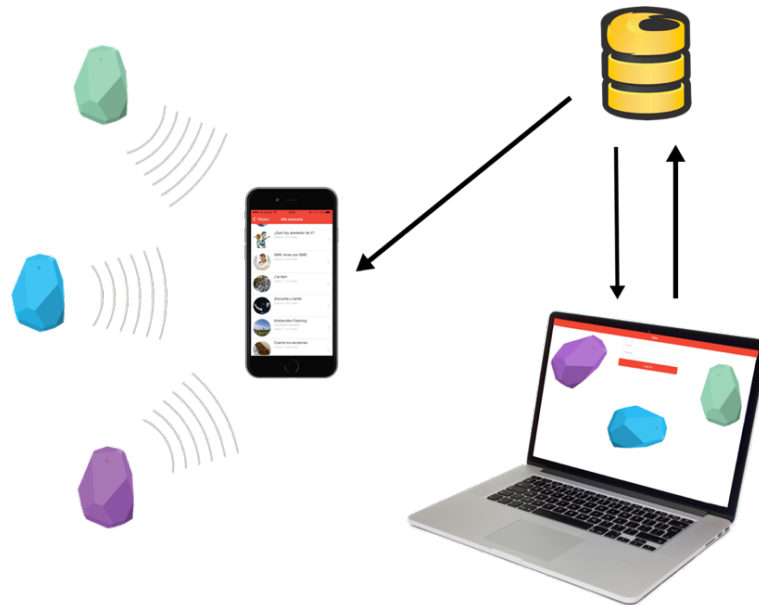


FIGURE 11 - EDIGI OVERVIEW

At startup, the mobile application downloads a data package from the data storage. This data package consists of beacon IDs with corresponding data fields such as task text, task title, video and image gallery. Beacons, placed at various locations, perform their purpose of broadcasting IDs. At runtime, the mobile application ranges for beacon IDs and matches them to the information in the downloaded data package. It is important to emphasize that the beacons do not transfer the content shown in the mobile application.

The web portal is created for managing content displayed at each beacon. In contrast to the mobile application, which is used by pupils, the web portal is a tool for teachers. When a teacher edits content in the web portal, the new content is saved in the data storage and a push notification is sent to the mobile application in order to immediately update the content shown at each beacon. As a consequence, it is not necessary for pupils to restart the application or re-download the data package manually to receive updated content. This feature was deemed useful in situations where teachers discover content errors during usage of the system.

4.3 Edigi Mobile Application

This section introduces the mobile application used during the experiments with pupils, alongside design guidelines followed during implementation. Adhering to requirement **MR9** in Table 12, the mobile application is functional on both Android and iOS mobile operating system. As the user interface adapts to all screen dimensions, the Edigi mobile application is usable on differently sized mobile phones and on tablets.

4.3.1 Design Guidelines

During development it has been focused on following design guidelines for mobile learning in order to improve usability and make the interface suitable for educational purposes. In [48], Teall et al. present a thorough review of existing literature of design guidelines for mobile learning. Although they state that this particular field suffers from lack of research, they are able to summarize specific guidelines, which are displayed in Table 13.

TABLE 13 - DESIGN GUIDELINES FOR MOBILE LEARNING [48]

Guideline	Description
1. Choosing technology	Consider the type of technology to use and its suitability for the type of learning.
2. Usability	Ensure that one considers issues of usability as they relate to using small mobile devices and requirements of learners who will be using the devices.
3. Platform and format	Design for as many platforms as possible using cross-platform compatible formats (PDFs, HTML, mp3, etc.) while reducing file size and subsequent processor requirements.
4. Tools and user interface	Simplify user interface to avoid adding to cognitive load and take away from desired learning.
5. Design of content	Ensure content is chunked and ensure only required content is presented to ensure information is displayed on screen to reduce the need for scrolling if possible.
6. Range of user technology	Design content to be accessible by users with limited mobile technology (e.g. texting or SMS) while being ready to leverage options available through technologies such as 3G and 4G mobile devices.

Guideline 1 addresses the importance of choosing the right technology. Section 2.2.2 - Reasoning for Utilization summarized the discussion for applying beacon technology, which was originally conducted during the computer science specialization project.

Guideline 2 concerns usability, which was the focus of the computer science specialization project conducted last fall. ISO/IEC [49] defines usability as *“degree to which a product or*

system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.” Following this definition, the user interface is implemented for the purpose of being utilized for educational situations. Changes implemented due to the findings acquired during the computer science specialization project are shown in 4.3.2.1 - Main View.

Guideline 3 and 6 focus on the ability to utilize modern technology. Hardware support for Bluetooth Low Energy technology could be a factor, as it was unsupported in the earlier versions of mobile operating systems. Android introduced Bluetooth Low Energy support in Android 4.3 [50], released in July, 2013 [51]. Currently, the newest Android operating system version is Android 6.0 – Marshmallow, launched on October 5, 2015 [52]. Apple introduced Bluetooth Low Energy support in iPhone 4s [53], which was released during the fall of 2013.

Guideline 4 and 5, which introduces the need for a simple interface and minimum distractions, have been adhered to. Especially, swiping between content was implemented to reduce the need for scrolling. Additionally, only relevant functionality has been implemented in order to remove distractions.

4.3.2 Mobile Application Views

The following section illustrates and explains the views of the mobile application. Views with a sole purpose of enhancing usability, such as loading screens and animations, are not shown as they are deemed irrelevant for demonstrating the usage of the mobile application.

4.3.2.1 MAIN VIEW

The Main View of the application has support for showing content in the form of text, images and video. The user interface can be seen in Figure 12. A user can swipe between types of content in order to keep the need for scrolling to a minimum. When a user moves while using the mobile application the information in the view will automatically update in line with the nearest beacon. This effect can be seen in Figure 13, where different content are displayed on the two mobile phones.

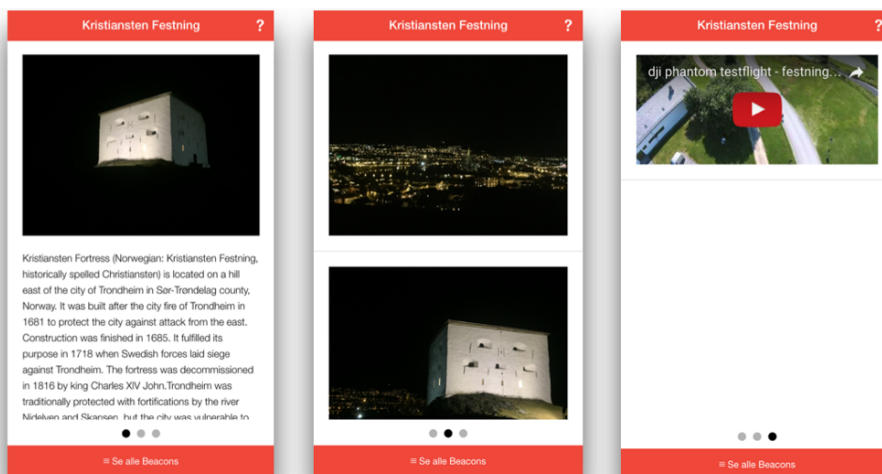


FIGURE 12 - MAIN VIEW

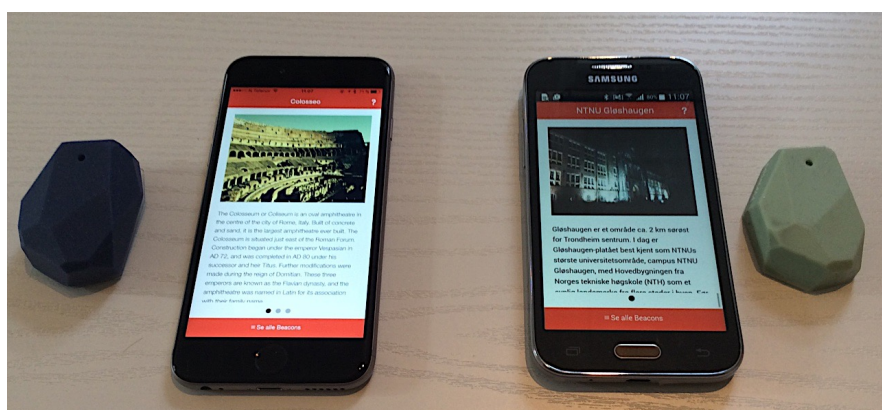


FIGURE 13 - AUTOMATIC CONTENT CHANGE

As introduced in 2.5.4 - Usability Testing, interface improvements were identified during usability testing conducted as part of the computer science specialization project. The changes made from the prototype are illustrated in Figure 14. Buttons used to alternate between text, image and video are removed to free more space for content. An icon is added to the footer-button for improved visibility. A help icon is introduced in the top right corner, which links to a view explaining how beacons work and that information shown changes based on the nearest beacon. This was deemed usable as the concept of automatically changing content based on movement is unfamiliar to most users. Finally, the background color of the content is changed from gray to white.

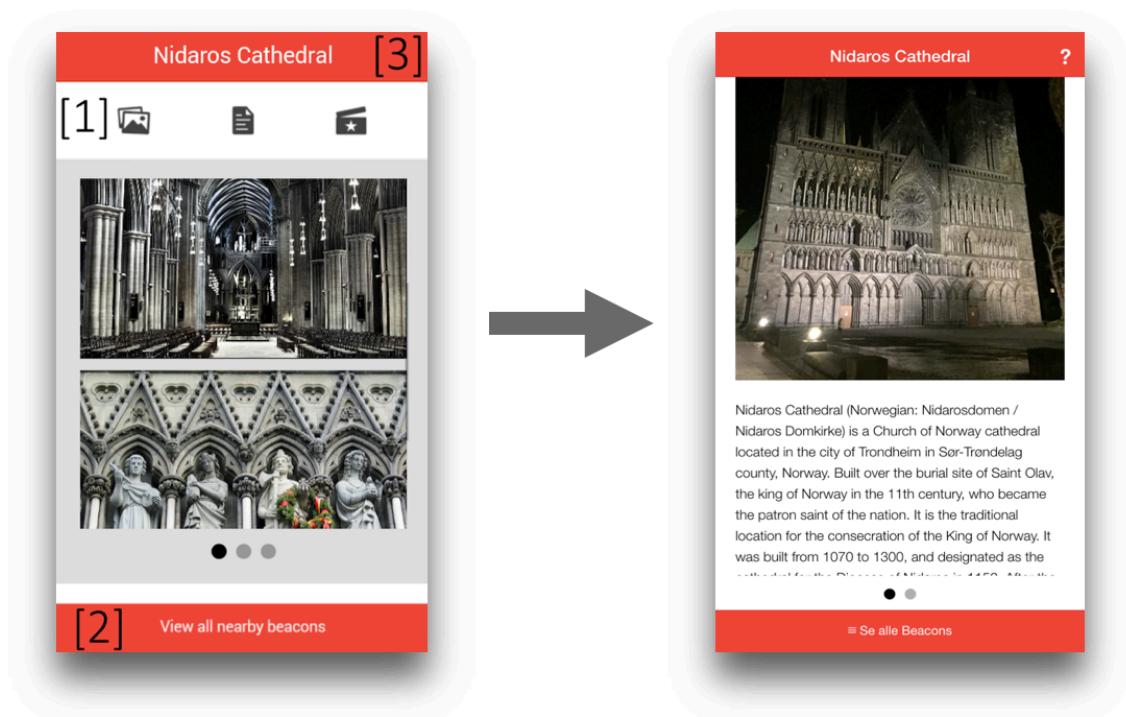


FIGURE 14 - MAIN VIEW CHANGES

4.3.2.2 ALL BEACONS VIEW

The All Beacons-view lists all detected beacons and is reached by clicking the footer-button of the Main View. The view is shown in Figure 15. For each element in the list, a small image, title, a small description and the estimated distance are given. This view was implemented in order to give the user the control of what content to view. By clicking on one of the element in the list, the user is directed to the Chosen Beacon view.

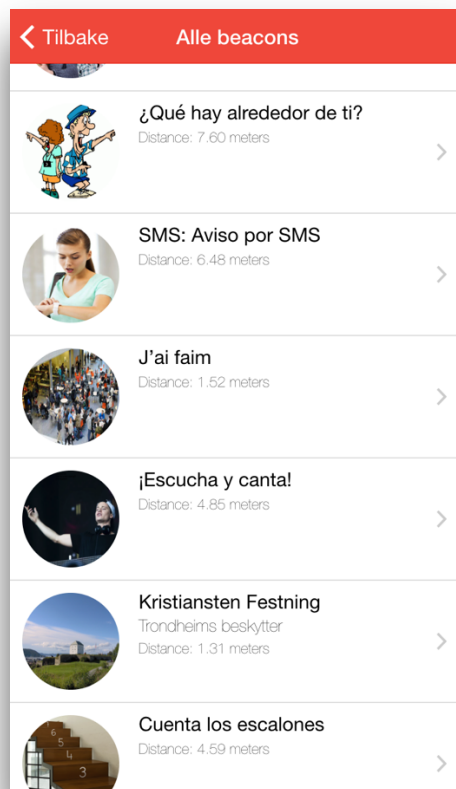


FIGURE 15 - ALL BEACONS VIEW

4.3.2.3 CHOSEN BEACON VIEW

The Chosen Beacon view is almost identical to the Main View. The differences are that this view does not include a button to list all beacons at the bottom or the link to the Help View, and that it does not automatically update information in line with the closest beacon. The view is shown in Figure 16. For this specific beacon, scrolling between types of content is not possible as the teacher has not included an image gallery or video content.



FIGURE 16 - CHOSEN BEACON VIEW

4.3.3 Technological Aspects

The mobile application was built as a hybrid mobile application. A hybrid mobile application is built with web technologies such as HTML, CSS and JavaScript. Hybrid mobile applications are hosted inside a native application, which gives access to device specific capabilities including accelerometer, camera and contacts. Compared to native mobile application development, hybrid mobile application development is not locked to a target platform such as Android or iOS. Native development, on the other hand, has stronger support of advanced functionality and achieves higher performance.

The app logic control was built with AngularJS [54], an open-source web application framework by Google. Ionic [55], optimized for AngularJS, was chosen as a library for mobile optimized HTML, CSS and JavaScript components. Apache Cordova [56] was utilized to wrap the web-based code in a native shell.



FIGURE 17 - MOBILE APPLICATION TECHNOLOGY STACK

4.4 Edigi Web Portal

The following section demonstrates the Edigi web portal intended to manage content displayed at each location. The section begins with an overview of the requirements of the web portal, before the various views are presented. Continued, a section on mobile phone and tablet support is given, while a presentation of requirements fulfillment concludes the chapter.

4.4.1 Web Portal Requirements

The requirements identified for the web portal are all listed in Table 14. Mostly, the requirements relate to essential functionality, such as being able to add new beacons and edit content. Additionally, a usability related requirement of making the web portal usable on tablets and mobile phones is included.

TABLE 14 - WEB PORTAL REQUIREMENTS

ID	Description
WR1	A user must be able to register.
WR2	A user must be able to log in.
WR3	A user must be able to log out
WR4	A user must be able to list all beacons.
WR5	A user must be able to add new beacons.
WR6	A user must be able to delete a beacon.
WR7	A user must be able to edit the title, the task text, the image gallery, the video and the main image of a beacon.
WR8	The web portal must have a responsive layout to make the web portal usable on a desktop, on a mobile phone and on a tablet.
WR9	When content is updated, the data must be stored in a cloud based data storage.
WR10	When content is updated, the content displayed in the mobile application should update instantly.

4.4.2 Web Portal Views

The following section shows the main views of the web portal. User interface details implemented for improved usability such as loading screens, alert messages and confirmation popups are not shown as they are not deemed important for demonstrational purposes. The web portal is intended for Norwegian educational institutions, which is reflected in the language of the screenshots of the web portal. Even for a reader not skilled in Norwegian, the combination of screenshots and text should be sufficient to understand the system.

4.4.2.1 LOG IN VIEW

The Log In View, shown in Figure 18, is used by teachers to log in to the web portal. This view is designed intentionally simple and serves the purposes of logging in a teacher and registering new users. Therefore, the view only has two fields for username and password, a log-in button and a register new user button. The background of the view displays three beacons in various colors. After a successful login attempt, the user is directed to the Beacons View.

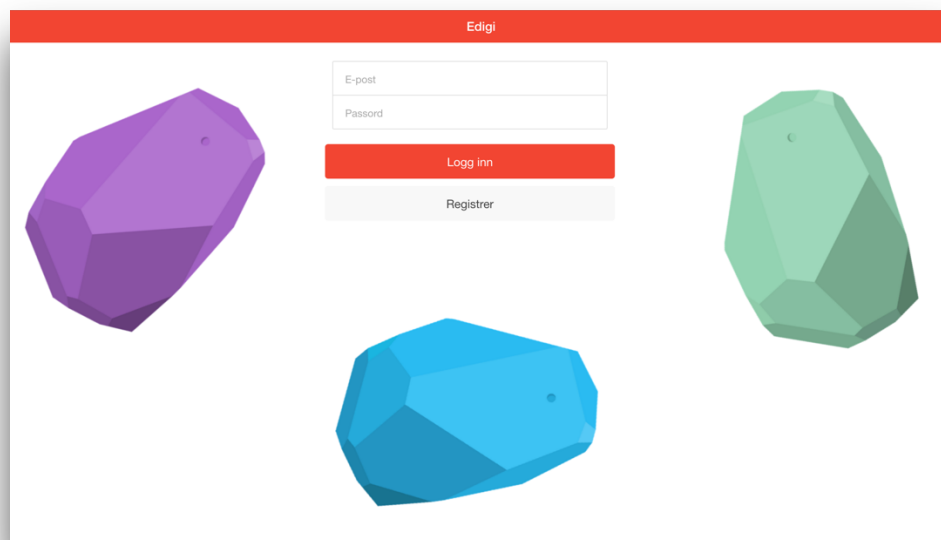


FIGURE 18 - LOG IN VIEW

4.4.2.2 BEACONS VIEW

The Beacons View is displayed after login and lists beacons in a gallery of cards. The view is seen in Figure 19. Each card consists of an image, a title and an ID. The ID corresponds to a beacon's broadcasted ID. The cards are clickable and directs the user to the Edit Beacon View where the content can be altered. The log out-button is positioned in the top right corner. When clicked, the user is logged out and directed to the Log In - View. In the top left corner, a button to add new beacons is located. Figure 20 shows the pop-up window displayed when this button is clicked. In the popup, the user is asked to fill in the desired title and the broadcast ID of the new beacon.

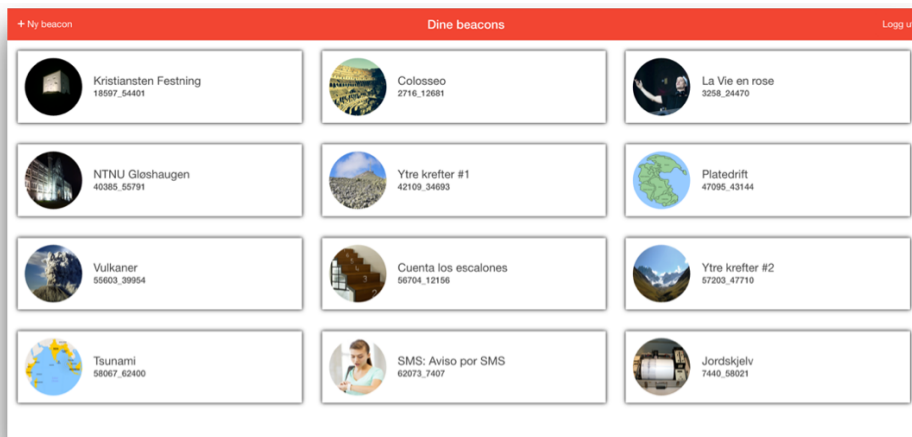


FIGURE 19 - BEACONS VIEW

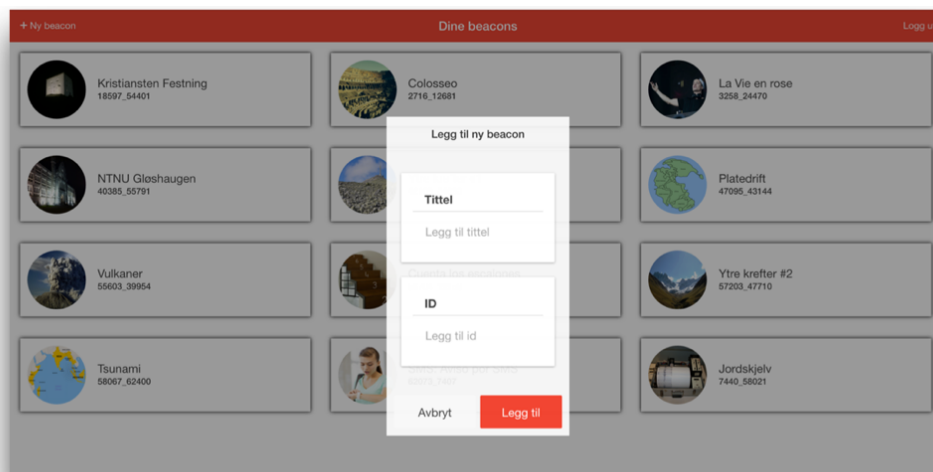


FIGURE 20 - ADD NEW BEACON VIEW

4.4.2.3 EDIT BEACON VIEW

The Edit Beacon View is utilized for changing the content displayed at each beacon. It contains fields for updating the main image, the title, the sub-title, the text, the image gallery and the video. At the bottom of the page, the save-button is positioned. The header bar displays the beacon title, a delete beacon-button and a log-out button. When clicking the delete beacon-button, the user is required to confirm this action in order to avoid performing it unintentionally. Below, illustrations of the Edit Beacon View are presented.

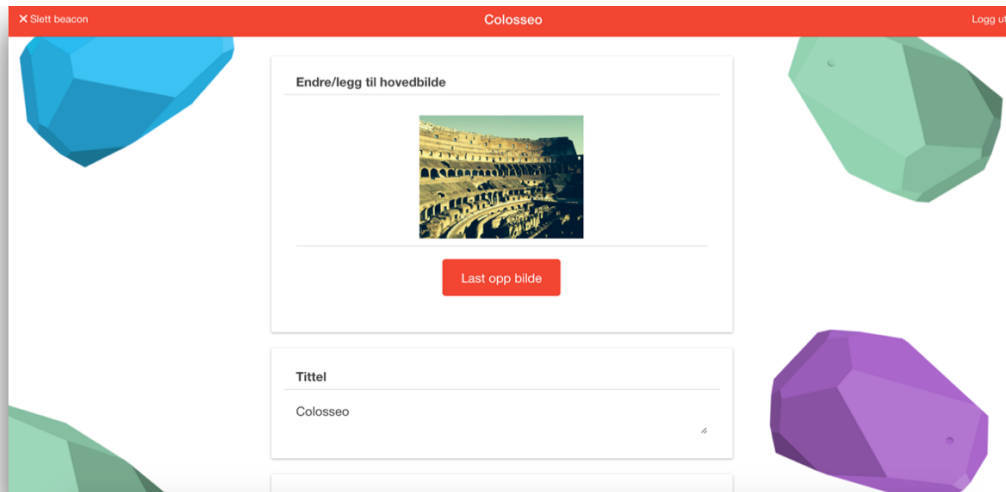


FIGURE 21 - EDIT BEACON VIEW PART 1

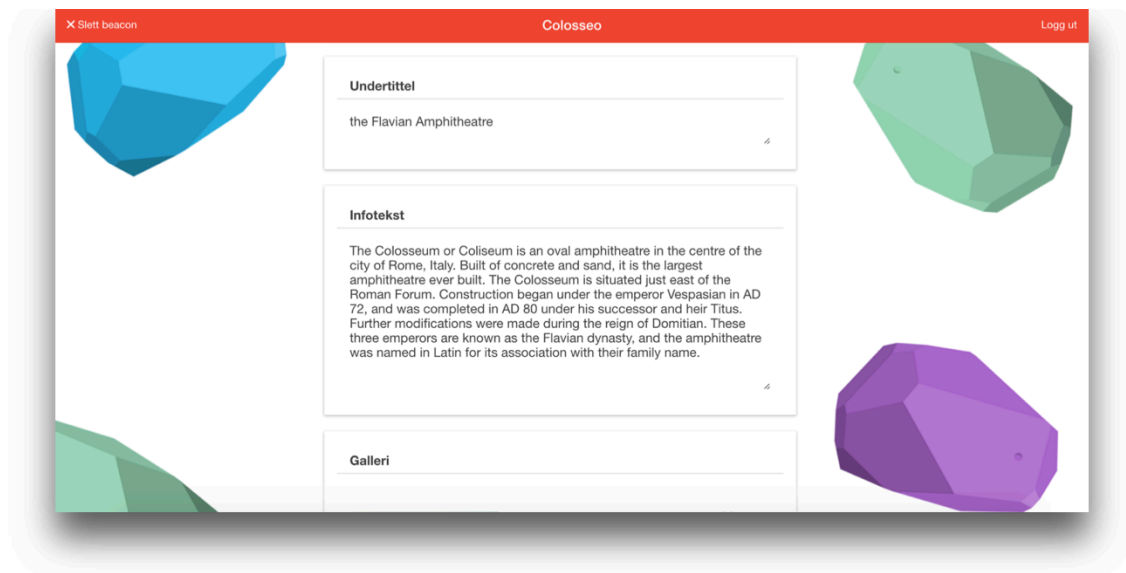


FIGURE 22 - EDIT BEACON VIEW PART 2

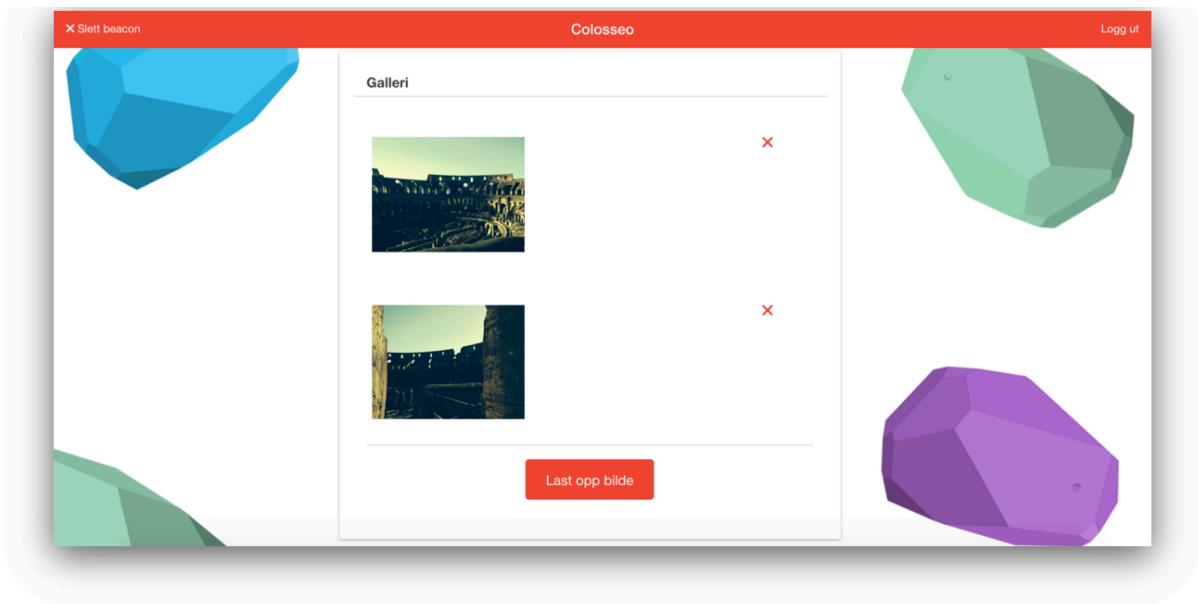


FIGURE 23 - EDIT BEACON VIEW PART 3

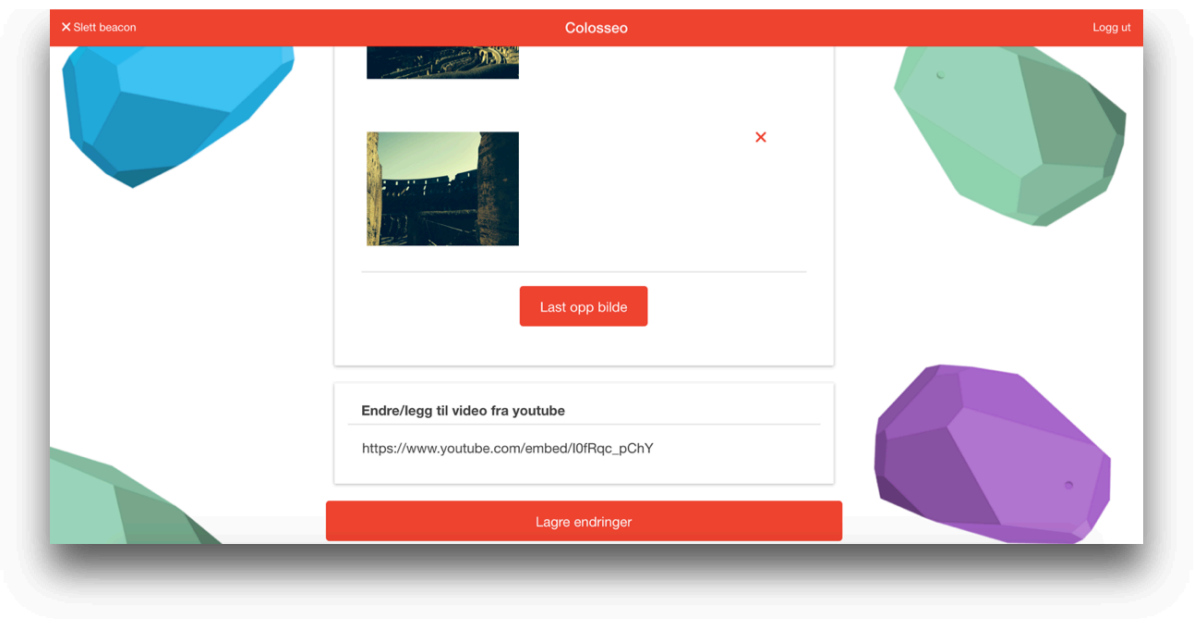


FIGURE 24 - EDIT BEACON VIEW PART 4

4.4.3 Responsive Layout

WR8 in Table 14 states that the web portal must be usable on tablets and on mobile phones due to teachers' possible utilization of different types of electronic devices. Figure 25 displays selected views on mobile phones and tablets.

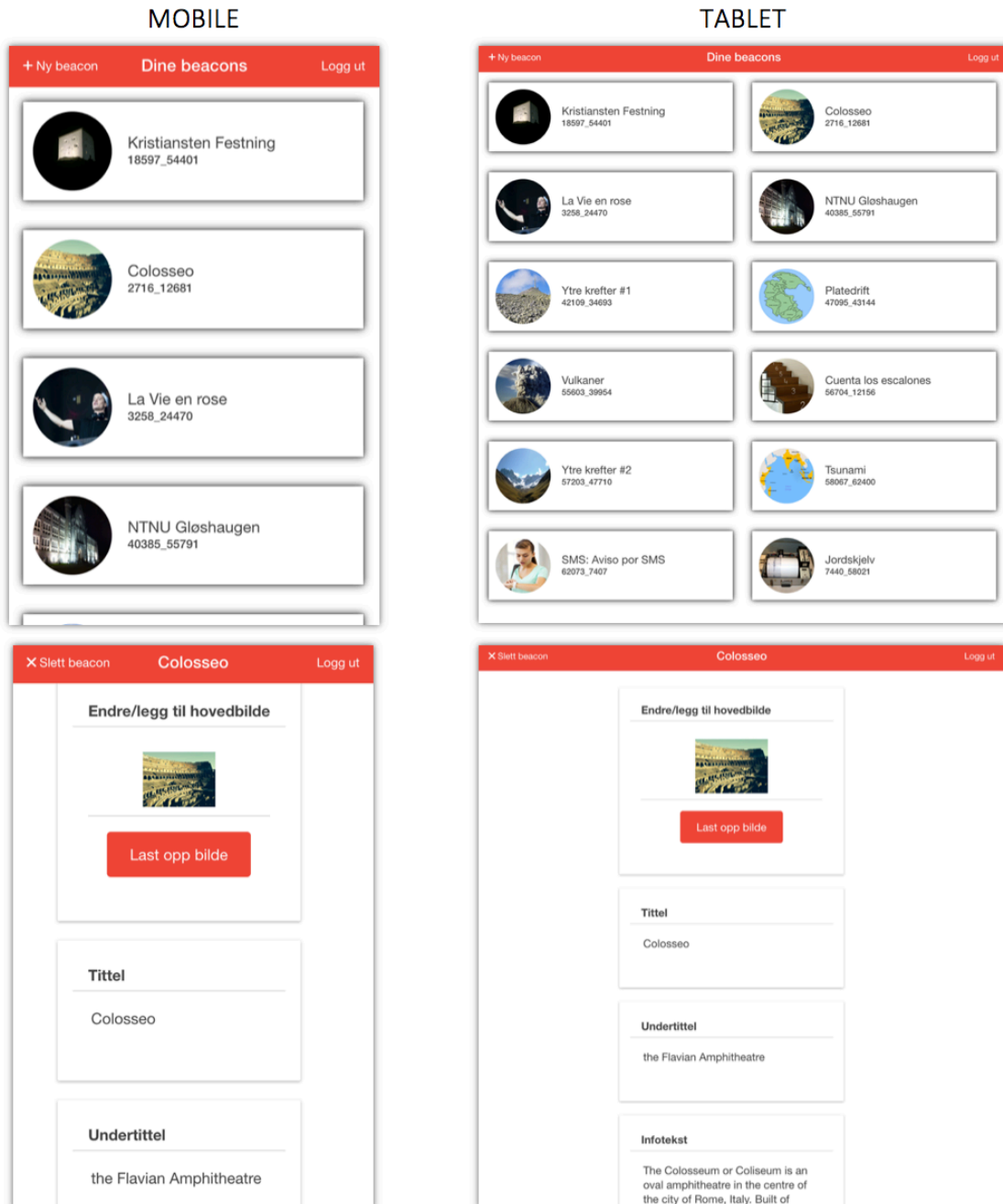


FIGURE 25 - MOBILE & TABLET LAYOUT

4.4.4 Web Portal Requirements Fulfillment

Several requirements guided the development of the Edigi web portal. Table 15 lists the requirements and shows that they were all achieved.

TABLE 15 - WEB PORTAL REQUIREMENTS FULFILLMENT

ID	Description	Achieved
WR1	A user must be able to register.	✓
WR2	A user must be able to log in.	✓
WR3	A user must be able to log out	✓
WR4	A user must be able to list all beacons.	✓
WR5	A user must be able to add new beacons.	✓
WR6	A user must be able to delete a beacon.	✓
WR7	A user must be able to edit the title, the task text, the image gallery, the video and the main image of a beacon.	✓
WR8	The web portal must have a responsive layout to make the web portal usable on a desktop, on a mobile phone and on a tablet.	✓
WR9	When content is updated, the data must be stored in a cloud based data storage.	✓
WR10	When content is updated, the content displayed in the mobile application should update instantly.	✓

CHAPTER 5 – EVALUATION & RESULTS

This chapter starts with an explanation of how the experiments were conducted. Following, both the quantitative and qualitative results are presented. A section on implemented mobile application improvements based on findings acquired during the experiments concludes the chapter.

5.1 Execution

5.1.1 Timeline

As data collection methods, both a quantitative and a qualitative approach were applied. To evaluate the application's affect on pupils' attitudes, a questionnaire was given to pupils in advance and after the mobile application had been integrated in a course. The questionnaires were identical pre and post treatment in order to compare answers from the first to the second. In order to detect the reasons behind a possible change, a qualitative approach in the form of semi-structured interviews was applied. The timeline of the data collection can be seen in Figure 26.



FIGURE 26 - PROJECT TIMELINE

5.1.2 Treatment

The application was tested in three different courses, in French, Spanish and geology. For each course, the responsible teacher was in charge of creating the tasks. This was deemed most suitable as they are experts of their domains. All teachers adhered to a form of gallery walk, where groups roamed the school building in search of beacons.

In relation to the pedagogical theory discussed in section 2.3 - Pedagogical Theory, all three experiments consisted of computer-supported collaborative tasks. Additionally, cognitive aspects such as activity while learning and method of loci were existing in the experiments.

During the experiments task texts for language courses were given in the corresponding language, while task texts in the geology course were presented in Norwegian. All task texts have been translated into English in this report for the convenience of the reader.

5.1.2.1 FRENCH

The mobile application was tested by 16 pupils, currently in their twelfth school year. The pupils were divided into four groups. All the tasks presented to the pupils are found in Table 16.

TABLE 16 - FRENCH TASKS

Title	Task text
At the movies	Do you want to go to the movies with your French teacher? You must send an invitation to the teacher. You can use Talking Tom, Instagram, Snapchat, email etc. You must mention the date, time and place in French.
La Vie en rose	Do you like music? You need to find a French song and learn at least three lines of the song by heart. Film yourselves singing the song. Post the video on your blog, send it to the teacher by e-mail or post it on the learning platform.
The stranger	You are a French tourist at the school. You need to find someone who speaks French to talk to for a minute. You must ask for directions, for example to the toilet and canteen.
Duolingo	Play the learning application Duolingo in order to learn French. You have to play for 15 minutes.
I am hungry	You are now in the canteen. You feel hungry and thirsty. You must order a drink and something to eat in French. Film yourselves placing the order. Post the video on your blog, send it to the teacher by e-mail or post it on the learning platform.

5.1.2.2 SPANISH

For the Spanish course 14 pupils, divided into four groups, currently in their twelfth school year participated. Table 17 present the tasks for the Spanish course.

TABLE 17 - SPANISH TASKS

Title	Task text
What is around you?	Where are you? What things are there? Who are you with? Make a video (approximately 1 minute) with a description of what you see. Send the video to the teacher by e-mail.
Listen and sing!	Listen to the song "Bailando" and learn three lines. Film yourselves singing the chorus. Send the video to the teacher by e-mail. (<i>A video of the song "Bailando" was presented on the mobile application at the location</i>)
Count the steps	Go up the stairs while counting the steps going up to 20 in Spanish. Record it with your phone. Send the video to the teacher by e-mail.
I am hungry	You are in the school cafeteria and you are going to order food and a drink in Spanish. For example: "I want a cheese sandwich, please." Make a video of yourself placing the order. Send the video to the teacher by e-mail.
Notice by SMS	Send a message to the teacher explaining that you are late for class. You also have to explain why. Send the message to number XXXXXXXX.

5.1.2.3 GEOLOGY

In geology, the mobile application was tested by 28 pupils, divided in nine groups, currently in their eighth school year.

For the geology course, in contrast to the tasks utilized in the language courses, all tasks were connected. For each question, the corresponding first letter of the correct answers was a part of a final keyword. The pupils were tasked with finding the final keyword by utilizing the letters acquired during their search for beacons. Table 18 displays the tasks.

TABLE 18 - GEOLOGY TASKS

Title	Task text
External Forces #1	Weathering is the breakdown of rocks and minerals under the influence of external forces. The image shows a so-called stone sea with large stones that you can find in the mountains. Which external influences have created this block sea when it freezes?
Continental Drift	For 250 million years ago the continents were assembled in a supercontinent. What is this supercontinent called?
Volcanos	Yellowstone is a type of volcano that is expected to achieve an outbreak of more than 1000 km ³ mass. What are such volcanoes called?
External Forces #2	A valley is created by flowing water or glaciers that transports dissolved material from one location on the Earth's crust to another. What is this process called?
Tsunami	In 2004, a large tsunami occurred in Indian Ocean. Which country had the most casualties?
Earthquakes	Earthquakes create seismic waves. The strength of these waves determines the size of earthquakes and can be measured using a seismograph. What is the name of the scale that is used to measure the strength of an earthquake?

5.2 Quantitative Data Analysis

This section presents the quantitative data collected pre and post treatment. In total, 58 data samples were collected. They were distributed across 16 pupils from a French course, 14 pupils from a Spanish course and 28 pupils from a geology course. The answers to statements with negative wording, such as “I am often frustrated when working with this subject.” were inversed in the analysis. For instance, the bottom score of 1 was set to the top score of 7. This means that in the data analysis, all positive differences in responses were improvements. The data of this section was produced using IBM SPSS [57]. Table 19 relists the statements in the questionnaire for the convenience of the reader.

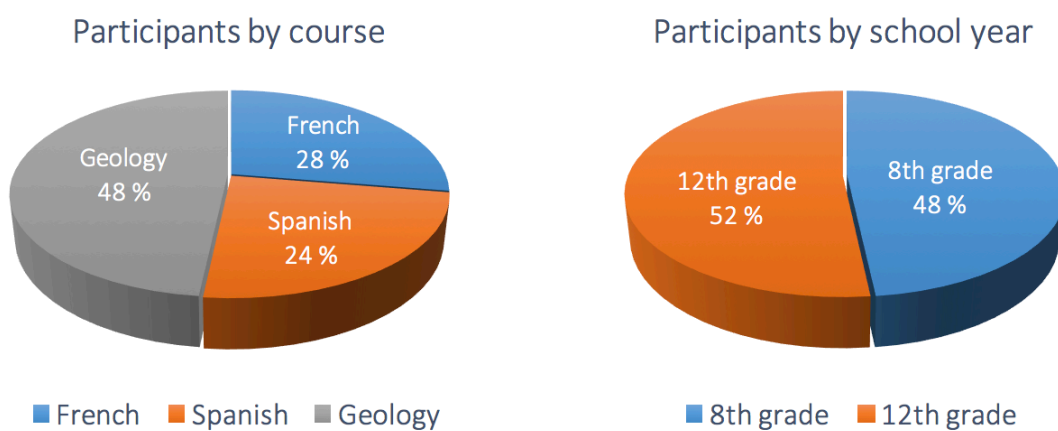


FIGURE 27 - QUANTITATIVE PARTICIPANTS STATISTICS

TABLE 19 - STATEMENTS

Q1	I like this subject.
Q2	I like the teaching methods utilized in this subject.
Q3	I am often frustrated when working with this subject.
Q4	This subject contributes positively to my overall school experience.
Q5	This subject is more fun than the average of all subjects.
Q6	I find this subject motivating.
Q7	It is important to me to finish all tasks given in this subject.
Q8	I am quickly bored when working with this subject.
Q9	This subject inspires me.
Q10	I get a boost of energy when working with this subject.
Q11	This subject is one of the subjects where I am most active.
Q12	I do things I am not supposed to be doing in this subject (e.g. social media).
Q13	I want to participate actively in this subject.
Q14	I keep my focus when working with this subject.
Q15	I only do what I have to do in this subject.

5.2.1 Descriptive Statistics

5.2.1.1 OVERALL

Figure 28 displays the distribution of changes in answers from pre to post treatment for each item in the questionnaire. The orange part of a column shows the number of pupils who responded more positively in the post treatment questionnaire compared to the pre treatment questionnaire. Similarly, the blue part of the column represents ties and the gray part of the column indicates the number of pupils who responded more negatively on the second questionnaire compared to the first.

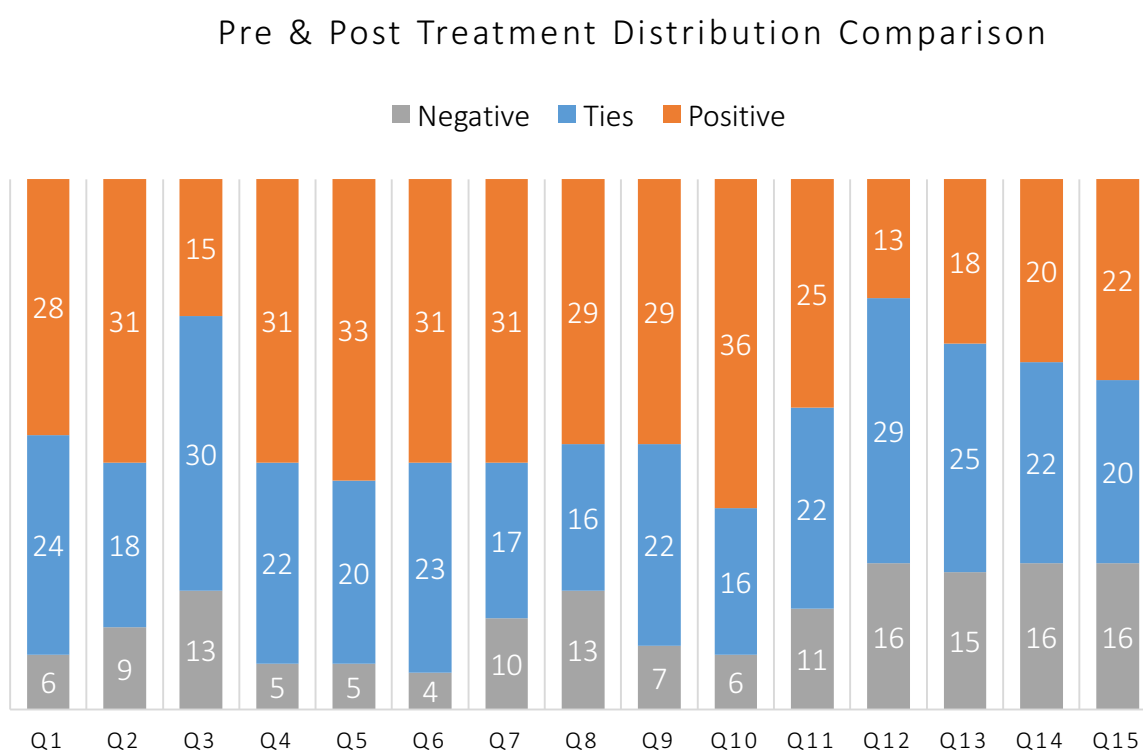


FIGURE 28 - PRE & POST TREATMENT DISTRIBUTION COMPARISON

Firstly, it is observable that fourteen statements had a higher number of positive responses than negative responses. Only Q12 (“I do things I am not supposed to be doing in this subject (e.g. social media).”) had a higher number of negative responses with 16 negatives versus 13 positives. The highest number of negative responses is 16, which can be seen in Q12 (“I do things I am not supposed to be doing in this subject (e.g. social media).”), Q14 (“I keep my focus when working with this subject. “) and Q15 (“I only do what I have to do in this subject.”). Q6 (“I find this subject motivating”) stands out as the statement with the fewest negative responses. Q10 (“I get a boost of energy when working with this subject.”) is the statement with the highest number of positive responses, with 36 positives. Q3 (“I am often frustrated when working with this subject.”) is the statement with the highest number of ties.

5.2.1.2 SATISFACTION

This section introduces descriptive statistics for statements relating to the satisfaction dimension (Q1-Q5). Table 20 shows that the mean differences from pre to post treatment were positive for all items, with Q3 (“I am often frustrated when working with this subject.”) as the statement with the lowest positive change and Q5 (“This subject is more fun than the average of all subjects.”) as the statement with the highest positive change. Additionally, it is observable that all the POST results have a smaller standard deviation than their corresponding PRE results. The Min and Max columns reveals that the full scale is used for almost every question. For Q2 POST (“I like the teaching methods utilized in this subject”) and Q4 POST (“This subject contributes positively to my overall school experience. ”) is the minimum value of 1 not used, which is regarded as an improvement.

Q2 POST (“I like the teaching methods utilized in this subject”) has a mean of 5.379, which is the highest mean of all fifteen statements both pre and post test. As the Edigi system is a new teaching method, it is satisfying to observe that the system receives a high score for this statement. A mean positive difference of 0.862 from pre to post treatment for the same statement contributes to the positive results regarding this questionnaire item.

TABLE 20 - SATISFACTION SUMMARY STATISTICS

	Mean	Median	Min	Max	Std. Deviation	Mode	Mean Difference
Q1 PRE	4.241	4.000	1.0	7.0	1.406	5.0	
Q1 POST	4.983	5.000	1.0	7.0	1.304	5.0	0.742
Q2 PRE	4.517	4.000	1.0	7.0	1.380	4.0	
Q2 POST	5.379	5.000	2.0	7.0	1.197	5.0	0.862
Q3 PRE	4.879	5.000	1.0	7.0	1.874	6.0 ^a	
Q3 POST	5.103	5.000	1.0	7.0	1.459	5.0	0.224
Q4 PRE	3.690	4.000	1.0	7.0	1.489	4.0	
Q4 POST	4.638	5.000	2.0	7.0	1.435	4.0	0.948
Q5 PRE	3.741	4.000	1.0	7.0	1.596	4.0	
Q5 POST	4.862	5.000	1.0	7.0	1.480	4.0 ^a	1.121

a = Multiple modes exist. The smallest value is shown

Figure 29 displays the frequency distribution of the pre and post answers for Q1-Q5. After examining the histogram, it is clear that the post answers have a higher share of the values to the right than their corresponding pre answers. Table 21 shows the frequency distributions in table format.

Satisfaction Histogram Comparison

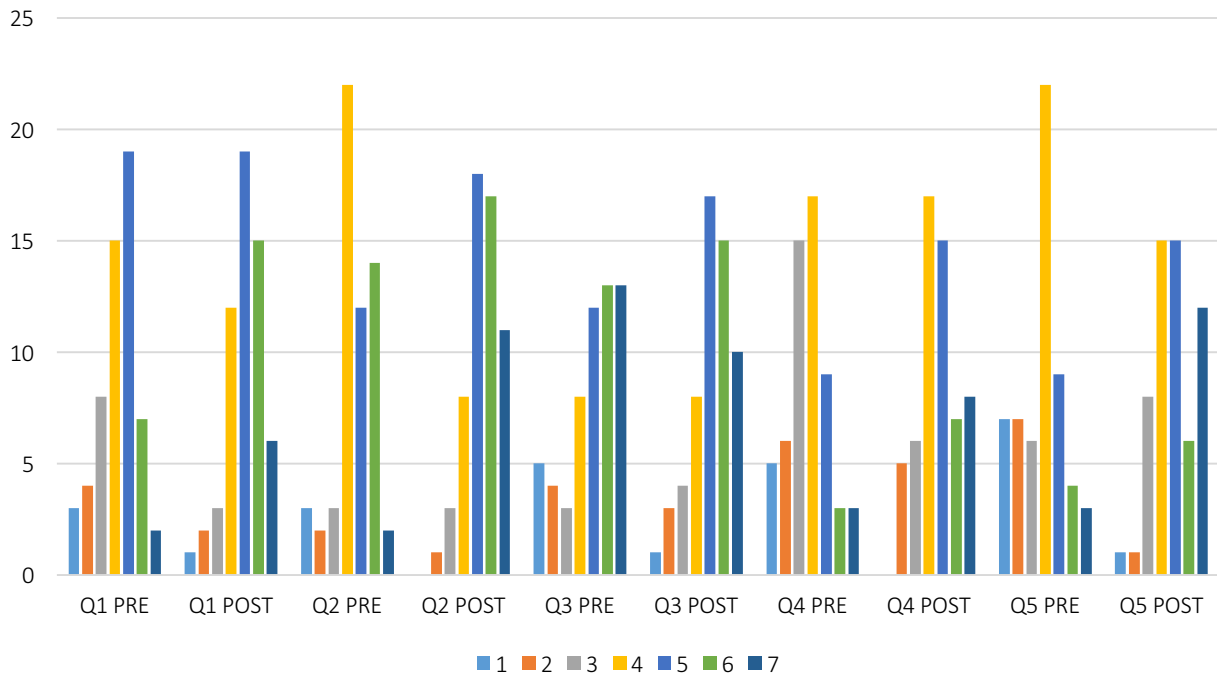


FIGURE 29 - SATISFACTION HISTOGRAM COMPARISON

TABLE 21 - SATISFACTION FREQUENCY STATISTICS

	1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Q1 PRE	3	5.2	4	6.9	8	13.8	15	25.9	19	32.8	7	12.1	2	3.4
Q1 POST	1	1.7	2	3.4	3	5.2	12	20.7	19	32.8	15	25.9	6	10.3
Q2 PRE	3	5.2	2	3.4	3	5.2	22	37.9	12	20.7	14	24.1	2	3.4
Q2 POST	0	0.0	1	1.7	3	5.2	8	13.8	18	31	17	29.3	11	19.0
Q3 PRE	5	8.6	4	6.9	3	5.2	8	13.8	12	20.7	13	22.4	13	22.4
Q3 POST	1	1.7	3	5.2	4	6.9	8	13.8	17	29.3	15	25.9	10	17.2
Q4 PRE	5	8.6	6	10.3	15	25.9	17	29.3	9	15.5	3	5.2	3	5.2
Q4 POST	0	0.0	5	8.6	6	10.3	17	29.3	15	25.9	7	12.1	8	13.8
Q5 PRE	7	12.1	7	12.1	6	10.3	22	37.9	9	15.5	4	6.9	3	5.2
Q5 POST	1	1.7	1	1.7	8	13.8	15	25.9	15	25.9	6	10.3	12	20.7

5.2.1.3 MOTIVATION

This section introduces descriptive statistics for statements relating to the motivation dimension (Q6-Q10). Table 22 shows that the mean differences from pre to post treatment were positive for all items. The Min and Max columns reveals that only for Q7 POST (“It is important to me to finish all tasks given in this subject. “), Q8 POST (“I am quickly bored when working with this subject. “) and Q10 PRE (“I get a boost of energy when working with this subject.”) is the full scale not used. Interestingly, of all fifteen statements asked, Q10 PRE (“I get a boost of energy when working with this subject.”) is the only statement with a mean below 3.0. Q10 POST (“I get a boost of energy when working with this subject.”) has a mean value of 4.241, indicating a mean increase of 1.431 from the pre treatment results. This is the highest mean increase of all fifteen statements.

TABLE 22 - MOTIVATION SUMMARY STATISTICS

	Mean	Median	Min	Max	Std. Deviation	Mode	Mean Difference
Q6 PRE	3.517	3.500	1.0	7.0	1.614	3.0	0.862
Q6 POST	4.379	4.000	1.0	7.0	1.520	4.0	
Q7 PRE	4.483	5.000	1.0	7.0	1.581	5.0	0.776
Q7 POST	5.259	5.000	2.0	7.0	1.371	5.0 ^a	
Q8 PRE	4.069	4.000	1.0	7.0	1.653	3.0	0.517
Q8 POST	4.586	4.500	2.0	7.0	1.579	6.0	
Q9 PRE	3.224	3.000	1.0	7.0	1.579	3.0	0.742
Q9 POST	3.966	4.000	1.0	7.0	1.475	4.0	
Q10 PRE	2.810	3.000	1.0	6.0	1.348	3.0	1.431
Q10 POST	4.241	4.500	1.0	7.0	1.647	5.0	

a = Multiple modes exist. The smallest value is shown

The frequency distribution of the pre and post answers for Q6-Q10 are displayed in Figure 30. In general, it is observable that the post answers are more positive than the corresponding pre answers. The frequency distributions in table format is shown in Table 23.

Motivation Histogram Comparison

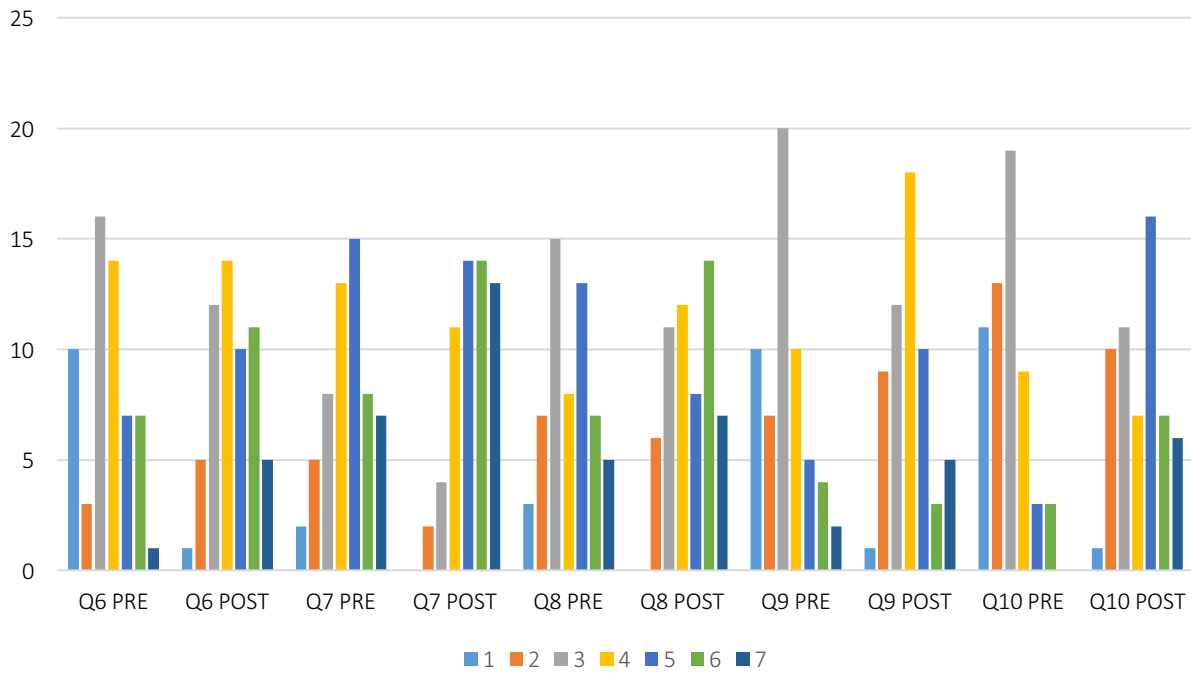


FIGURE 30 - MOTIVATION HISTOGRAM COMPARISON

TABLE 23 - MOTIVATION FREQUENCY STATISTICS

	1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Q6 PRE	10	17.2	3	5.2	16	27.6	14	24.1	7	12.1	7	12.1	1	1.7
Q6 POST	1	1.7	5	8.6	12	20.7	14	24.1	10	17.2	11	19.0	5	8.6
Q7 PRE	2	3.4	5	8.6	8	13.8	13	22.4	15	25.9	8	13.8	7	12.1
Q7 POST	0	0.0	2	3.4	4	6.9	11	19.0	14	24.1	14	24.1	13	22.4
Q8 PRE	3	5.2	7	12.1	15	25.9	8	13.8	13	22.4	7	12.1	5	8.6
Q8 POST	0	0.0	6	10.3	11	19.0	12	20.7	8	13.8	14	24.1	7	12.1
Q9 PRE	10	17.2	7	12.1	20	34.5	10	17.2	5	8.6	4	6.9	2	3.4
Q9 POST	1	1.7	9	15.5	12	20.7	18	31.0	10	17.2	3	5.2	5	8.6
Q10 PRE	11	19.0	13	22.4	19	32.8	9	15.5	3	5.2	3	5.2	0	0.0
Q10 POST	1	1.7	10	17.2	11	19.0	7	12.1	16	27.6	7	12.1	6	10.3

5.2.1.4 ENGAGEMENT

This section introduces descriptive statistics for statements relating to the engagement dimension (Q11-Q15). Table 24 reveals that Q12 (“I do things I am not supposed to be doing in this subject (e.g. social media)”) have a negative mean difference from pre to post treatment. This is the only item in the questionnaire that achieved a negative result. The Min and Max columns demonstrates that the minimum value of 1 is not checked for Q13 POST (“I want to participate actively in this subject. “), making Q13 POST the only item in this dimension where the full scale is not used. Generally, the mean differences are smaller for the engagement dimension than for satisfaction and motivation. Q11 PRE (“This subject is one of the subjects where I am most active. “) and Q15 PRE (“I only do what I have to do in this subject. “) are the only statements of all fifteen question, both pre and post treatment, where a mode as low as 2 is present.

TABLE 24 - ENGAGEMENT SUMMARY STATISTICS

	Mean	Median	Min	Max	Std. Deviation	Mode	Mean Difference
Q11 PRE	3.655	3.000	1.0	7.0	1.773	2.0	0.586
Q11 POST	4.241	4.000	1.0	7.0	1.626	4.0	
Q12 PRE	4.845	5.000	1.0	7.0	1.853	7.0	- 0.242
Q12 POST	4.603	5.000	1.0	7.0	1.937	6.0	
Q13 PRE	4.621	4.000	1.0	7.0	1.588	4.0	0.138
Q13 POST	4.759	5.000	2.0	7.0	1.418	4.0	
Q14 PRE	4.362	4.000	1.0	7.0	1.597	4.0	0.224
Q14 POST	4.586	4.500	2.0	7.0	1.451	4.0	
Q15 PRE	3.121	3.000	1.0	7.0	1.601	2.0	0.276
Q15 POST	3.397	3.000	1.0	7.0	1.600	3.0	

a = Multiple modes exist. The smallest value is shown

Figure 31 reveals the frequency distributions of answers related to the engagement dimension. Compared to the histograms of other dimensions there is observable that the results of these histograms are less positive. This is especially evident for Q12 (“I do things I am not supposed to be doing in this subject (e.g. social media)”) where the results are better for the pre treatment answers. A positive effect is present for the other questions, although to a lesser degree than for other dimensions. Table 25 lists the frequency statistics in table format.

Engagement Histogram Comparison

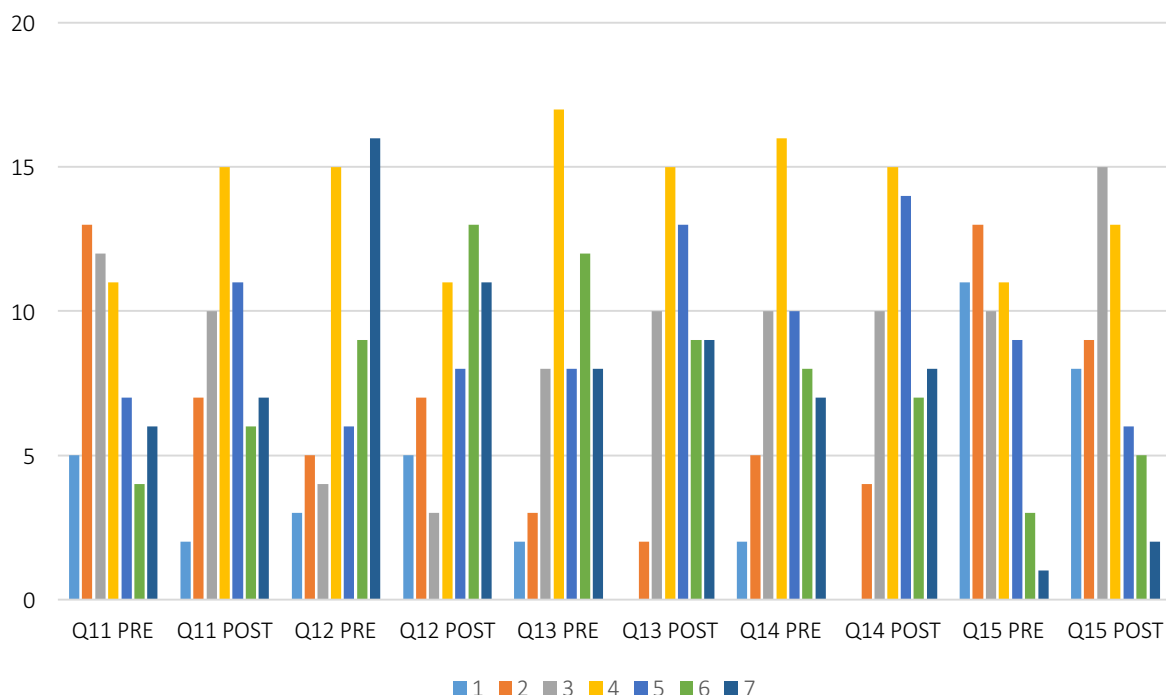


FIGURE 31 - ENGAGEMENT HISTOGRAM COMPARISON

TABLE 25 - ENGAGEMENT FREQUENCY STATISTICS

	1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Q11 PRE	5	8.6	13	22.4	12	20.7	11	19.0	7	12.1	4	6.9	6	10.3
Q11 POST	2	3.4	7	12.1	10	17.2	15	25.9	11	19.0	6	10.3	7	12.1
Q12 PRE	3	5.2	5	8.6	4	6.9	15	25.9	6	10.3	9	15.5	16	27.6
Q12 POST	5	8.6	7	12.1	3	5.2	11	19.0	8	13.8	13	22.4	11	19.0
Q13 PRE	2	3.4	3	5.2	8	13.8	17	29.3	8	13.8	12	20.7	8	13.8
Q13 POST	0	0.0	2	3.4	10	17.2	15	25.9	13	22.4	9	15.5	9	15.5
Q14 PRE	2	3.4	5	8.6	10	17.2	16	27.6	10	17.2	8	13.8	7	12.1
Q14 POST	0	0.0	4	6.9	10	17.2	15	25.9	14	24.1	7	12.1	8	13.8
Q15 PRE	11	19.0	13	22.4	10	17.2	11	19.0	9	15.5	3	5.2	1	1.7
Q15 POST	8	13.8	9	15.5	15	25.9	13	22.4	6	10.3	5	8.6	2	3.4

5.2.2 Wilcoxon Signed-Rank Test

As ordinal data are not normally distributed the non-parametric Wilcoxon Signed Rank-test [45] was utilized in order to determine whether changes in responses from pre to post treatment were significant. The Wilcoxon-Signed Rank test is deemed as a suited replacement of a parametric test for dependent samples when the responses are not normally distributed. In addition, it is applicable to repeated measures with dependent data samples, which is the nature of this research. Table 26 reveals that ten of fifteen items had a significant positive change from pre to post treatment. In the satisfaction dimension the change in four items were significant positive, while changes in all items were significant positive in the motivation dimension. Interestingly, in the engagement dimension, the change in only one item was significant positive.

TABLE 26 - WILCOXON SIGNED-RANK TEST RESULTS

ID	Question	Z-value	P-value (two-tailed)	Significant ($\alpha = 0.05$)
Satisfaction				
Q1	I like this subject.	- 3.778	0.000	✓
Q2	I like the teaching methods utilized in this subject.	- 3.608	0.000	✓
Q3	I am often frustrated when working with this subject.	- 0.724	0.469	✗
Q4	This subject contributes positively to my overall school experience.	- 4.543	0.000	✓
Q5	This subject is more fun than the average of all subjects.	- 4.654	0.000	✓
Motivation				
Q6	I find this subject motivating.	- 4.273	0.000	✓
Q7	It is important to me to finish all tasks given in this subject.	- 3.368	0.001	✓
Q8	I am quickly bored when working with this subject.	- 2.301	0.021	✓
Q9	This subject inspires me.	- 3.801	0.000	✓
Q10	I get a boost of energy when working with this subject.	- 5.022	0.000	✓
Engagement				
Q11	This subject is one of the subjects where I am most active.	- 2.904	0.004	✓
Q12	I do things I am not supposed to be doing in this subject (e.g. social media).	- 0.733 ^a	0.464	✗
Q13	I want to participate actively in this subject.	- 0.519	0.603	✗
Q14	I keep my focus when working with this subject.	- 0.918	0.358	✗
Q15	I only do what I have to do in this subject.	- 0.800	0.424	✗

a = negative change

5.2.3 Aggregated Variables

In order to achieve higher statistical reliability, it was desired to aggregate the five items for each attitude dimension to one variable. For this project, there were six possible aggregated variables. These were Satisfaction PRE, Satisfaction POST, Motivation PRE, Motivation POST, Engagement PRE and Engagement POST.

5.2.3.1 DATA VALIDATION

Two tests were performed in order to determine whether the quantitative results were statistically suited to create aggregated variables. These tests were the Cronbach’s Alpha test [43] and Spearman’s Rank Order Correlation test [44].

The results of the Cronbach’s Alpha test are shown in Table 27. The acceptance level of the test is debated, but a value above 0.7 is generally regarded as acceptable [58]. The results demonstrate that the data for the satisfaction and motivation dimension pass the Cronbach’s Alpha test. Additionally, it shows that the data for the engagement dimension does not pass the test.

TABLE 27 - CRONBACH'S ALPHA TEST RESULTS

Aggregated Variable	Items	Cronbach’s Alpha	Accepted
Satisfaction PRE	Q1 – Q5 PRE	0.836	✓
Satisfaction POST	Q1 – Q5 POST	0.870	✓
Motivation PRE	Q6 – Q10 PRE	0.865	✓
Motivation POST	Q6 – Q10 POST	0.870	✓
Engagement PRE	Q11 – Q15 PRE	0.584	✗
Engagement POST	Q11 – Q15 POST	0.268	✗

Spearman’s Rank Order Correlation test have two assumptions. Firstly, the variables should be ordinal, interval or ratio data. This holds for the data collected during this project. Secondly, the two variables tested should have a monotonic relationship. To determine whether this relationship existed among the data, scatter plots of the data variables was created and visually inspected. This inspection revealed that the data for Satisfaction PRE, Satisfaction POST, Motivation PRE and Motivation POST were acceptable. Simultaneously it was found that data for Engagement PRE and Engagement POST do not have monotonic relationships. Therefore, the Spearman’s Rank Order Correlations test was only performed for the satisfaction and the motivation dimension. The results are presented below.

TABLE 28 - SATISFACTION PRE - SPEARMAN'S RANK ORDER CORRELATION TEST RESULTS

		Satisfaction PRE				
		Q1 PRE	Q2 PRE	Q3 PRE	Q4 PRE	Q5 PRE
Q1 PRE	Correlation Coefficient		** 0.623	**0.593	**0.581	**0.627
	Significance level (2-tailed)		0.000	0.000	0.000	0.000
Q2 PRE	Correlation Coefficient	**0.623		**0.353	**0.667	**0.573
	Significance level (2-tailed)	0.000		0.006	0.000	0.000
Q3 PRE	Correlation Coefficient	**0.593	**0.353		*0.304	0.253
	Significance level (2-tailed)	0.000	0.006		0.020	0.055
Q4 PRE	Correlation Coefficient	**0.581	**0.667	*0.304		**0.654
	Significance level (2-tailed)	0.000	0.000	0.020		0.000
Q5 PRE	Correlation Coefficient	**0.627	*0.573	0.253	**0.654	
	Significance level (2-tailed)	0.000	0.000	0.055	0.000	

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

TABLE 29 - SATISFACTION POST - SPEARMAN'S RANK ORDER CORRELATION TEST RESULTS

		Satisfaction POST				
		Q1 POST	Q2 POST	Q3 POST	Q4 POST	Q5 POST
Q1 POST	Correlation Coefficient		** 0.702	**0.607	**0.752	**0.689
	Significance level (2-tailed)		0.000	0.000	0.000	0.000
Q2 POST	Correlation Coefficient	**0.702		**0.545	**0.665	**0.616
	Significance level (2-tailed)	0.000		0.000	0.000	0.000
Q3 POST	Correlation Coefficient	**0.607	**0.545		**0.445	**0.467
	Significance level (2-tailed)	0.000	0.000		0.000	0.000
Q4 POST	Correlation Coefficient	**0.752	**0.665	**0.445		**0.734
	Significance level (2-tailed)	0.000	0.000	0.000		0.000
Q5 POST	Correlation Coefficient	**0.689	**0.616	**0.467	**0.734	
	Significance level (2-tailed)	0.000	0.000	0.000	0.000	

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

The correlation between Q3 PRE and Q5 PRE is the only insignificant correlation in the satisfaction dimension both pre and post treatment. Although this correlation is insignificant, the results are deemed good enough to create aggregated variables. This is based on the fact that all other correlations are significant, most of them at 0.01 level, and that the Q3 PRE - Q5 PRE correlation is close to significant with $p = 0.055$.

TABLE 30 - MOTIVATION PRE - SPEARMAN'S RANK ORDER CORRELATION TEST RESULTS

		Motivation PRE				
		Q6 PRE	Q7 PRE	Q8 PRE	Q9 PRE	Q10 PRE
Q6 PRE	Correlation Coefficient		**0.524	**0.573	**0.749	**0.701
	Significance level (2-tailed)		0.000	0.000	0.000	0.000
Q7 PRE	Correlation Coefficient	**0.524		**0.413	**0.420	**0.356
	Significance level (2-tailed)	0.000		0.001	0.001	0.006
Q8 PRE	Correlation Coefficient	**0.573	**0.413		**0.481	**0.413
	Significance level (2-tailed)	0.000	0.001		0.000	0.001
Q9 PRE	Correlation Coefficient	**0.749	**0.420	**0.481		**0.789
	Significance level (2-tailed)	0.000	0.001	0.000		0.000
Q10 PRE	Correlation Coefficient	**0.701	**0.356	**0.413	**0.789	
	Significance level (2-tailed)	0.000	0.006	0.001	0.000	

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

TABLE 31 - MOTIVATION POST - SPEARMAN'S RANK ORDER CORRELATION TEST RESULTS

		Motivation POST				
		Q6 POST	Q7 POST	Q8 POST	Q9 POST	Q10 POST
Q6 POST	Correlation Coefficient		**0.548	**0.390	**0.790	**0.729
	Significance level (2-tailed)		0.000	0.002	0.000	0.000
Q7 POST	Correlation Coefficient	**0.548		**0.463	**0.529	**0.685
	Significance level (2-tailed)	0.000		0.000	0.000	0.000
Q8 POST	Correlation Coefficient	**0.390	**0.463		**0.453	**0.405
	Significance level (2-tailed)	0.002	0.000		0.000	0.002
Q9 POST	Correlation Coefficient	**0.790	**0.529	**0.453		**0.716
	Significance level (2-tailed)	0.000	0.000	0.000		0.000
Q10 POST	Correlation Coefficient	**0.729	**0.685	**0.405	**0.716	
	Significance level (2-tailed)	0.000	0.000	0.002	0.000	

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

For the motivation dimension all correlations were significant at 0.01 level both for pre and post treatment results, which shows that the data for the motivation dimension pass the Spearman's Rank Order Correlation test.

5.2.3.2 ANALYSIS

Due to the results from Cronbach’s Alpha test and Spearman’s Rank Order Correlation test it was concluded that aggregated variables could be created for the satisfaction and the motivation dimension. Consequently, Satisfaction PRE, Satisfaction POST, Motivation PRE and Motivation POST were computed as the equally weighted average of the answers for the corresponding items. The data for the engagement dimension could not be used to create aggregated variables. Therefore, the difference in answers in this dimension were only significance tested with the per item based non-parametric analysis already presented in 5.2.2 - Wilcoxon Signed-Rank Test. Table 32 displays the descriptive statistics for the four aggregated variables.

TABLE 32 - AGGREGATED VARIABLE DESCRIPTIVE STATISTICS

Aggregated Variable	Mean	Std. Deviation	Std. Error Mean
Satisfaction PRE	4.214	1.212	0.159
Satisfaction POST	4.993	1.119	0.147
Motivation PRE	3.621	1.255	0.165
Motivation POST	4.486	1.234	0.162

To rule whether a parametric or a non-parametric significance test should be utilized for the aggregated variables, a normality test of the results was conducted. The Shapiro-Wilk normality test [46] was applied with the results seen in Table 33. In the Shapiro-Wilk test a significance value above 0.05 means that the data are normally distributed. Results shows that all of the aggregated values were normally distributed, which indicates that a parametric test can be used.

TABLE 33 - SHAPIRO–WILK NORMALITY TEST

ID	Significance	Normally Distributed
Satisfaction PRE	0.749	✓
Satisfaction POST	0.082	✓
Motivation PRE	0.584	✓
Motivation POST	0.328	✓

T-test [47] for dependent samples was utilized as the parametric significance test. The t-test compares the means of data in order to determine significance. The results of the test can be seen in Table 34, which reveals that the difference of the aggregated variables from pre to post treatment were significant at $p < 0.001$ for both dimensions.

TABLE 34 - AGGREGATED VARIABLE T-TEST RESULTS

Aggregated Variable Pair	Mean difference	T-value	P-value (two-tailed)	Significant
Satisfaction PRE – Satisfaction POST	0.779	4.682	0.000	✓
Motivation PRE – Motivation POST	0.866	5.503	0.000	✓

5.3 Qualitative Data Analysis

After the treatment pupils participated in semi-structured interviews conducted by the author. In total, 48 pupils were interviewed, where 14 were from the French course, 12 from the Spanish course and 22 from the geology course. The interviews lasted for about 10 minutes and were conducted in groups. The groups ranged in size from two to five participants. The questions listed in Table 35 were used as a template for the interview sessions.

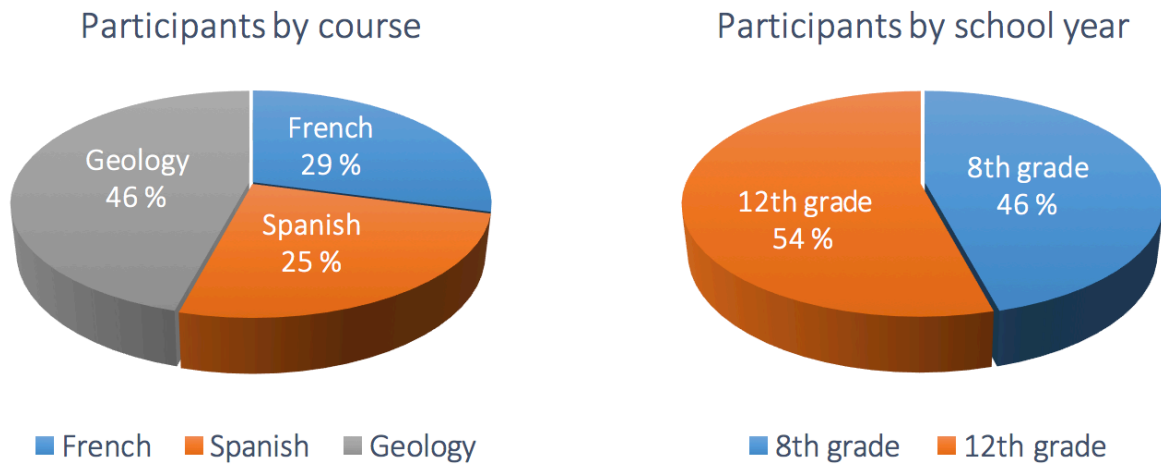


FIGURE 32 - QUALITATIVE PARTICIPANTS STATISTICS

TABLE 35 - INTERVIEW QUESTIONS

Interview Questions
Describe your experience using the application.
In what way did the application affect the course?
What did you think of the tasks?
What are the advantages of using the system?
What are the disadvantages of using the system?
Any suggestion which could improve the application?
How often would you want the application to be used in your courses?
Do you have any last comments?

When describing their experiences using the application, most pupils began by discussing that the application was a new way of learning which they had not previously experienced. They highly appreciated that they were forced to move as this was seen in contrast to a normal session where they sit for a long period of time. Consequently, the pupils acknowledged that information was easier to remember when walking around. It was also stated that the application was engaging and that it gave a sense of wanting to finish all tasks. Ultimately, the pupils generally described the experience as highly rewarding and more fun than their normal teaching sessions.

In response to how the application affected the course, pupils stated that they were more motivated and that they wanted to do things right. It was focused on the fact they did not have to sit passively listening to a teacher lecture and that the application made the pupils more active. As a consequence, it was easier for pupils to discuss and cooperate and that opinions of all the group members were heard. The application forced pupils to work and think for themselves, in addition to the fact that it made them more motivated to participate. It was deemed especially rewarding that the application had included pupils who do not normally participate actively. For the language courses, it was acknowledged that it was challenging for some pupils to complete a few of the tasks as they were not sufficiently skilled in the foreign language. As a consequence, some language course pupils meant that even though the application had functioned well for language courses, it was even better suited for other types of courses. One of the positive effects of utilizing the application for language courses was that it forced pupils to speak the language.

As the author anticipated that the tasks would highly influence the experience of the system, the pupils were asked to comment on them. For the language courses, many of the tasks required the pupils to step out of their comfort zone. Examples of these tasks are singing a song and order food in the school cafeteria in the corresponding foreign language while filming themselves. Especially for groups where the members did not know each other well these types of tasks were experienced as awkward. Additionally, it was declared that the tasks worked well in terms of variation, but for the system to be usable in the long run they should be more theoretical. For the geology course, a different approach with simpler tasks was utilized. At each location, pupils were asked a question where the first letter of the correct answer was a part of a final keyword. The pupils stated that the tasks were fine, but nothing special in either a positive or a negative way. The author assumes that the reasons behind this evaluation were that pupils are familiar with this approach and that it is neither especially challenging nor forces pupils out of their comfort zone.

When asked to specifically state the advantages of utilizing the system pupils responded that it was more fun and that it made them more active compared to normal teaching methods. Furthermore, it was elaborated that the pupils collaborated and became better acquainted. It was deemed positive that pupils were able to learn independently in other locations than the classroom. As a consequence, the session was more memorable and it was easier to remember the curriculum. Additionally, it was declared that pupils were more motivated to learn, more

eager to participate in the session and that it activated those who normally do not participate actively. For language courses it was stated that one does not learn proper grammar with this method, but pupils learn through real-life situation how and when a foreign language can be useful.

As a drawback it was acknowledged that pupils were easily distracted by notifications on their mobile phones and that unwanted use of social media may become a factor if the system was used often. The tasks were also mentioned as a drawback, which has been previously discussed.

For the younger pupils, the element of competition became a factor which influenced the experience. It was clear that the pupils wanted to find the final keyword first, which was rewarding to observe as this must be regarded as an indication that they appreciated the system. Simultaneously, pupils felt frustrated as other groups followed them to find beacons and that it was easy for groups to observe when a beacon was located by another group. This may have influenced the experience of utilizing the mobile application negatively.

During the interviews the pupils were specifically asked how often they would want the application to be used. The answers to this question are of course of a subjective nature, but it gave an indication of how often the pupils would want the application utilized. For the two age groups, the answers varied. For the older pupils in the language courses, a usage of one to two times a month was desired. For the younger pupils the answers ranged from every session in every course to thrice a month.

Towards the end of the semi-structured interviews pupils were given the opportunity to suggest improvements to the application. Firstly, the pupils desired that the process of finding beacons was more challenging. During the experiments, the beacons were shown in the All Beacons View as soon as they were discovered, making them viewable at distances above 20 meters. This made it possible to read the tasks without knowing their exact location. Furthermore, it was requested a way of indicating which tasks one had visited as it was easy to lose track of this. Reasoned by a similar argument, finding a new way of searching for beacons was suggested. Additionally, for future versions it was suggested that one could deliver files and check answers directly in the mobile application. Section 5.4 - Mobile Application Improvements illustrates how this feedback was applied to create a new version of the mobile application.

5.4 Mobile Application Improvements

Adhering to input collected during semi-structured interviews and observations of the mobile application being used, changes have been made to the mobile application. This section presents the changes and the reasons for implementing them.

5.4.1 Main View Improvements

The Main View of the mobile application was previously implemented to display information in line with the nearest beacon. A problem with this approach was that users did not receive indication of how close other beacons were. Additionally, when users are located at approximately the same distance to two or more beacons the view changes frequently, which can negatively affect the user experience. In order to resolve this issue, a way to visualize the distance parameter and create a more interactive view was desired. This was achieved through a radar scanner visualization, with the beacons' distance determining how far from the center of the screen beacons are rendered. The change of the view can be seen in Figure 33. As with the old implementation, the view updates automatically. This means that a beacon is rendered on a new position on the screen on changed distance estimate. Each icon in the radar view is clickable, directing the user directly to the Chosen Beacon View where the content of the beacon is displayed. An additional change made to the view is that visited beacons are now displayed with a green font color. This feature was requested by pupils, to indicate whether a beacon had already been visited or not.

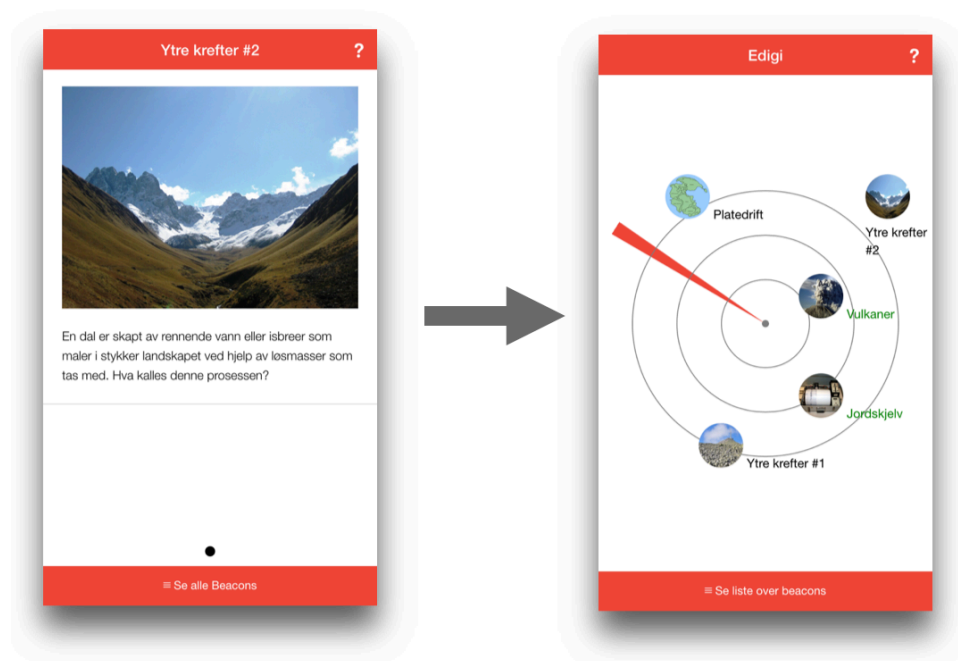


FIGURE 33 - MAIN VIEW IMPROVEMENTS

5.4.2 All Beacons View Improvements

During semi-structured interviews it was expressed by pupils that they found beacons too quickly. Beacons were discovered at a distance of above 20 meters, which made pupils receive tasks without knowing exactly where the beacons were located. Pupils stated that it would be more fun if the search for beacons was more challenging. Adhering to this input, changes shown in Figure 34 were implemented. Beacons with a distance of over ten meters are now blurred and made non-clickable.

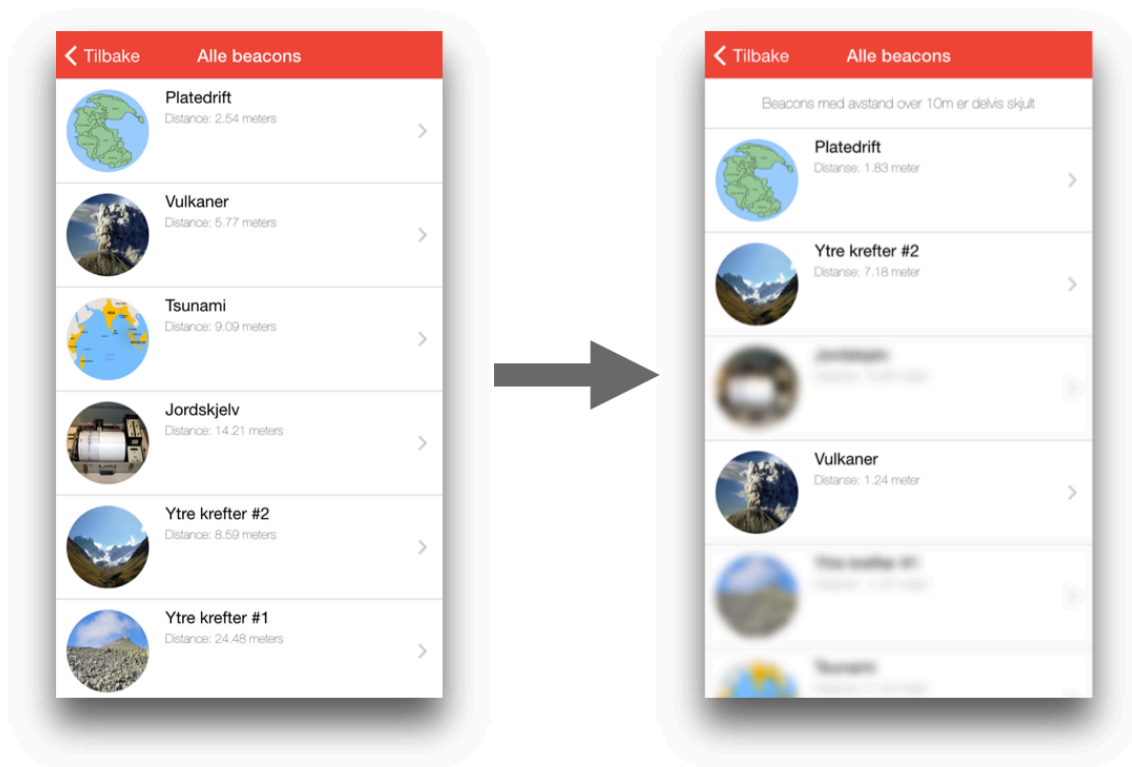


FIGURE 34 - ALL BEACONS VIEW IMPROVEMENTS

5.4.3 Chosen Beacon View Improvements

Adhering to feedback collected during semi-structured interviews, a new functionality of checking answers directly in the application has been implemented. This is suited for area of usages similar to the experiment conducted for the geology course, where pupils were tasked with answering questions at each location. Figure 35 shows the new answer field and answer button at the bottom of the view, where pupils can check their answers immediately. Additionally, the response messages displayed based on the answer being correct or not are also shown. In the web portal, teachers have the option of including this answer field or not. For beacons where teachers do not want pupils to check their answers, or where the field is unsuited for the content, the answer field is not displayed.

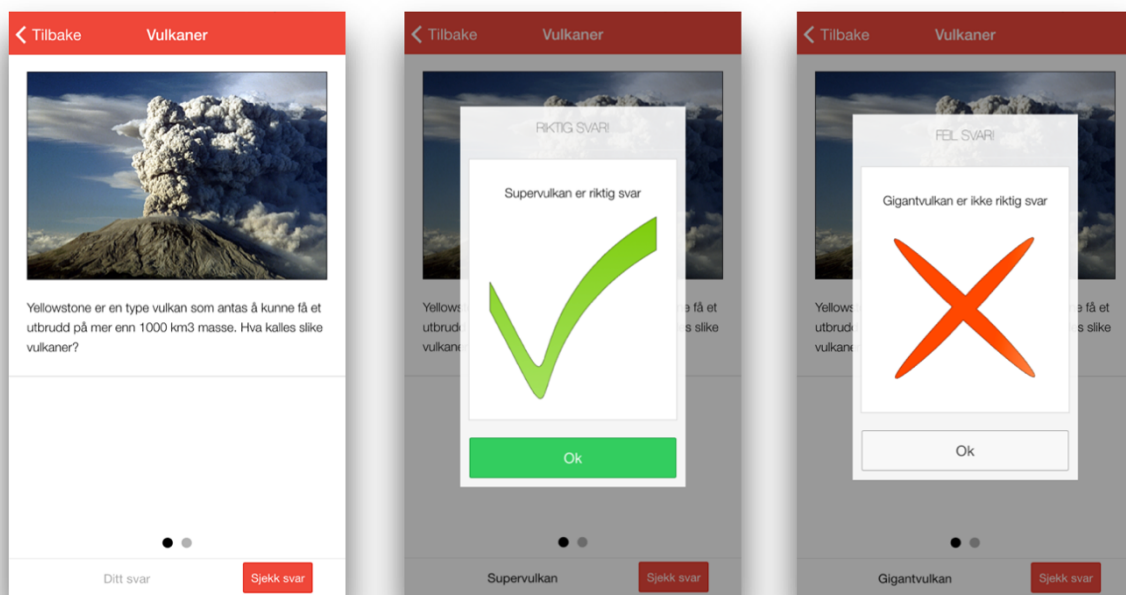


FIGURE 35 - CHOSEN BEACON VIEW IMPROVEMENTS

CHAPTER 6 – DISCUSSION

6.1 Discussion of Results

This research has investigated the use of location-based learning in educational institutions. Experiments have addressed how a location-aware mobile application affects pupils' satisfaction, motivation and engagement. This section discusses the results found for these attitude dimensions. For each of the dimensions, the significance test results are relisted for the convenience of the reader.

6.1.1 Satisfaction

This project has acquired significance positive results in terms of satisfaction. Two aggregated variables, Satisfaction PRE and Satisfaction POST, were constructed and consequently tested with a dependent samples t-test. The results showed a significant positive change at $t(57) = 4.682, p < 0.001$. This result was supported by findings during semi-structured interviews where pupils elaborated on how they had enjoyed the experience. Together, it reveals that pupils found the experience rewarding and that the use of the Edigi system had a positive effect on pupils' satisfaction.

Additionally, a per item based Wilcoxon Signed-Rank test showed significant positive change for four of the five items on the questionnaire. The results shown in Table 36, shows that the four significant changes were statistically significant at $p < 0.001$.

TABLE 36 - SATISFACTION WILCOXON SIGNED-RANK TEST RESULTS

ID	Question	Z-value	P-value (two-tailed)	Significant ($\alpha = 0.05$)
Satisfaction				
Q1	I like this subject.	- 3.778	0.000	✓
Q2	I like the teaching methods utilized in this subject.	- 3.608	0.000	✓
Q3	I am often frustrated when working with this subject.	- 0.724	0.469	✗
Q4	This subject contributes positively to my overall school experience.	- 4.543	0.000	✓
Q5	This subject is more fun than the average of all subjects.	- 4.654	0.000	✓

Interestingly, the difference in results for Q3 (“I am often frustrated when working with this subject. ”) was not significant. During the semi-structured interviews pupils expressed possible reasons for this result. Pupils in the language courses felt that tasks were awkward at times, especially if the members of the group were unfamiliar with each other. Additionally, younger

pupils in the geology course clearly wanted to finish all tasks first and saw the experience as a competition between the groups. They expressed frustration that groups followed each other and that one could easily copy another group’s discovery of a beacon. Finally, distortion of the Bluetooth signal may have been a factor as the estimated distance parameter will never be completely correct [6]. Combined, these three factors may be the reason to why the change in answers to this item did not achieve positive significance.

6.1.2 Motivation

The results acquired during this project show that the application had a significant positive effect on pupils’ motivation. Two constructed aggregated variables, Motivation PRE and Motivation POST, were tested with a dependent samples t-test. The results showed a significant positive change at $t(57) = 5.503, p < 0.001$.

A per item based non-parametric test showed that five out of five items had a significant positive change from pre to post treatment. The results are seen in Table 37. The difference for Q6 (“I find this subject motivating.”), Q9 (“This subject inspires me.”) and Q10 (“I get a boost of energy when working with this subject.”) were all significant at $p < 0.001$. The change for Q7 (“It is important to me to finish all tasks given in this subject.”) was significant at $p < 0.01$, while the difference for Q8 (“I am quickly bored when working with this subject.”) was significant at $p < 0.05$.

TABLE 37 - MOTIVATION WILCOXON SIGNED-RANK TEST RESULTS

ID	Question	Z-value	P-value (two-tailed)	Significant ($\alpha = 0.05$)
Motivation				
Q6	I find this subject motivating.	- 4.273	0.000	✓
Q7	It is important to me to finish all tasks given in this subject.	- 3.368	0.001	✓
Q8	I am quickly bored when working with this subject.	- 2.301	0.021	✓
Q9	This subject inspires me.	- 3.801	0.000	✓
Q10	I get a boost of energy when working with this subject.	- 5.022	0.000	✓

During semi-structured interview the pupils identified the probable reasons for the increase in motivation. It was expressed that the need for movement while simultaneously using new technology made the sessions more memorable and inspiring. Pupils confessed that the system made it easier to cooperate and it made the pupils more active. Furthermore, it was declared that the system activated pupils who normally do not participate actively. Even though some pupils acknowledged that they did not like the tasks, a positive motivational effect is still

acquired. This is an interesting finding as it reveals that the tasks do not have to be especially popular for the system to have an effect. Simultaneously, it is assumed that the motivational effect would increase even more with tasks that were higher rated by pupils.

6.1.3 Engagement

The data for the engagement dimension failed the Cronbach’s Alpha test and Spearman’s Rank Order Correlation test and has therefore only been tested non-parametrically with the Wilcoxon Signed-Rank test in a per item based analysis.

The results of the research have not detected a positive effect for engagement, with only one out of five items achieving a significant positive change. Table 38 shows the results for this dimension. Q11 (“This subject is one of the subjects where I am most active. “) was the only item with a significant positive difference, with $p < 0.01$. Q12 (“I do things I am not supposed to be doing in this subject (e.g. social media).”) is the only statement in the questionnaire that had a negative change from pre to post treatment, although not significant.

TABLE 38 - ENGAGEMENT WILCOXON SIGNED-RANK TEST RESULTS

ID	Question	Z-value	P-value (two-tailed)	Significant ($\alpha = 0.05$)
Q11	This subject is one of the subjects where I am most active.	- 2.904	0.004	✓
Q12	I do things I am not supposed to be doing in this subject (e.g. social media).	- 0.733 ^a	0.464	✗
Q13	I want to participate actively in this subject.	- 0.519	0.603	✗
Q14	I keep my focus when working with this subject.	- 0.918	0.358	✗
Q15	I only do what I have to do in this subject.	- 0.800	0.424	✗

a = Negative change

Figure 36, column 7, reveals an interesting finding regarding Q12 (“I do things I am not supposed to be doing in this subject (e.g. social media).”). The number of pupils who stated that they did not do things they were not supposed to be doing at all were lower for the post answers than the pre answers. This is an indication that the use of the system served as a distraction for those pupils who are usually focused during class. It is assumed that when pupils were using their mobile phones they were easily distracted by notifications from social media such as Facebook and Snapchat. This assumption was supported by pupils confessing to the use of social media during the semi-structured interviews. Additionally, as pupils were aware that their classmates were using their mobile phones, it was possibly even easier to start communicating with each other using mobile technology. The fact that they were distracted by social media also negatively influenced Q14 (“I keep my focus when working with this subject.”).

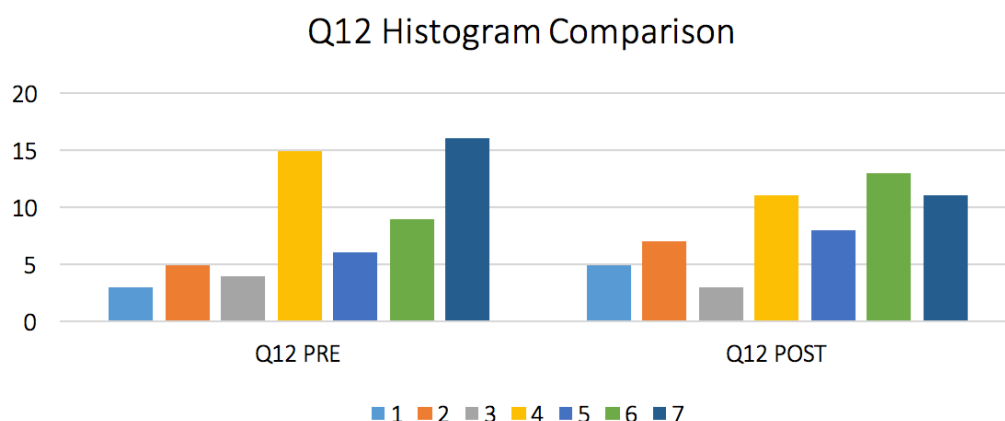


FIGURE 36 - Q12 HISTOGRAM COMPARISON

The change for Q15 (“I only do what I have to do in this subject.”) is not significant. In hindsight, this statement should not have been included as it was not possible for pupils to do extra work during the experiment. Beforehand it was assumed that the tasks would take longer time, which would require that the pupils did extra work in order to complete all tasks. Consequently, pupils would do more than what was required. To better measure this effect, optional tasks should have been included in the experiments.

Summarized, it is declared that the application made the pupils more active (Q11 (“This subject is one of the subjects where I am most active. “)), but it also made the them more vulnerable to distractions (Q12 (“I do things I am not supposed to be doing in this subject (e.g. social media).”) & Q14 (“I keep my focus when working with this subject.”)). The mobile application did not significantly change pupils’ desire to participate in the session (Q13 (“I want to participate actively in this subject.”)).

6.2 Threat to Validity of Results

During this research positive results for the use of a location-aware learning application has been collected. Even though this is gratifying, it is important to discuss the possible limitations of the results.

Firstly, this research has not evaluated the long term effects of using the application. A new and technology based learning method may be rated highly by pupils at first as it makes the learning experience more varied. As a consequence, the positive effect may not be equally high over a longer period of time. Simultaneously, the research has not evaluated the possible positive long term effects of using the application. As an example it could be possible that pupils were more eager to participate in the class if the system had been used frequently.

Secondly, the tasks given to pupils may have influenced the results in a negative or positive manner. As an example, some pupils in the language courses acknowledged that they

experienced the tasks as awkward, which can have negatively influenced the results. As it is assumed that the tasks are a pivotal part of the experience, higher rated tasks may have given better results.

Thirdly, erroneous and careless responding are possible limitations of all questionnaire based researches. As an example, there is a tradition of including both negatively and positively worded questions in questionnaires [59], an approach which has been utilized for this research. This is conducted in order to force the respondents to carefully consider each statement before answering. This approach is debated as it is argued that it leads to confusion, misinterpretation and mistakes by the respondent [59] [60]. Additionally, it is a possible that pupils interpreted the items on the questionnaire differently.

The approach of the research was a time series design, with data collected from the same group pre and post treatment. The time series design experiment achieves weaker results seen in contrast to experiments where both a control group and experimental group are evaluated. The results of the study would have been stronger if the experiment had followed that type of approach.

Finally, semi-structured interviews were utilized to receive feedback on the experience of using the mobile application. The qualitative results acquired are prone to effects of asking leading questions, failure to listen closely and repeating questions. In addition, interpretation of qualitative data may be affected by misunderstandings or by researcher's personal views and skills. Even though an effort has been made to reduce these effects, they constitute a possible limitation.

CHAPTER 7 – CONCLUSION & FURTHER WORK

7.1 Conclusion

This research has investigated possible changes in pupils' attitudes due to the use of a location-aware mobile learning application. Both qualitative and quantitative data collection methods have been utilized. The project was guided by the following research goal:

Goal: How are pupils' attitudes affected by using location to present learning material?

A dependent t-test of aggregated variables showed a significant increase in pupils' satisfaction, $t(57) = 4.682, p < 0.001$, and motivation, $t(57) = 5.503, p < 0.001$. Data collected for the engagement dimension were not statistically suited for an aggregated variable analysis. A per item based analysis of this dimension did not reveal a significant positive change.

The research concluded with acceptance of H1 ("The use of the location-based application has a positive effect on pupils' satisfaction.") and H2 ("The use of the location-based application has a positive effect on pupils' motivation."). H3 ("The use of the location-based application has a positive effect on pupils' engagement.") was rejected.

TABLE 39 - HYPOTHESES ACCEPTANCE

ID	Hypothesis	Accepted
H1	The use of the location-based application has a positive effect on pupils' satisfaction.	✓
H2	The use of the location-based application has a positive effect on pupils' motivation.	✓
H3	The use of the location-based application has a positive effect on pupils' engagement.	✗

7.2 Further Work

For further research the author suggests two possible approaches. Firstly, in order to evaluate the long term effects of using the application, a study over a longer period of time should be conducted. It would be interesting to utilize a true experiment approach with both a control group and an experimental group over a whole school year. That approach would reduce the possible limitation of the mobile application being rated too highly at first just because it is something new that makes the teaching methods more varied.

Secondly, the author would like to suggest to test if pupils learn better using the application. For this research, no data is collected to evaluate the learning outcome of applying location-based learning. As pedagogical theories, such as method of loci [23], values the effect of linking

information to space, it would be intriguing to study if pupils could achieve higher remembrance when utilizing the mobile application due to subconscious mental markers of information at each location.

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APPENDIX A – QUESTIONNAIRE ENGLISH

	<i>Strongly disagree</i>				<i>Strongly agree</i>		
	1	2	3	4	5	6	7
1. I like this subject							
2. I like the teaching methods utilized in this subject							
3. I am often frustrated when working with this subject.							
4. This subject contributes positively to my overall school experience.							
5. This subject is more fun than the average of all subjects.							
6. I find this subject motivating.							
7. It is important to me to finish all tasks given in this subject.							
8. I am quickly bored when working with this subject.							
9. This subject inspires me.							
10. I get a boost of energy when working with this subject.							
11. This subject is one of the subjects where I am most active.							
12. I do things I am not supposed to be doing in this subject (e.g. social media)							
13. I want to participate actively in this subject.							
14. I keep my focus when working with this subject.							
15. I only do what I have to do in this subject.							

APPENDIX B – QUESTIONNAIRE NORWEGIAN

Svært uenig

Svært enig

1 2 3 4 5 6 7

1. Jeg liker dette faget.
2. Jeg liker undervisningsformen i dette faget.
3. Jeg er ofte frustrert i dette faget.
4. Dette faget bidrar til en bedre skolehverdag.
5. Dette faget er morsommere enn gjennomsnittet av andre fag.
6. Jeg synes faget er motiverende.
7. Jeg er opptatt av å fullføre oppgavene i dette faget.
8. Jeg blir fort lei når jeg jobber med dette faget.
9. Dette faget inspirerer meg.
10. Jeg får energi av å jobbe med dette faget.
11. Dette faget er et av de fagene jeg er mest aktiv i.
12. Jeg gjør ting jeg ikke skal i dette faget (f.eks. sosial medier).
13. Jeg ønsker å delta aktivt i dette faget.
14. Jeg holder fokus mens jeg jobber med dette faget.
15. Jeg gjør kun det jeg må i dette faget.

APPENDIX C – INTERVIEW GUIDE

1. Describe your experience using the application
2. In what way did the application affect the course?
3. What did you think of the tasks?
4. What are the advantages of using the system?
5. What are the disadvantages of using the system?
6. Any suggestion which would improve the application?
7. How often would you want the application to be used in your courses?
8. Do you have any last comments?