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DESIGNING AN ADVANCED EDUCATIONAL
PLATFORM USING CO-CREATION AND
GAMIFICATION

THE USE CASE OF CREATING AN USER FRIENDLY TOOL
FOR EDUCATORS



MSC MEDIALOGY MASTER THESIS

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ABSTRACT

The thesis revolves around designing and developing an educational platform to help both educators and students with the learning process. The purpose of the thesis is to increase educator's interest towards using more technology in the classroom and make learning more engaging for students. Specifically, the system aims to motivate the usage of games in the classroom as either a learning activity or an evaluation tool. The thesis will look at four methods for achieving this: through co-creation, gamification, multimodality, and the STEAM framework. An architecture of the overall educational platform will be presented together with a conceptual map of the system's design. The system is narrowed down to a proof of concept, which will be implemented and evaluated by qualified educators and by students. The results show that the overall architecture was welcomed by both the educators and students. The educators also responded that this approach would be successful with their younger students. Overall, the results gathered corroborate with the theoretical aspects researched, therefore it is possible to assume that the system is capable of impacting the educational scene and help educators decrease workload when working with daily quizzes.

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Thank you,
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CONTENTS

Abbreviations [vii](#)

1	INTRODUCTION	1
2	INVESTIGATION	3
2.1	Introduction	3
2.2	Keywords	3
2.2.1	Co-Creation	3
2.2.2	STEAM	4
2.2.3	Gamification	4
2.2.4	Multimodal	5
2.2.5	Budget	5
2.3	State of the Art	5
2.3.1	STEAM	5
2.3.1.1	Space Chef	5
2.3.1.2	Motion Math	6
2.3.1.3	Angry Birds and World of Goo	7
2.3.2	Multimodal	7
2.3.2.1	i>clicker	7
2.3.2.2	ConcertStudeo	7
2.3.3	Gamification	8
2.3.3.1	Kahoot	8
2.3.3.2	Duolingo	8
2.3.4	Co-Creation	9
2.3.4.1	Collaborative Problem Solving Game	9
2.3.4.2	EngAGe Assessment Tool	10
2.3.5	Sub-Conclusion	12
2.4	Education	13
2.4.1	Games in Education	13
2.4.2	Personalized Learning	17
2.4.3	Motivation	18
2.5	Technology	19
2.5.1	Multimodal Systems	19
2.5.1.1	Examples of multimodality	20
2.5.2	Mobile Technology	21
2.5.3	Open Architecture	23
2.6	A Survey regarding Educational Games	24
2.7	Conclusion	25
3	DESIGN	29
3.1	Introduction	29
3.2	Interface Design	29
3.3	User Experience	30

3.4	Learning Design	32
3.5	Game Design	33
3.6	Application	36
3.6.1	Architecture	36
3.6.2	Graphical User Interface	39
3.6.2.1	Interface Survey	42
3.6.2.2	User Interface Design	43
3.6.2.3	Educator Templates	48
3.6.3	Game Genre	51
3.6.3.1	Platformer	51
3.6.3.2	Adventure	52
3.6.3.3	Puzzle	53
3.6.3.4	Story	54
3.7	Conclusion	54
4	PROOF OF CONCEPT	55
4.1	Educator	56
4.2	Game	58
4.2.1	Game Rules	58
4.3	Conclusion	60
5	IMPLEMENTATION	63
5.1	Introduction	63
5.2	Application	63
5.2.1	Game	69
5.3	Conclusion	72
6	EVALUATION	73
6.1	Target group	74
6.2	Testing Methods	75
6.2.1	Test Scenario	76
6.3	Evaluation Results	77
6.3.1	Questionnaires	77
6.3.1.1	Educators	79
6.3.1.2	Students	80
6.3.2	Interviews and Observations	81
6.3.2.1	Feedback	82
6.4	Literature Comparison	84
6.4.1	User Friendly Interface	84
6.4.2	Assessment and Quizzes	85
6.4.3	Systems Comparisons	86
6.5	Conclusion	87
7	DISCUSSION	89
7.1	Future Aspects	91
7.1.1	Game Personalization	91
7.1.2	Connect Students to Educators	92
7.1.3	Live Results Updating	93
7.1.4	Open Architecture	93

8	CONCLUSION	95
	BIBLIOGRAPHY	97
	Appendix A OVERALL APPLICATION	105
	Appendix B TEST	107
	B.1 Educators	107
	B.2 Students	109

ABBREVIATIONS

PDA	Personal Digital Assistant
STEM	Science, Technology, Engineering & Mathematics
STEAM	Science, Technology, Engineering, Art & Mathematics
SRS	Student Response System
DGBL	Digital Game Based Learning
COTS	Commercial off-the-shelf
VR	Virtual Reality
AR	Augmented Reality
SG	Serious Games
GUI	Graphical User Interface
HCI	Human-Computer Interaction
API	Application Programming Interface
FTP	File Transfer Protocol
OAP	Open Architecture Product
OEM	Original Equipment Manufacture

1

INTRODUCTION

Technology is increasingly changing the way people go through their daily lives. Before technology impacted people's lives, students learned from memorizing information, direct instruction from educators and through completing traditional testing. Technology has, however, started to affect young learners and students both in the educational environment and in their daily lives through the constant use of technology. Currently, technology has reached so far as to affect the educational scene in the classroom through the usage of instructional tools as projected PowerPoint slides and Smartboards. However, one must ask themselves, how can we go further to use technology to improve the educational environment? How can we make learning more engaging for the new generation of students? And how can we help educators in this process?

An approach at improving the teaching methods is by putting focus on interaction achieved through technology. Various educational applications use interaction and gamification to engage students, some of these examples are Kahoot, Motion Math, Duolingo, etc. However, can these applications be easily used in the educational environment and is the educator able to understand and use these without training? The motivation of this thesis is to provide useful and user friendly help to educators in the process of adding technology and improve learning by engaging students through the usage of games as learning activities in the classroom.

The motivation can be divided into five keywords which characterize the goal of the thesis: *gamification*, *co-creation*, *STEAM*, *multimodal* and *budget*. Gamification is considered as an approach to engage students, co-creation representing the main approach at achieving personalized learning, by involving educators in the game creating process. The STEAM framework will be used as theoretical guidance for the system together with the multimodal aspects which can be considered. Since multimodal interfaces can be expensive to implement in educational environments such as classrooms, budget is considered as a keyword. By considering the budget, it will be possible to the decide on the technical tools to approach for schools, without schools and educational institutions requiring economical sacrifices to involve technology.

These keywords define and guide the thesis so that the design and implementation consider these aspects thoroughly, towards achieving the goal. The goal of the thesis is to design a system for personalized learning which uses co-creation, gamification and multimodal inputs and create an application where teachers can use personalized learning to adapt the lectures and knowledge to students, through gamification. The thesis is divided into two main points: designing this educational system and delimiting this system to a proof of concept which is implemented as a tablet application.

This educational system not only offers students the possibility of developing a heightened awareness of technology and be more open and understanding of the fast-paced advancing technology, but also aims to engage the learners in proactive interactive learning activities in class or at home. In order to delimit the system to the components requiring focus to be implemented and evaluated, the research gathered in investigation was used. The current state of research showed that there are existing learning applications which consider using gamification to improve learning, however,

the focus is mostly placed on making the learning process easier for students while educators being neglected. Therefore, when deciding on the aspects of the full educational system that will be represented in the proof of concept, the functionalities relevant to the educator were chosen. In the past, systems and games had been considered as addition to the lecture environment, however research proved that drawbacks of this approach had always been the lack of time for training educators in technology. However, since then, technology has spread and impacted people's lives in many ways leading to educators being aware, if not knowledgeable, of technology, thus making it easier to introduce technology to them nowadays. Therefore, the proof of concept approaches functionalities which improve the assessment process for the evaluator, give opportunities to make educators more productive and offers a simple and user friendly interface. This application is evaluated by qualified educators and students who will give feedback and information regarding the full system and the working functionalities of the application.

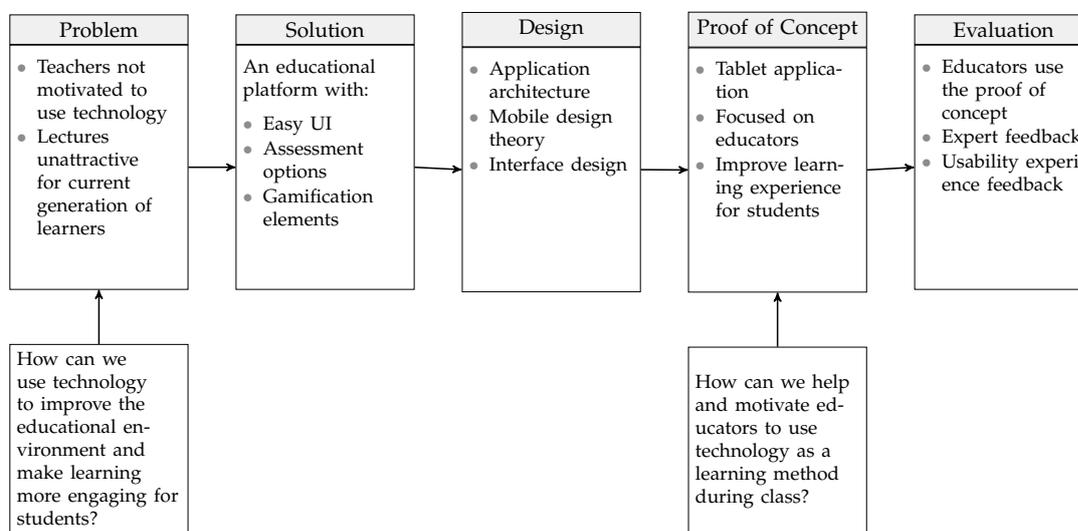


Figure 1: Research approach for developing an educational tool for personalized learning using gamification and co creation.

Figure 1 shows an overview of the five stages of the project. The Investigation will go in depth with the problem at hand and validate the problem, next a solution will be defined in a set of design requirements. This will lead towards the Design chapter, where an architecture will be created for the application. The proof of concept will be presented and implemented further on in the Implementation chapter where the application and the game was developed. Lastly, the Evaluation chapter, where the proof of concept was evaluated, will be presented and discussed.

2 | INVESTIGATION

2.1 INTRODUCTION

This chapter will give a short overview of the main keywords that will be considered within this project, such as; the budget, co-creation aspects, gamification the STEAM framework and multimodality. These keywords will be the guiding aspects of the project.

The topics required to be investigated will be shortly presented, the first topic being the *State of the Art* section which presents various systems that put focus on the keywords introduced. This is of interest to the research within this project as knowledge regarding the advantages and disadvantages of created gamified educational systems is crucial to the design and implementation of the system. The next sections will give an in depth description on the keywords presented at the start of this chapter, the research will be connected to topics such as *Education* and *Technology*. Relevant theories regarding Education, such as *Games in Education*, *Personalized Learning* and *Motivation* are investigated. The first topic is considered in order to get an insight on the current research on educational system's regards towards games and technology as a learning approach. As Personalized Learning is another approach that can be adapted when working with education, the term will be investigated and presented in this chapter. Furthermore, Motivation is investigated in order to understand and learn about what thrives people which will be of use when designing and creating a system to motivate students and educators to use technology in the educational environment. As technology can be widely represented in education, *Mobile Technology*, *Multimodal Systems* and *Open architecture* are investigated. This is made possible in order to learn whether mobile technology in learning is an approach to be considered towards creating the system and to learn how multimodal systems can be used in this situation. Open architecture was chosen as a research topic since the idea of supporting and expanding systems according to user's personal needs is a topic to be considered for this educational platform. The chapter will end with a short survey conducted to gather contemporary information on school's budget situations and usage of gamification in lectures.

2.2 KEYWORDS

The goal is to create an inexpensive platform for teachers and schools to use during lectures, in order to motivate schools to use various technology for educating students, therefore this section will present the keywords that will be used as guiding points for the system within this project.

2.2.1 Co-Creation

An aspect of the goal within this research is to help teachers better engage and motivate the students to learn and we believe that a good approach to this is by using co-creation.

Within a marketing aspect, co-creation is a form of creative collaboration which allows customers to be part of the designing and idea gathering process of the product. With the help of this type of information, the designers can create products which are valued higher by the consumers. Co-creation can be represented by involving customers in generating ideas to improve products, co-design of products, providing internet communities and by using user-generated content [LSE Enterprise, 2009]. By applying co-creation in an educational aspect, students should be involved in the presentation and investigation of the learning topic provided by the teacher. However, co-creation can also be achieved by involving the educators in the development of the system so that it achieves the desired functionalities and bring more support to the usage of technology in schools. Therefore, the application should focus on meeting the needs and interests of both the teacher and students, by involving the teachers in the implementation of the lecture and thus enhancing the students' abilities within the topic.

2.2.2 STEAM

STEAM is a further development of the STEM educational concept. STEAM is an abbreviation of Science, Technology, Engineering, Art and Mathematics. Where STEAM has an A for Art, the original concept of STEM does not contain Art, but the defining aspect of the framework are the same [STEAM Education, 2015]. STEM and STEAM are broad definitions of how education should be approached with any specific defining points. There are six defining parts of STEM which should be taken in consideration when creating a STEAM lesson [Jolly, 2014a].

- Focus on real world problems.
- Lessons should use an engineering design process.
- Focus on hands on learning.
- Focus on teamwork.
- Apply math and science content to problems.
- Allow for multiple right answers and do not focus on failure.

These aspects can be applied using a co-creative approach, by using creative planning where a brainstorm is done artistically or by designing the solution with the students before applying it [Jolly, 2014b]. Educational games can teach students problem solving, goals, rules and motivation. An approach to motivating students and applying a STEAM framework can be gamification.

2.2.3 Gamification

When thinking of gamification, the usage of game design and game elements within various interactive contexts comes to mind [Huotari and Hamari, 2012]. This sort of process can be implemented in an educational context and could aim to provide a good understanding of the educational topic at hand while also keeping the students focused and motivated. Therefore, based on this information, this paper aims to create an application that will follow simple game design rules that cut through distractions and combine entertainment with education to teach and engage students.

2.2.4 Multimodal

Creating multimodal interfaces for mobile devices and application has become increasingly popular [Caschera et al., 2013]. When using new modalities in conjunction with a mobile application it is possible to get a much more realistic feel of inputs. Input methods such as speech recognition, gestures and facial expressions can greatly help with making the application feel more fun, natural and intuitive [Christopoulos and Gaitatzes, 2009]. Some input models might not be ideal for every scenario, such as speech recognition in a crowded and noisy classroom or virtual reality in a low budget context, however it would be ideal to implement a fitting multimodal approach.

2.2.5 Budget

Educators and schools should not fear that the technology could require a high budget or high expertise with either the platform or technology that would be offered. The budget, however depends on the expectation that schools provide PDA and tablets to students to use in class and are able to run the educational application.

2.3 STATE OF THE ART

The state of the art section will first introduce a few applications that specifically uses STEAM to educate users, then describe specific devices and apps used in the classroom. These application use different concepts such as gamification, co-Creation and multimodality to improve their systems. The section will end with a table showing an overview of the different application's advantages and disadvantages.

2.3.1 STEAM

As mentioned earlier STEAM is a collaboration of Science, Technology, Engineering, Art and Mathematics. Combining these in a cross disciplinary teaching method can be done as shown on the "How To Smile" website [University of California, 2015]. There, teachers can find examples of how STEAM has been implemented in the classroom. Examples include mobile applications that teach how to eat healthy and nutritious, presentations about climate changes or demonstrations of how chemistry works [University of California, 2015]. "How To Smile" is not the only website of its kind. Websites like "Education Closet" [EducationCloset, 2015] has a collection of different resources for creating a STEAM education. These resources help teachers better create a STEAM lesson and education for students.

2.3.1.1 *Space Chef*

Space Chef is an educational STEAM game aimed at young students, to learn about healthy food combinations.

The game does not use all the aspects of STEAM but focuses on the Science, Art and Mathematics. The game is simple, you swipe ingredients on to the correct track and the Space Chef eats it. Although the idea is simple, the purpose of the game is hard to understand. It is supposed to teach recipes and eating healthy but all you receive are a

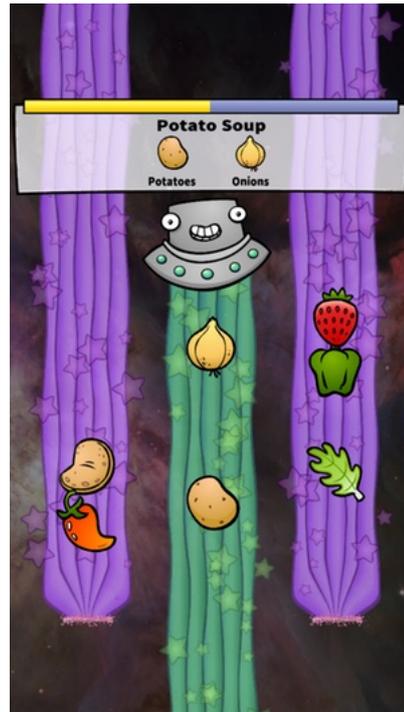


Figure 2: Space Chef iOS game.

few core ingredients and the game is fast paced and hard to understand what recipes you are trying to make.

2.3.1.2 *Motion Math*

Motion Math [Motion Math, 2016] is a series of mobile games that aim to teach different aspects of mathematics. These are simple games where addition and subtraction are the main focus, here students control a fish that needs to get the correct numbers by eating bubbles. Each bubble as seen in Figure 3 either adds or subtracts numbers from the fish until the target number is reached.

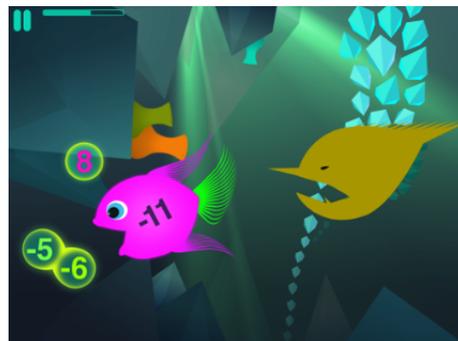


Figure 3: Example of the game Motion Math using addition and subtraction [Motion Math, 2016].

Other games are using more complex mathematics concepts where students need to work with fractions or estimate percentages. In most of these games, the students need to reach a target number but using a combination of different math concepts. Other forms of gameplay is to estimate the curve of a slingshot in order to hit a goal.

2.3.1.3 *Angry Birds and World of Goo*

The two previous games mentioned are made specifically for educational purposes. When looking at games made for the masses and not for education, both Angry Birds [Rovio, 2016] and World of Goo [2D BOY, 2015] are using STEAM principles in their core gameplay. Both games are incorporating all aspects of STEAM and also encouraging cooperative play and problem solving. STEAM is a broad definition and when designing creative games that use theories like iterative thinking, problem solving and free form building, STEAM is almost certainly going to play a role with or without the knowledge of the designer.

2.3.2 Multimodal

As mentioned earlier multimodal interfaces are becoming more and more popular [Caschera et al., 2013]. In the following sections two Student Response Systems (SRS) will be presented as way of bringing multimodal input systems in to the classroom.

2.3.2.1 *i>clicker*

The i>clicker is one way of having a multimodal input system in the class room. The idea behind the system is to avoid manually correcting quizzes and exams and instead have an automated real-time system to grade and correct assignments. In order to use this system, each student has to purchase a physical i>clicker remote that contains five answer buttons (a through e). Each remote has an unique identification number that is recorded by the professor and when a student answers a question, the software records it. This reduces the need for paper quizzes and exams and the time a professor needs to correct quizzes and exams. The i>clicker is widely adopted as one of the best SRSs to use in classrooms across the US and used by more than 2 million students [i>clicker, 2016]. It has also shown that using SRS, especially the i>clicker, in the classroom, it will positively impact students learning and on average receive higher grades [Whitehead and L. Ray, 2009].

2.3.2.2 *ConcertStudeo*

ConcertStudeo is a multimodal platform which provides tools for teacher-student interaction, such as quiz creation, voting, ranking and brainstorming. This platform was implemented by Peter Dawabi, Martin Wessner and Erich Neuhold at Fraunhofer Integrated Publication and Information Systems Institute (IPSI) in 2003 in Darmstadt, Germany. The platform consists of an electronic SMART board, a PC and PDAs provided to the students. The electronic board runs the software on the PC, this part of the platform is mainly used by the teacher, while students use the Pocket PCs Toshiba e740. The board implements the functionalities of the internet browser *Internet Explorer* and allows the teacher to show HTML files and powerpoint slides [Peter Dawabi et al., 2003].

The teacher can also display an interactive quiz with an animated question which displays the results underneath. The results are given by the students who are voting the answer on the PDAs and sends them to the SMART board. In Figure 4, it is possible to see the brainstorm process provided by ConcertStudeo, where the background image represents the SMART board with words which students could provide either by using text or multiple choice selection [Peter Dawabi et al., 2003].



Figure 4: PDA pocket that students hold can be seen in the left corner, while the board in the background.

2.3.3 Gamification

As mentioned, gamification can be approached in many different ways as gamification is defined as the usage of game elements in interactive contexts. Some of these elements can be achievements, rules, rewards, etc. and can work towards promoting learning and can be presented as a form of active learning. This section will describe two applications which use game elements to incentivize students and learners.

2.3.3.1 Kahoot

Kahoot is another educational system which focuses on motivating students to learn and remain engaged during lectures and allowing them to use technology such as PDAs and tablets during lectures. It is a digital application which allows the teachers to gamify their lectures through quizzes and discussions for the class. In order to be able to use Kahoot for their lecture, teachers need to create an account on www.getKahoot.com, however students can access these quizzes without having an account, from any device that can access the internet. Kahoot allows teachers to use various methods for their quizzes, such as videos, pictures and music, this is achieved simply by dragging and dropping function for picture or by selecting to choose the files (see Figure 5). Teachers can also choose a specific time limit on the video to be shown to the students. Once the question is written, it is required to also add the results the students can choose from and is also able to choose how much time each question will be shown for and how many points each question is worth.

This application allows the teacher to apply a different teaching method and also gives teachers the possibility to control the pace of the quiz, the points that can be achieved and motivate the students by showing the “winner” at the end of the quiz.

2.3.3.2 Duolingo

Another mobile applications who aims to educate and motivate is Duolingo, which provides lessons for each language, with both listening and speaking and allows the user to directly see the improvement they made by showing correct and wrong answers, and such motivating them to keep on learning [Vesselinov and Grego, 2012]. Duolingo also allows researchers to extract time of use for specific users and what their different activities involved when using the application, such as lessons and translations. Therefore, allowing researchers and educators to get information on the usage of the application. Another way the application motivates users is by using game design rules and gamification and showing users how many days they have spent on learning a language

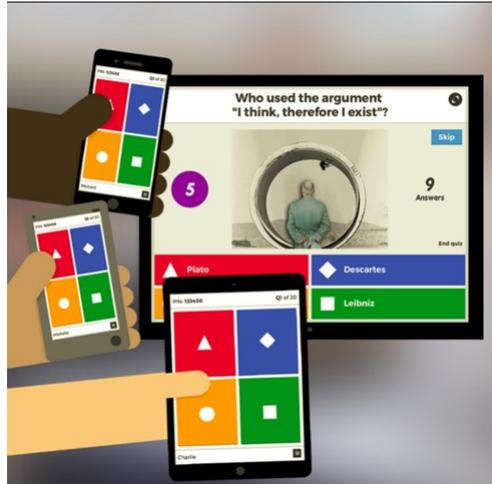


Figure 5: Kahoot! quiz on website and the application in use on the PDAs.

and forces users to pay more attention due to the limit of answers they can give, represented by hearts. Once the hearts run out, the user must start over with the challenge (see Figure 6).

2.3.4 Co-Creation

The co-creation process involves the user, learner or educator in this case, in the goal of achieving, a specific task. Co-Creation can be present in different aspects, so that the user can give feedback towards the designing and implementation of a product or can be the ones to edit the product to fit their needs. The following section will give two examples of educational approaches that involve educators as co-creators.

2.3.4.1 Collaborative Problem Solving Game

Researchers have also implemented big educational systems for low grade students to motivate them to learn. R. Al-Washmi, M. Baines, S. Organ, G. Hopkins and P. Blanchfield designed and implemented an educational game to teach mathematics to children aged between 7 and 9 years old. Al-Washmi et al. combine collaborative game elements with mathematics to teach problem solving in a fantasy/adventure genre game. The focus of their game being collaboration as a teaching method and therefore implementing multi-player aspects to allow exchange of views between the students. Their goal was

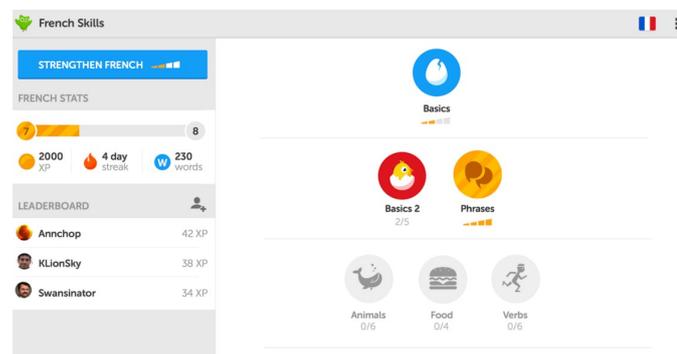


Figure 6: Gamified aspect of learning french in DuoLingo.

to incorporate fun into learning to make educational games more engaging and allow teachers to tailor the games to a specific group of learners.

The researchers used the input of a teacher working at a junior school to decide what the focus of the game should be, therefore two levels were created, one focusing on the number square and the other on various mathematical calculations. Both levels require the students to collaborate in order to reach to the right result. The two levels can be seen in Figure 7 and Figure 8. The first level requires the children to collect bugs from a spider web by taking turns and moving on the web to the right number. The second level is based on the number square problem and uses stepping stones to represent the numbers required to complete the number square. Players choose the number using the handle and select and place the number on the stone when they believe they have chosen the right one. This situation also requires the students to take turns with picking out numbers and allows them to discuss their choices with one another. [Al-Washmi et al., 2015].

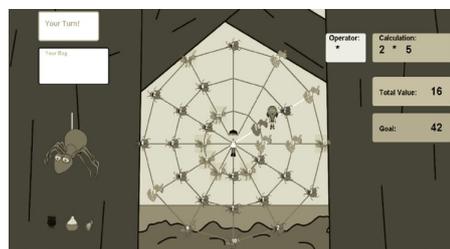


Figure 7: First level of the collaborative game, spider web level.



Figure 8: Second level of the collaborative game, stepping stone level.

Through the testing process of the presented game, the researchers have concluded that teachers should be allowed to tailor the level of difficulty of the game and were then given access to the game settings menu which included options for specifying the age of the players. Therefore, the game could be made simple for 5-7 years old and more challenging for children aged between 9 and 11 years. The teachers could also limit the operators to be used within both levels, for example only allowing addition in the spider web level. They can also define the amount of rows and columns to be used within the stepping stone game and other similar changes within the game [Al-Washmi et al., 2015].

2.3.4.2 EngAGe Assessment Tool

Researchers also put more focus on assessment as learning process in educational games and Yaëlle Chaudy, Thomas M. Connolly, Thomas Hainey researched into the EngAGe assessment engine, which is a link between educational games and developers and educators and allows both the developers and teachers to contribute to the serious games implemented for usage in class as a learning tool. A serious game's (SG) goal

is to educate using games technology and entertainment, while assessment can be defined as the usage of data gathered from student learning to improve and refine study programs. Assessment is therefore used to check whether teachers achieved their goal to teach the students and gives the student an idea of their learning progress. This tool allows the assessment separation from the game mechanics and does not require developers to spend time on implementing and thinking the assessment process through. EngAGE is represented by a domain specific language (DSL) and a set of web services to analyze the DSL and perform assessment. A DSL has its own set of rules and semantics and the DSL created for EngAGE implements educational concepts such as Learning Analytics¹, feedback and assessment [Chaudy et al., 2014].

```

Evidence-model
associate-CountryCapital ( String country, String capital )
  european-capitals -> +1
  UK, London
  Italy, Rome
  Spain, Madrid
  France, Paris
End
  european-capitals -> +2
  Norway, Oslo
  Sweden, Stockholm
  Greece, Athens
  Hungary, Budapest
End
  european-capitals -> -1
  others
End
When
  any(+) : correctMatch
  any(-) : wrongMatch
End
End

```

Figure 9: Configuration file excerpt of actions.

The engine works in the way that the developer needs to define the configuration file which is independent from the game. The configuration file contains information about the name and description of the game, learning outcomes, feedback information, logic of the assessment and the points calculations. The latter can be seen in an excerpt from the configuration file in Figure 9, this excerpt represents how the developer defines the assessment and shows which actions are meaningful. Once the configuration file is completed, the web services are used to process a specific communication protocol to perform the assessment of the games and allows the developer to implement the game using this data. EngAGE also offers a simplified web interface for teachers to manage their created files and students and allowing them to visualize all the data collected from students playing their games. Learning analytics are also provided in this area, the analytics are gathered according to demographics data added to the configuration file. Such aspect can allow the teacher to see whether a part of the implemented game is too difficult if the majority of the students got it wrong or too easy. The end goal of the EngAGE tool is to hide the configuration file behind a visual programming language making it easier for teachers to edit these types of information which can be used within the games implemented. Therefore the goal of separating the assessment from the game mechanics is to support learning analytics. [Chaudy et al., 2014].

¹ "Learning analytics is an emerging field in which sophisticated analytic tools are used to improve learning and education" [Elias, 2011].

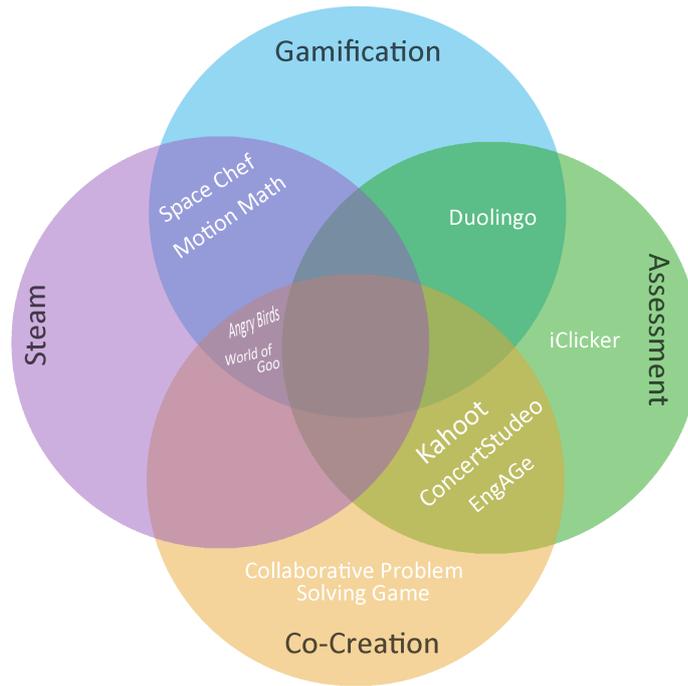


Figure 10: A representation of all the State of the Art examples with keyword category

2.3.5 Sub-Conclusion

After looking at the ten different applications and devices that all use different theories within educational aspects, these applications are categorized using the STEAM framework, Co-creation, Gamification and Assessment terms and are displayed in Figure 10. These terms are chosen since these play an important role in the creation of educational systems and by giving attention to these terms it is possible to motivate both students and educators in the learning process, therefore this paper will aim to create an application which will have as theories all four terms.

As seen in Figure 10, most applications and devices only use two of the theories, however, popular games such as Angry Birds and World of Goo could potentially fall under three of the categories. Although both of those games are not specially made for education, they offer a lot of educational aspects but lack an important feature of assessment, which then renders them unfitting. Therefore it is important to develop a game that contains all four aspects. Table 1 goes in depth with the advantages and disadvantages of each system presented to get an overview of all the systems and use these points as guidance or inspiration for the application created in this paper. The advantages point out how the mentioned theories are used in each application and the disadvantages put focus on the important features each system is lacking. Therefore, these advantages and disadvantages help direct the project towards the full design of the system and put focus on the points relevant to the system that will be implemented within this research.

	Advantages	Disadvantages
Space Chef	<ul style="list-style-type: none"> ✓Uses STEAM framework to teach healthy eating ✓Gamified 	<ul style="list-style-type: none"> ✗Hard to understand ✗Does not involve teachers ✗Does not have assessment functionality
Motion Math	<ul style="list-style-type: none"> ✓Teaches addition and subtraction ✓Gamified and uses STEAM framework 	<ul style="list-style-type: none"> ✗Does not involve teachers ✗Limited target group
Angry Birds World of Goo	<ul style="list-style-type: none"> ✓Uses STEAM principles ✓Gamified 	<ul style="list-style-type: none"> ✗Don't teach specific educational topics
i>clicker	<ul style="list-style-type: none"> ✓Multimodality ✓Reduces assessment time for teachers ✓Can be used in classroom 	<ul style="list-style-type: none"> ✗Limited functionality ✗No gamification
ConcertStudeo	<ul style="list-style-type: none"> ✓Allows students to vote answers in the classroom ✓Makes quiz process easier for teachers 	<ul style="list-style-type: none"> ✗No gamification
Kahoot	<ul style="list-style-type: none"> ✓Gamified quizzes and lecture ✓Teachers can add points, time limit, pictures and videos to quizzes ✓Shows "winner" at the end of the quiz and motivates students 	<ul style="list-style-type: none"> ✗Limited to quiz types
DuoLingo	<ul style="list-style-type: none"> ✓Both listening and speaking ✓Gives representation of user's improvement / Motivates users to learn ✓Gamified aspects (Lives restricting answer limit, time spent, achievements) 	<ul style="list-style-type: none"> ✗Does not involve the teachers ✗Assessment is done by the system not the teacher
Collaborative problem solving game	<ul style="list-style-type: none"> ✓Multiplayer aspect ✓Gamified learning process ✓Allows teachers to edit the game 	<ul style="list-style-type: none"> ✗No proper assessment ✗Only for mathematics
EngAGE	<ul style="list-style-type: none"> ✓Makes assessing process easier for teachers ✓Provides learning analytics to teachers 	<ul style="list-style-type: none"> ✗Lack of gamification ✗Requires teachers to know coding language

Table 1: Table of advantages and disadvantages for State of the Art systems

2.4 EDUCATION

This section represents one of the two main terms within this study: Education and Technology, as improving education represents an important aspect of the goal. Therefore, games in relation to education are investigated, which will be followed by aspects of Personalized Learning. This topic is investigated as Personalized Learning has the potential of impacting the learner and learning environment. Motivation was chosen as a topic to investigate, since the goal involves both motivating educators to apply technology and motivating students to learn.

2.4.1 Games in Education

According to Marc Prensky, an instructional game designer and author of the book "*Digital Game-Based Learning*", students are having a harder time learning using the old educational system since the introduction of games and new technology [Prensky, 2001]. In his book, Prensky explains that students require interactivity in this generation, in

order to engage the learners, however, he also points out that this strategy might not be best for all learning situations and therefore books should not be replaced. Prensky believes that appealing visuals are necessary to sustain attention, however they are not necessary in a situation where the goal is to teach and learn. [Prensky, 2001].

In a learning environment what games require the most is feedback and Prensky argues that games or e-learning should not necessarily replace the teachers, since teachers play an important role of whether the students understood the issue and can reflect on problems and conflicts, since games are good at making an interactive situation however not good at making you reflect or give answers to your questions. Based on this information, perhaps it is an important aspect to add “*reflection*” as a design rule and force students/players to reflect by posing the questions for themselves or leading them to these questions. What motivates people to learn? Self-motivation through the content, people who want to know about a specific subject will start learning and people who enjoy learning in general will feel motivated to learn. However, not everybody enjoys learning and is self-motivated to learn. For students, fear of a low grade can motivate them to study harder and not return home with a bad report card, however fear causes stress. There are four other important motivators that would not prove to have consequences such as fear, these are:

- Ego-gratification
- Winning
- Pleasure
- Fun [Prensky, 2001]

What does a game offer differently than a book or a movie? Interaction and socialization. Many scientists believe that playing is interconnected with learning, Robert Fagan defines playing as “*optimal generic learning by experimentation in a relaxed field*” while Diane Ackerman defines it as “*play is our brain’s favourite way of learning things*” [Prensky, 2001, chapter 5]. In order to make learning easier, it should involve playing and fun, and one way to combine these is to implement them into a game. However one must ask what makes games engaging? What rules must be followed to design fun games? Prensky believes there are 12 elements that makes games engaging:

1. Games are a form of fun which gives enjoyment and pleasure
2. Games are form of play which gives intense and passionate involvement
3. Games have rules to give structure
4. Games have goals which gives motivation
5. Games are interactive which lets us do
6. Games are adaptive which gives flow
7. Games have outcomes and feedback which promotes learning
8. Games have win states which gives ego gratification
9. Games have conflict / competition / challenge / opposition which gives us adrenaline
10. Games have problem solving to spark creativity
11. Games have interaction to support social groups
12. Games have representation and story to give emotion

The reason to why games engage us is due to the elements that the games are composed of such as rules to achieve organized play, which makes games fair and exciting [Prensky, 2001, chapter 5]. Boardgames and cardgames usually have written rules, while digital games implement the rules within the game. Goals and objectives are also core elements that define games and achieving a goal is a great motivator to play the game and to learn. Feedback as game element, gives direct information on whether the action performed is positive or negative. This type of element can be shown in various ways, numbers, and graphical images or through tactile feedback. Through feedback, learning takes place and an abundance of feedback can lead to frustration of the player, therefore feedback should not simply reveal the right answer after a failed attempt. An effective way to approach presenting the right answer is pointing out to the student why the answer was wrong. Shalom M. Fisch gives an example of how to approach it, if the student is supposed to find a triangle and they don't find the triangle in their first try, it is ideal to point out another attribute of the triangle such as "*Find a triangle – it has three sides*" and avoid saying the answer is wrong. On a second attempt and mistake, a response could be "*Find a triangle - it is shaped like a piece of pizza*" [Fisch, 2005]. Games must also pose a challenge/conflict/competition to make the user excited about playing the game. Prensky points out that a game is a problem and solving that problem is playing the game. Lastly, the game needs to have interaction and representation, which the game focuses on, something specific such as "*Tetris*" focuses on recognizing patterns and building and "*Age of Empires*" on history [Prensky, 2001, chapter 5]. Digital game based learning (DGBL) research focuses on learning principles, theories and models of implementing games, as source of engagement and fun with academic subjects. Using video games as part of the learning process is nothing new, it has been studied since the early 90' when computer games started to be on the rise for consumers [Alavi, 1994] [Betz, 1996]. When working with educational games it is not only important to engage the user but there is a fine line between making the game fun and entertaining while still getting the educational message through to the player [Prensky, 2001]. In his article, Richard Van Eck talks about the importance of DGBL and steps to consider when working with DGBL, Van Eck stresses that developers must be careful to not fully "*academize*" the games and leave the fun aspects out, he suggests to find a balance between pedagogical aspects and the engaging parts of the game. The article also provides various points to be considered when working with DGBL, and in order to improve the quality of educational games, the design of the game should be left up to game designers and allow the learning aspect to be designed by the teachers. Another point the article provides is to not make games easy, games that will be solved quickly are not engaging and should constantly require input from the learner and give feedback with each answer. [Van Eck, 2006].

There are three approaches that DGBL researchers put in use when working with games in education:

- Have students build games themselves
- Have the developers build educational games to teach students
- Integrate commercial "*off-the-shelf*" games (COTS) into the classroom

Richard Van Eck gives a few examples of COTS games in his article, these involve using Civilization to teach history in class, CSI to teach criminal justice and SimCity to give students government and civil engineering skills [Van Eck, 2006]. Many of these examples place the educational content in the actual game play and therefore players/students can use their academic skills to play through the game. Therefore, it

is important to keep the educational content connected to the gameplay and encourage players to see the educational content as fun and useful to solve the game [Fisch, 2005]. Even though there are a long list of success stories with educational games there is an even longer list of failed attempts. It is increasingly harder to make an educational game that captures the attention of a wide range of students. Computer games in general are widely adopted as an entertainment genre and it is virtually impossible to make a game that everyone enjoys. It would be equal to making a movie that spans every genre and is liked by everyone [Moreno-Ger et al., 2008]. Not everyone has the same level of skill when it comes to playing computer games. Some might be fast at adapting the controls and get the idea of the game, because they are used to playing games while others might struggle for a long time before understanding the concept.

One thing to keep in mind when working with or developing educational games is where they are going to be used. Is the game going to be used in a classroom setting where the teacher can use breaks between game sessions to discuss ideas and concepts of the topic taught by the game, or is the game used for homework or self-study and therefore being used outside the classroom. If the latter is the case then it is important to keep the topic of the game focused. In Polsani's article about the learning object model it is advised to keep learning sessions between 2-15 minutes [Polsani, 2006].

When trying to get teachers to use educational games in their teaching, the game should offer something that would help the teacher or improve the course. This could be visualizing complex concepts or help with grading. If a teacher normally would hand out a set of papers for the student to read at home the teacher will not know if the student read the papers or not. If the teacher then gave the students a quiz about said material, there would be extra time involved for the teacher to correct the answers and grade the papers. In a game this could all be automated. If the students are presented with a set of games that will teach a specific subject and contains a short quiz after completion of the game, the game could be able to log the time spent in the game, the answers from the quiz, what the students did in the game and so on. This automates a lot of the processes for the teacher and reduces the workload the teacher has to use outside of class. It is also possible to combine both grading, behaviour and time spent in the game to get a better assessment of the student. While a regular reading assignment and quiz does not show how much work the student has put in to this subject. Maybe the student does not understand the subject so well and have used a lot of time with the paper, but still show bad results afterwards. With an automated assessment system that combines the data gathered it would give the teacher a much more personalized overview of each student and their dedication to the course or subject [Moreno-Ger et al., 2008].

Previous sections have talked about how games can be used in a educational setting but how should they be created? As far back as 1910, Dewey discussed that knowledge about science should not just be presented to students but that they should experience it and practice it, before understanding it properly [Dewey, 1910]. This is also discussed by Annetta who proposes that educational games should not just be presented to students for their use but instead should be created by the students [Annetta, 2010]. This leads back to co-creation, which is basically what happens when users create games for other users or participate in the creation process. Here, the teacher will be able to introduce concepts in class and create games together with the students in order to further teach them about the topics and the concepts. Learning by doing is a saying often used and by making a game, the students learn about the topic. The students can then go home and play other student's games and see what values they have focused on.

2.4.2 Personalized Learning

Adaptive learning falls under the broad umbrella term that is personalized learning. Adaptive learning is defined as “an approach to creating a personalized learning experience for students that employs a *sophisticated, data-driven, and in some cases, nonlinear approach to instruction and remediation, adjusting to a learner’s interactions and demonstrated performance level, and subsequently anticipating what types of content and resources learners need at a specific point in time to make progress.*” [Waters, 2014].

Maria H. Andersen speaks in her article about personalized learning in the past and due to its cost-ineffectiveness, it was replaced by conventional methods, such as teaching 20-30 students at once [Andersen, 2011]. Andersen explains that technology can fulfil the need of personalized learning in the future, either by engaging e-learning or by artificial intelligence. However, this might take a while, therefore she points out means the technology has offered to help students learn, such as software that allows you to take notes on, highlight valuable information in books and search information. Though, Andersen states that students rarely go back to this information and in order for deep learning to occur, repeated exposure to the information is required and time to reflect on this information. Andersen proposes in her article an idea of how personalized learning can be implemented using the current available technology, this is presented by two steps:

1. Creating a new learning media using the Internet.
2. Creating software to easily manage media (such as adding “Like”, “Tweet this”, “Learn This” buttons).

The article then presents the idea “SOCRAIT”, which is based on intrinsic motivation, and it involves a system which allows the students to read an article, then lets them add a question and answer to the article. When they have time again they return to the article and go through the questions and answer them for themselves, afterwards, the students are asked to rate it how well they knew the answers. The software then redirects the students, based on the rating, to the article again or further ahead. It can also suggest different questions for different learners, and base the information given on the questions they chose to answer. The system can also be influenced by your social network and give questions and topics based on what questions your friends have chosen to answer. The personalized learning aspect can also spread through areas they want to know about and subscribe to a set of specific questions or areas where students already know about, so that they can choose to skip reading the article and just answer questions. [Andersen, 2011].

If they feel they cannot answer some questions they can delve into the subject. In the system imagined by Andersen, teachers play the role of a learning coach who designate topics the students must cover and these students will all read the article or book with the designated topic however will also be able to select areas that they are interested in and connected with the topic, for example if the topic is calculus the student can find questions tagged with marketing and management. Andersen believes that a system for personalized learning should not grow from within the educational system and should start from the outside such as the previously described “SOCRAIT” system does. [Andersen, 2011].

2.4.3 Motivation

When dealing with motivation and motivating teachers or students, it is important to know what motivation is defined as. Motivation is mostly used as a descriptor to processes that can initiate certain behaviours in an individual, give purpose, allowing behaviour to persist and choosing a particular behaviour.

According to Tonya Hammer, motivation is represented by an instinctual drive to achieve a task, for example satisfying hunger or obtaining a certain job. [Hammer, 2011] McClelland has theorized motivation as individual's needs for power, affiliation and achievement. By analysing these three concepts, McClelland developed a well-known assessment process called "*Thematic Apperception Test*" [McClelland, 1987]. On the other hand, J. B. Rotter went in depth with the internal and external factors of motivation and presented the terms as intrinsic and extrinsic motivation. The intrinsic motivation refers to instincts and biological drives of a person, which in return gives the person a feeling of satisfaction and accomplishment. When a child is playing a game, intrinsic motivation occurs when the child expresses his desire to achieve a certain goal within the game. [Rotter, 1973].

Extrinsic motivating factors are represented by pressure or rewards from external processes, an example of such factors can be recognition from peers after completing a task or reaching a goal. Another factor can be the desire to avoid disappointment in the person's life, which then drives the person to achieve, extrinsic motivators are considered more powerful than intrinsic. An example of such can be parental pride motivating a child to study harder and get better grades or praise from friends for completing a level in a game. [Hammer, 2011].

When talking about motivation, it has been researched that job performance is highly influenced by motivation and the causes and components of such types of motivation have been thoroughly presented. The main causes being personality traits and abilities of the person, which can greatly influence the motivation of the worker when it comes to their job, according to Jerald Greenberg [Greenberg, 2011, chp. 7]. This way of looking at motivation is known as the motivational fit approach. This type of approach represents the motivation that arises as result of qualities of an individual and their requirements for the job. According to the theory, if people's abilities and skills fit the requirements of the job, it is highly more likely for the individuals to be motivated. The motivational fit approach can be broken into four motivational traits:

- Achievement, the person is interested in excelling at their task
- Anxiety, the person is particularly apprehensive or nervous about tasks
- Emotion control, the person is capable of controlling his emotions and focus on the task
- Motivation control, the person is able to push himself even when their interest begin to decrease

These motivational traits can be the cause of how motivation is achieved in different types of individuals. For example, an individual with high achievement values will seek challenging situations while increasing the risk of failure which will then require emotion control and thus also motivational control, leading them to develop better motivational skills. Besides this aspect, motivation can also be achieved by setting goals. People can respond differently when being assigned goals. According to the goal setting theory, assigning goals can have an impact on both the self-efficacy of the

individual and their personal goals. Goals can motivate individuals to test their abilities and their current capacity to achieve the set goal. Achieving a goal will then give the individuals a feeling of competence and will feel successful. [Greenberg, 2011, chp. 7].

Overall, researchers have been solely connecting motivation in education with students and have relied in the teacher's abilities of helping students to develop goals and beliefs as they believe that teacher's play the most important role in motivating students. Research shows that the ability of the teacher to manage the class can greatly influence students' motivation and behaviour. According to Nancy Ray, if a student believes their teacher is caring, cooperative and fair, it will have a higher chance at motivating the student to do well in class while the opposite can happen if the student thinks lowly of the educator. Ray believes that if the teacher shares something of value with the student, he can deliver the message to the students; that learning can be fun. Therefore, it can be believed that if the educator can manage to implement technology for class, there is a higher chance that students will be more motivated to learn. A cause of this is due to the technology playing such an important role in the lives of the current generation of students. [N. L. Ray, 1992].

2.5 TECHNOLOGY

The second term investigated will present information regarding Multimodal Systems, Mobile Technology and Open Architecture, such that these approaches have the potential for change. Multimodality is presented through the different types of inputs which can be considered when working with technology, while Mobile Technology gives an overview of advantages and disadvantages of using mobile interfaces and Open Architecture presents the importance of supporting external plug ins and add-ons.

2.5.1 Multimodal Systems

Multimodality refers to the use of two or more user input types, speech, touch, gestures, gaze etc, in one combined software with multimedia output. Multimodal systems can replace conventional interfaces with the lone possibility of pressing buttons. Multimodality aims to copy natural human language and movements and make interfaces intuitive and natural. Therefore, by using multimodality, it is expected that interfaces will be easier to learn to use and provide a wider range of possibilities of implementing challenging applications. Currently, there are various systems using combined modalities to gather information, systems that include speech, pen input, lip movements manual gesturing and gaze tracking all together in one system. [Oviatt, 2002].

An advantage of multimodality is the ability to allow users to cope with a temporary disability, for example not being able to look at the mobile phone in the car, the system still allows the user to speak and to touch screen as input. Multimodality allows users to choose how to interact with the system, when the system provides more than two ways of interacting with it and therefore being able to accommodate a broad target group with users of different ages, skill levels and impairments. The possibility to switch between input methods can also be effective in preventing overuse and damage to the system.

When compared to unimodal systems, multimodal interfaces are less prone to give errors. This can be due to the fact that the user will know which input mode they will

choose in the situation they are so that it will avoid errors or the user will switch mode if the system is faced with recognition errors. [Oviatt, 2002].

2.5.1.1 Examples of multimodality

Multimodal inputs can be implemented in a lot of different ways. The Microsoft Kinect [Microsoft, 2016] is one of the widely used input methods for multimodal interaction. The Kinect is an inexpensive device that can track people and create depth maps. This makes it easy to use body movements to control aspects of a game or an application. The Kinect has several official and unofficial libraries that each has their own implementation method of skeleton tracking, gesture recognition, depth map and so on. Kinect is not the only device that is great for gesture recognition the Leap Motion [Leap Motion, 2016b] is another great inexpensive device for hand-tracking. The Kinect is best for full body tracking where the smaller Leap Motion is designed for just hand-tracking.

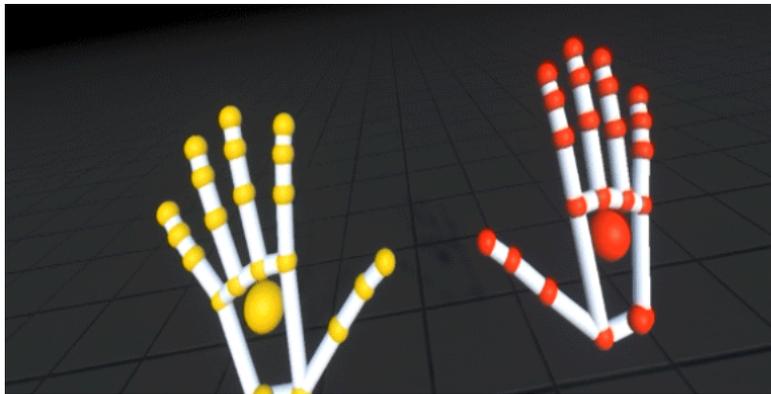


Figure 11: Example of the Leap Motion hand tracking [Leap Motion, 2016a]

Figure 11 shows an example of how two hands can be tracking in a virtual environment. Both Leap Motion and Kinect use input methods that are native and intuitive to every person. Instead of using a mouse, keyboard or touch screen the user is able to use intuitive gestures to control the application.

Another multimodal input method is speech. For a long time speech was not used at all for inputs but only for outputs (audio feedback), but with the rise in personal assistants such as Siri [Apple, 2011], Cortana [Microsoft, 2014] and Google Now [Google, 2012] speech has been more widely accepted as a form of input. But even though speech is accepted as an intuitive form of input, it is not necessarily socially accepted form of input. Rico and Brewster did a study about the social acceptance of using speech as input methods in a public setting, which shows that speech is not necessarily accepted in the public setting [Rico and Brewster, 2010]. As mentioned, Siri, Cortana and Google Now are multimodal input methods for mobile devices. These applications give the user an easy and hand-free way of interacting with their mobile device. Speech input can be implemented fairly easily using Google's speech API [Google, n.d.] and other libraries such as npm for node.js has easy access to the API [npm, n.d.].

Multimodalities do not necessarily have to be input methods as shown in the examples above. Outputs can also be multimodal and some of the mentioned devices could work as outputs too. New devices such as the Oculus Rift [Oculus VR, 2016] can increase the realism and immersion in a game or application and work as a multimodal interface. Virtual Reality (VR) is becoming a more and more popular output method

for games and Augmented Reality (AR) is catching up. AR can be implemented using libraries such as Qualcomm's Vuforia [Vuforia, 2016] and used in combination with mobile devices to bring objects on screen to life. AR can be described as a pseudo-hologram where the object is displayed only on the screen while using feed from reality.

So far multimodal input has been presented as a set of new technologies (kinect, leap motion, AR, VR etc.) but some of the simplest multimodal inputs and outputs can be accomplished using very simple electronics such as LEDs, buttons and knobs. Using a microchip like the PIC32MX250F128B or a more complete solution like an Arduino can be connected to a mobile device and used for input and output. When working with buttons on a mobile device it might not always be intuitive where to press or if you have a knob, it might be hard to rotate it using a touch screen or a mouse. But if an Arduino is connected to a rotary knob and a button it might be more intuitive than a touch screen. This could be because of the tactile feedback from the click of a physical button or the resistance of a rotary knob.

When implementing a multimodal system the goal is for the user to use the new modalities to control the system, this might not always be the case. Oviatt writes about ten myths of multimodal interaction:

1. *"If you build a multimodal system, users will interact multimodally"*
2. *"Speech and pointing is the dominant multimodal integration pattern"*
3. *"Multimodal input involves simultaneous signals"*
4. *"Speech is the primary input mode in any multimodal system that includes it"*
5. *"Multimodal language does not differ linguistically from unimodal language"*
6. *"Multimodal integration involves redundancy of content between modes"*
7. *"Individual error-prone recognition technologies combine multimodally to produce even greater unreliability"*
8. *"All users' multimodal commands are integrated in a uniform way."*
9. *"Different input modes are capable of transmitting comparable content."*
10. *"Enhanced efficiency is the main advantage of multimodal systems" [Oviatt, 1999].*

These "myths" should be taken in to consideration when building a multimodal system. It is especially important to notice #1, #4, #9 and #10. These four points are the great pitfalls when working with multimodal systems. It is easy to implement a multimodal system that have both speech input and touch input, but just because the system has these options it does not mean they are going to be used that way. In a study from Intelligent Voice they conclude that Apple "has oversold Siri" [Intelligent Voice, 2013]. When participants were asked, out of 2330 responses 84.8% say they never used Siri on iOS 7. This clearly shows that even though there are different input methods, making the system multimodal, it does not mean they are going to be used. The research debunks both myth #1, #2 and #4 as it clearly shows the opposite. [Naumann et al., 2009].

2.5.2 Mobile Technology

Mobile technology has the potential of changing the future of educational environment both within class and at home. Currently, mobiles play an important role in connectivity, communication and collaboration in everyday lives and these can open up to the opportunities of creating relevant and engaging experiences for students. Technology in

classroom has been used for years, computers and laptops playing an important role in attempting to revolutionize education however mobile devices have a greater potential at changing the way students learn. [Kosturko et al., 2015, chp. 1]

As Marc Prensky states “*today’s students are no longer the people our educational system was designed to teach.*” [Prensky, 2001], therefore students have a good chance at adapting to new approaches and expect new approaches in classrooms to help them engage and learn more effectively. Mobile technology in learning offers a new way to teach while also teaching future relevant skills to the students and give them practical knowledge on technology and the advances of it. What mobile technology offers is something that PC could not offer in the past, which is enabling learning anywhere and anytime and instant access to personalized knowledge. By adapting mobile technology in learning in classrooms, the lines between formal and informal learning will start to blur and it will open the path for students to learn using the latest advances in mobile technology. [Kosturko et al., 2015, chp. 1].

There are various advantages that mobile technology offers which can improve and personalize student education, these are:

- **Ability to learn on the go**, this way learning will not be limited within the school hours of 8am to 3pm and will allow students to access knowledge wherever they are. This experience will also play a better role in preparing the students for real life as it reflects upon the reality of adult’s life.
- **Affordable by most schools**, compared to other types of technologies, mobile technology requires a lower cost per student for a tablet as tablets are often less expensive than computers and laptops. Therefore, mobile technology can offer a different financial model which can be adopted in the educational scene. This approach can then open up the doors to more possibilities for lower income students, since tablets can take you to virtual museums and provide simulated experiences.
- **Improve thinking skills**, mobile technology also has the potential of improving higher order thinking skills, such as critical thinking problem solving and creativity.
- **Enable personalized learning**, using this technology, educators have the possibility of personalizing the knowledge taught to specify the students struggling and assign homework and assignments accordingly.
- **Motivate students**, most importantly, mobile devices can motivate students by engaging them through novelty and personalization and will always keep them entertained and engaged as the usage of technology can give new meaning and excitement to lessons.

As there are so many advantages which mobile systems offers, the technology also presents a range of difficulties that can be encountered when using mobile technology [Kosturko et al., 2015, chp. 1]. The first challenge is keeping students focused, as tablets and phones can offer academic help they can also give entertainment and can there be used as distraction. Therefore, when working with mobile technology in education, students would require monitoring. There are also other difficulties such as increase screen time usage which can affect the student’s health and keeping students from sharing personal information on the Internet. Compared to PCs and laptops, which cannot be moved around and are taking up more space than tablets or phones, mobile technology is given more advantages when it comes to usage in classrooms. PCs and laptops have the disadvantage of blocking the view to the board or the educator from

seeing the student, while mobiles are not as large in size to block the view or prevent students from focusing on the board in class. [Wessner and P Dawabi, 2004]. Another disadvantage when working with mobile interfaces is the lack of keyboard, as most tablets do not come with keyboards and therefore makes it harder for the users to type on a tablet compared to a PC.

However, there are many designers who are working around these problems and there are few who complain about the usage of touch screen devices and digital natives would not feel hindered by using mobile technology. Overall, when looking at both the advantages and disadvantages of mobile technology in learning, there are various aspects to be considered when designing for mobile as an educational tool, however, comparing the other possibilities available and their disadvantages and advantages it can be concluded that mobile technology would be the ideal candidate for bringing technology in education.

2.5.3 Open Architecture

An open architecture is a system that will implement an API where users and developers can develop plug-ins for their personal use. Fujita and Kageyama propose an Open Architecture as a with the following features:

1. *“A common interface for various components such as sensors and actuators.”*
2. *“A mechanism for obtaining information on functions of components and their configurations.”*
3. *“Layered architecture for hardware adaptation, system services, and application for efficient development of hardware and software components.”* [Fujita and Kageyama, 1997].

Furthermore Kanehiro et al. proposes their Open Architecture Humanoid Robotics Platform (OpenHRP) to contain Modularity, Open Architecture and Portability in order to allow for the software to be modular, expandable and portable. Each application, robots in their case, should work with new addition without possible errors and in order to keep users input at a minimum. [Kanehiro et al., 2004]. Koren, Hu, et al. talks about open architecture in their paper as additional modules that can be added or swapped with original modules on a product. In order to develop an Open Architecture Product (OAP) Koren, Hu, et al. mentions that the Original Equipment Manufacture (OEM) must support these new modules. This is done using a common software and hardware interfaces. The customer can buy or create new modules as they please and add on to their initial product. OAP does not necessarily need to be made by third-party vendors as many OEM develop addition modules themselves. [Koren, Hu, et al., 2013] [Zhang et al., 2015].

Koren, Hu, et al. gives multiple examples of how an OAP can be used. Examples include an open architecture car, where consumers can specify what modules they would like so the car can be tailored to their specific needs [Koren, Hu, et al., 2013]. Another example is a CNC machines where consumers can buy the exact tools as modules to a bigger machine [Koren and Kota, 1999] [Altintas and Munasinghe, 1994].

These modules should be *“plug-and-play”* where the device does not need a driver and can be plugged into a tablet using, for example, an USB interface.

2.6 A SURVEY REGARDING EDUCATIONAL GAMES

During the investigation process, an online survey was conducted in order to gather information about the target group and to estimate their interest in educational games. The survey was distributed on the internet forum www.reddit.com, more specifically under two subforums aimed at students and teachers. The survey had 46 responses with an average gender of 54% males and 41% females. The age range of the participants ranges between 15 and 32 with the majority being 16 year old students, who attend high school.

Some of the important information gathered during the conducted survey was the participant's educational level and their occupation. This was an important aspect to consider due to the help it can offer to define the target group. The majority of the participants were high school students representing 45% of the results, bachelor students accounted for 33% and Master students only accounted for 22%. When asked about their occupation, as expected, the majority proved to be students however 17 educators also responded to the survey. Further information that was required to keep in mind, since working with schools with a low budget is one of the focus points, was whether the school where the teachers and students attend, provides tablets or laptops. This is also asked in order to get an overview of what type of hardware is available for students and/or teachers to use in the classroom.

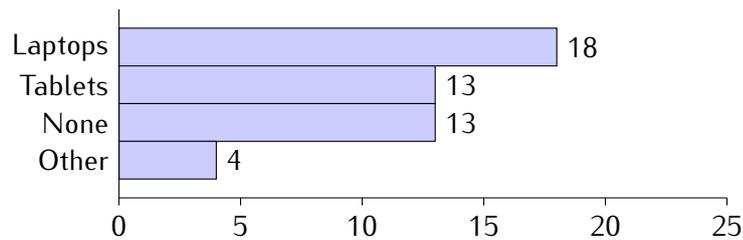


Figure 12: If you are a student or teacher, does your school provide tablets or laptops for students?

In Figure 12 multiple answers can be selected and 5 participants answered that both tablets and laptops were provided. As for the "Other" section, some participants answered that desktops were provided or that they had to provide either laptops or tablets themselves. At least 13 participants said that nothing was provided but did not specify if they had to bring anything themselves.

In order to see how widespread it is to use games in the classroom, a question regarding the frequency of using educational games was asked. A surprisingly high number of students and teachers replies showed that they use educational games in the classroom. Exactly 50% said yes, which shows that there is already a high usage of these types of games in the classroom. In order to get an idea of how the teachers feel about using educational games during lecture, they were asked whether they would use SGs during lecture. A large percentage (81%) said they would like to use mobile games in the classroom. Based on the previous question, 3 teachers would like to use educational games in the classroom and are currently not using them. Although one teacher states he is currently using educational games but would prefer not to use them. As for students' replies, all who did not currently use educational games (4 students) would like to use them. Participants were also asked to rate on a rating scale from Strongly Disagree (1) to Strongly Agree (7), how they feel about using games to teach educational topics in class. The results can be seen in Figure 13 and it can be seen that the majority

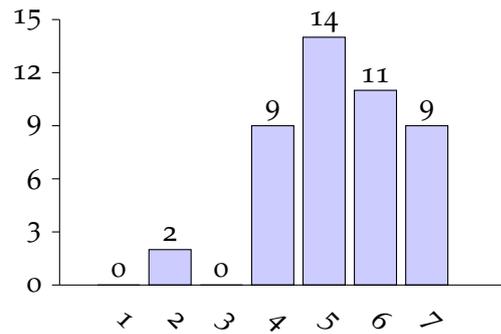


Figure 13: Average score = 5.31 (n=45). Would you use educational games in class?

of the participants have a positive approach towards using SGs as the rating's average is 5.31, which is above neutral.

Students and teachers were also asked what kind of games they use in class, if they use any. The majority of the participants that answered said that they used Kahoot (10 participants).

2.7 CONCLUSION

During the investigation, the main focus points of the research within this paper, education and gamification were presented. This chapter considers the wide range of terms related to these fields and narrows them down to related theories that can improve education while using technology. Using the keywords, we defined the goal of the research within this paper based on the initial idea of combining education with gamification. As education and technology were our main points of focus, the investigation helped narrow these fields into a few keywords that will be used to define the project. The keywords helped shape the idea of the system and its functionalities, bringing us further in the research phase.

As mentioned, the State of the Art section presents various systems of other researchers who go in depth with some or all of these keywords. This was done in order to get an insight on these games and systems, such that features researched and implemented within these system can be used as inspiration and guidance for the current application.

These keywords: *Co-creation, STEAM, Gamification, Multimodal and Budget* become requirements guidance of the application and therefore the theoretical aspects of the terms are considered in depth, which narrow the research down to the winning factors. As [Prensky](#) states, educators should not be replaced by technology and, instead, offer the opportunity to use the educator's knowledge to reflect on the information gathered from games. Therefore, the system that will be built in this paper will focus on how to motivate the usage of gamification in an educational aspect through the educator's help. [Moreno-Ger et al.](#) also points out important aspects to consider when working with educational games, one of these points being to offer functionalities within the game which helps the teacher, such as automating processes and help reduce workload in class. [Oviatt](#) explains the advantages and the importance of multimodality, Section 2.5.1.1 Examples of Multimodality, presents technology which can be adapted in the educational environment. Therefore the multimodal implementation is supported in this system and considered an educational advantage. The winning factors are relevant

to the goal of supporting technology usage within educational environments by gamifying and personalizing learning. In order to achieve these goals, specific requirements considered for the system researched in this paper, which would impact the educational scene, are given. These requirements, also called winning factors of the system, put focus on the opportunity of assisting educators during the assessment process and giving educators a greater sense of control than the currently presented State of the Art systems. An approach of this is by giving the educator the opportunity to create and edit templates within the application, for example, they can edit the template by changing the difficulty level, similarly to the system created by [Al-Washmi et al.](#) Based on the investigation some winning factors are set up, which can be seen in Table 2.

Winning factors	Description	Examples
User- friendly Interface	Easy to use in class Simple interface Assessment opportunity	Get result from quizzes Learning analysis
Assessment opportunities for teachers	Application should be able to be used to assess knowledge taught in class	Students will answer quizzes on the application and the results will be sent to the educator
Different templates to choose from	Different genres/challenges Different functionality from each template	Quiz template can be used to assess students knowledge Adventure game can be used to teach a subject or tell a story.
Opportunity to personalize learning to specific students	With the different templates educator can assign games to students accordingly Educator can use assessment knowledge for personalizing	Adventure games for avid readers Daily quizzes for diligent students
Easy access to sharing and downloading simple games for students	Educators should be able to access simple templates and create games for students in class or at home	Download new templates Upload your own templates Easy to edit and reuse templates
Gamified & Multimodal approach	Application allows multimodal implementation in gamified aspects	Allow multimodal plug ins AR visualizing for geometry Speech recognition

Table 2: Description of winning factors for the design phase.

Before starting on the design, some requirements should be set up that will define the design and show the direction of the project. When looking at the previous table and chart in Section 2.3.5 Sub-Conclusion it is possible to see that the design of the application needs to stand out from other already existing options through the winning factors presented above.

Design Requirements

- The application should incorporate co-creation, STEAM and gamification while having options to assess student's results and usage.
- The application should be implemented on a mobile interface as mobile technology has a better advantage at improving education (see Section 2.5.2 Mobile Technology).
- It should be easy for the teachers to use already existing templates to modify and distribute while still giving them enough options to customize the game for their linking.
- The educator should have easy access to assessment information from each individual student, this will help motivate teachers to use said application, as it should be able to minimize their time used on assessing students manually.

- When using gamified content in the classroom, it should be able to help and motivate students in learning the content and answering questions.
- Gamification can happen multiple different ways such as an adventure game, achievements, high score lists, multiplayer games and so on.
- The game should be general and fit any theme the educator might require to teach the students.
- The game should force users to reflect on their choices (Prensky in Section 2.4.1 Games in Education).
- The game should not “*academize*” and leave out the fun game aspects (Van Eck in Section 2.4.1 Games in Education).
- Learning sessions should be between 2-15 minutes (Polsani in Section 2.4.1 Games in Education).

3 | DESIGN

3.1 INTRODUCTION

During the Investigation, the keywords presented led to various topics such as gamification and co-creation which have been presented and discussed. In the following sections, these topics will take form and will be presented as design models which can be adapted later on in the implementation phase. The chapter will be split into the core topics for the application and will be used to present relevant guidelines and theories to the design of the application. These sections present relevant branches of design such as interface, learning and game design, these principles being the main guidelines to design and create the application in this project, which will later be applied in the application section. The application presents the most important aspect of the paper, as it gives an in depth description of the application's architecture that can combine gamification, co-creation and assessment into a full system. Lastly, examples of the game design, which can be considered for the educational application, are given.

3.2 INTERFACE DESIGN

Interface design is defined as the input surface that the users will see and be in contact with. The interface can either be physical, like a keyboard, or digital, as the graphical user interface (GUI) on a computer or tablet.

When designing a new interface it needs to be familiar and user friendly [Lazar et al., 2010, p. 9]. When working with a fixed aspect ratio like the layout of a tablet, it is useful to start with a simple grid layout to define margins, leadings and so on. To do this, the design philosophy of the grid system should be incorporated. This will help systematize and clarify the design layout and *"adopt a positive, forward-looking attitude"* while showing *"recognition of the importance of education and the effect of work devised in a constructive and creative spirit"* [Müller-Brockmann, 2010, p. 10]. The grid can be virtually any size, but it is important to remember the rule that *"The fewer the differences in the size of the illustrations, the quieter the impression created by the design"* [Müller-Brockmann, 2010, p. 11]. When creating interactive applications, windows, menus and icons play an important role in the interface. These elements are there to help guide the user and present all the relevant information [Rogers et al., 2011, p. 161-169].

Another aspect to think about is Fitts' Law. Fitts' Law [Fitts, 1954] describes the time it takes to reach a target using a pointing device, such as a pen or finger. The law can help designers specify where buttons should be on a device or application, in order for the user to most optimally reach said buttons. The less seconds the user needs to move per bit the better, as the user should not use too much time to move around between objects on the screen.

When working with mobile devices such as tablets and smartphones there are two distinct orientations to think about; portrait and landscape. When designing an application it is important to find the optimal orientation for said application. Not much

research has been conducted in device orientation, but Sprint did an online survey among their customers to gauge their habits. 541 Sprint customers participated in the survey and were asked to explain their habits of either using portrait, landscape or both when performing six different tasks.

Each participant was also asked if the smartphone had a virtual keyboard or a slide out Qwerty keyboard. Some tasks show different results when using a slide out keyboard compared to a virtual keyboard. Only two categories agreed to the orientation based on the type of keyboard. When dialing a phone number both keyboard types said they use portrait and when watching a video both said they use landscape. Every other category is split between portrait, for virtual keyboard, and landscape, for slide out keyboard. [Quinn et al., 2013].

This shows that the application design and the device design plays a big role in the deciding factor of using either portrait or landscape. When designing an application, the application itself can determine what orientation the user will use based on how the layout of the application is made.

The interface design of an application needs to consider three main parts: orientation, menu and button placement and the layout of the application. When combining the grid system with Fitts' Law it is possible to create an interface that looks pleasing while still functional and easy to use.

3.3 USER EXPERIENCE

The user experience is a relevant aspect to the interface design as it refers to the user's overall impression of how they feel about the system and interface they are using, whether this makes sense to them or whether it is easy to use [Rogers et al., 2011]. The interface design process involves user experience greatly, it points out that the process must involve 4 basic activities:

- Identify the requirements for the user experience
- Create various designs which fulfils these
- Assess the designs using information from users
- Evaluate the process and the user experience

These 4 steps can improve the design created for the application. Knowledge that considers the user's emotions, skills and limitations can improve the design of the application. Therefore, it is encouraged to create systems that give positive responses from the users and make sure they are enjoying the experience. Interfaces can also elicit affective behaviour. "Affective" behaviour refers to interfaces and designs who can trigger emotional responses to the experience, such as smile or get angry. Therefore, there are various components that can be used to represent expressive information, these can be sounds, animations icons or emoticons. [Rogers et al., 2011].

There are also various examples of softwares which use emoticons to represent specific situations of the software, for example a smiling icon which MacOS used to reassure the user that the system is working properly. MacOS also uses the sad icon for the iPod to represent that the software needs to be update or fixed. An advantage of using these expressive interfaces is that they provide reassuring feedback to the user. Various actions and interfaces can also cause user frustration and therefore elicit negative responses. Some of the reasons to why users can be frustrated can be waiting, images

or websites that take a long time to load when there is also no indication to the fact that the website is loading. [Rogers et al., 2011].

Another frustrating aspect of an application can be appearance, for example overloaded text and graphics can make it difficult for the user to access the information they are looking for. Distracting components can also cause frustration to the user's experience. Affective responses can also be influenced both by colors, shapes, fonts, graphical elements and their combination. Studies have shown that a visually pleasing interface can have a positive impact on the user experience and that usability is not the only component that influences the user experience. Therefore, it was discovered that there's a higher chance for users to become less frustrated at the system and be more tolerant towards waiting, for example. Usability experience can be greatly improved by understanding the users you are designing for, learning the environment the system will be used in. Keeping in mind people's sensitivities when designing is also just as important. The information stated can be classified as usability and user experience goals. To sum up, the usability of a system can be divided into:

- **Effectiveness**, represents how good the system is at achieving its functionality.
- **Efficiency**, it refers to the efficacy of the system at supporting users in performing tasks.
- **Safety**, making sure that users are not put into uncomfortable and undesirable situations.
- **Utility**, refers to the system being able to supply the user with what they need to achieve their tasks.
- **Learnability**, represents whether the system is easy to learn.
- **Memorability**, once learned, memorability refers to the users being able to remember what they have learned about the system.

Mobile interfaces can affect the user experience in different ways, through the fact that there are various points and guidelines to be considered for a pleasant user experience when working with mobile devices. Jun Gong and Peter Tarasewich present in their paper a set of guidelines to be followed for mobile interface design. [Gong and Tarasewich, 2004].

Some of the mentioned guidelines are:

- **Enabling users to use shortcuts**, the designers must make sure that performing a task does not require them to perform numerous actions in order to achieve it, because time is important for the user and the longer a task takes the more frustration is caused.
- **Offer informative feedback**, similar to other devices, mobiles also need to focus on giving proper feedback to make the user actions understandable.
- **Design Dialogues to give closure**, users should feel satisfied and a sense of accomplishment when performing tasks.
- **Support Internal Control**, make sure the user feels in charge of the system and not the other way around. The user should initiate an action and not be the one to respond to actions from the system.
- **Consistency**, Gong and Tarasewich insist that consistency needs to be kept when working with mobiles, especially with mobiles who have constant connection to PCs/desktops.

- **Short-term memory load**, as mentioned for other interactive devices, mobile devices also need to avoid overloading the user's memory such that very little memorization is required to perform a task.

Overall, mobile interfaces are not very different from other types of interfaces and in order to achieve mobile user friendly interfaces, the same rules presented previously, apply, however the guidelines mentioned must be kept in mind.

3.4 LEARNING DESIGN

To get an insight on learning and supporting learners in their efforts, it is researched into relevant information such as Learning Design, so that to understand methods adopted by other researchers of engaging students and educators. Learning Design is a wide term that has been defined by various learners and researchers. Diana Laurillard states that Learning Design's role is to structure a learner's engagement with knowledge and allowing them to practice their skills and make the knowledge their own [Laurillard, 2008]. Craft, Maina and Mor on the other hand, define it as a way to achieve new educational aims by creating new plans and devising new resources and tools [Craft et al., 2015]. Overall, learning design is a process to achieve educational aims, a creative practice, a search for knowledge informed by theory and it strives to make the world better by responding to change. Learning design is also an iterative process and acknowledges the limitations that are posed when working with educational contexts. Lastly, learning design also needs to be able to support learners in their efforts and aims. [Craft et al., 2015].

According to these definitions, the learning design field seeks to develop a framework for teaching and assisting teachers in adopting new educational ideas. Craft, Maina and Mor state that there are three crucial points to improve learning through learning design:

- To represent the knowledge in a familiar way
- To support the educators and learners with useful open tools
- To support learning design as a design practice

In order to better define and improve this framework, the "*Larnaca Declaration*" was created, which can be defined as a methodology to allow teachers to make better educational decisions [Craft et al., 2015]. An important aspect of the Larnaca Declaration is presenting the teacher's design process and learning activities universally, so that it is easy to be shared with other educators and easy to be understood. The declaration also discusses the importance of applying learning design to various topics and levels of education and not limit it to schools and universities. As example of what it is meant by making the learning and design process universally accessible, the Larnaca Declaration uses the music notation to describe the idea behind learning design. Such as, music notation can be used to describe the sounds and melodies for others to adopt as well, it is supported that an "*educational notation*", Learning Design in this case, can achieve the same results. Therefore, the Learning Design can also be represented by a thorough description of learning flow and activities of educators and learners in classrooms and online environments. [Dalziel, 2015].

J. Dalziel believes that by describing a step by step process of new teaching activities it can encourage educators to adopt new teaching methods. Therefore, Learning Design

fosters the idea of using a common descriptive framework to represent these activities. A wide sharing of teaching practices has both pedagogical benefits and productivity benefits, thus decreasing the time the educator spends to prepare for class and can therefore re-use effective ideas from other educators.

There are many attempts at trying to make a neutral framework of learning design to fit all needs which can be given to other educators to understand and re-use. One such major element of the Larnaca Declaration is the “*Learning Design Conceptual Map*”. The map presents a wide range of elements that should be considered when making design decisions, however without being specific and bound to a certain topic. This map can be seen in Figure 14.

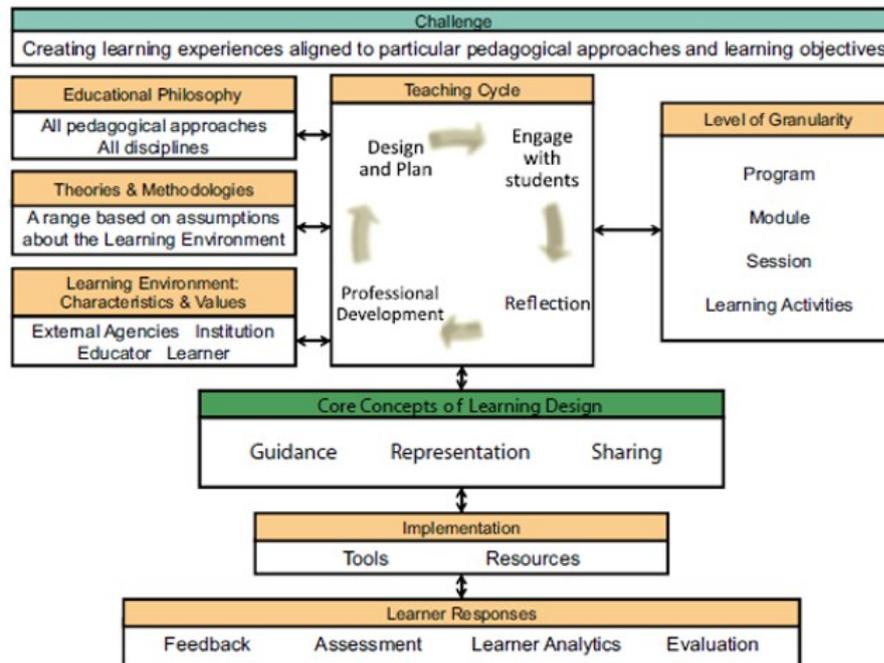


Figure 14: The Larnaca Declaration “*Learning Design Conceptual Map*”

The core idea of using Learning Design maps is to support representation, sharing and guidance for educators. This map can be used to analyze pedagogical theories and to share the approach used to analyze these theories, with other researchers and educators. As certain components of the map are more relevant to certain theories, drawing them within this map makes it more clear which areas are of common interest within these theories and which are different. Therefore, this paper will support the approach of sharing, representing and guiding future researchers by providing a personal conceptual map, which will be adapted and created to fit the needs and requirements of the system that will be implemented within this paper.

3.5 GAME DESIGN

The goal of a game is that it should be fun, when designing a game one must ask themselves, which parts of the game are fun and which could be amplified. The designer must make sure to fill the game with interesting surprises, answer questions such as “*What would surprise the players?*”. According to Jesse Schell, surprise is a crucial part of games, since our brains are wired to enjoy surprises. Another aspect that a game

should touch upon is curiosity, Schell explains that the designers need to make sure the game motivates the player and that developers should focus on what thoughts and questions the game brings into the player's mind [Schell, 2008].

Game designer Chris Crawford explains in his book, that a game must have a goal and a topic and believes that the fundamental elements of common computer games are:

- Representation - The game is a subjective and simplified subset representation of the emotional reality
- Interaction - Is an important element of games and the degree of interaction defines the Gamification degree
- Conflict - Conflict appears from the player interacting with elements in the game and obstacles prevent him from reaching the goal and must be present in every game
- Safety - Games must be a safe way to experience reality

According to Crawford, the design of a game is dependent on three structures: I/O structure, game structure and program structure and they must be well balanced in order to work together. I/O represents the communication between the computer, the game in this case, and the player. The game can give output to the player through visuals or audio. A game structure relies on the environment and the rules created within the game which implements the goal into a workable system. However, Crawford suggests to not crowd the game structure with many features. Lastly, the program structure refers to the implementation of the game where program flow and performance represent the important aspects [Crawford, 1984]. Overall, the role of a game designer is to create the rules of the game, the system that allows the game to function as it does, however, the role of implementing all these together falls into the hands of the level designer. Most of the time, a player experiences the game through the levels and therefore level design is an important aspect to consider when creating a game. Ed Byrne describes the main elements required, also called "*building blocks*" to create a good complete level design [Byrne, 2004]:

- **Concept:** Refers to pinpointing down all the specific information the game focuses on, such as characters, the role of the character, the story of how the character entered that environment and situation. The concept also includes information on how the character entered the environment and situation. The concept also includes information on how the controls work, what the player can do and cannot do.
- **Environment:** The environment must represent the theme presented in the concept and graphics should fulfil the concept's needs such as a circus theme for example would use circus elements. In a level, the environment consists also of the background and the elements that help him progress through the level, such as lives, energy or other metrics.
- **Beginning and Ending:** The beginning of a level can usually be at the left of the screen, top, bottom or middle and can be represented as a door, for example. The ending needs to be clear to the player and should be clear that there's a challenge or obstacle in the way to reach it.
- **Goal:** The goal of the level must also be made clear to the player, for example, to goal is made clear through the story and it is to reach the exit and it should always have a solution or a way to reach the goal.

- **Challenge:** This element stands at the bottom of why the player is having fun, therefore as a designer, a challenge must be provided but at the same time a solution must be available too, however, this must be within the theme and concept of the game as to avoid the player considering it silly.
- **Rewards:** Rewards can be of various types, it can be presented as unlocking the next level or as a short victory animation. This sort of element can drive the player to play the next level.
- **Failure:** Last element to consider is the action of what happens when the player does not complete the level and achieve the challenge. It is suggested that, a failure should only be applied if it's absolutely necessary and avoid the player blaming the designer instead of themselves for failing the level. [Byrne, 2004].

It is to be noticed that a core element of level and gameplay design is challenge, however a challenge can be the main aspect within the design that defines what type and genre the game can be represented as. Andrew Rollings and Ernest Adams describe in their book the different types of challenges a game can pose to the player and sorted them into two types: explicit and implicit challenges. An explicit challenge can be defined as an intentional challenge implemented by the designer, for example a specific amount of time required for the user to wait when dodging an obstacle. The implicit challenge, however, emerges from features that were implemented within the game such as figuring out an efficient way of how to distribute items within a group in an RPG game. Explicit challenges require more focus and concentration than implicit challenges. [Rollings and Adams, 2003, chp. 7].

- Logic and inference Challenges

These challenges can be divided into perfect information games such as chess and imperfect information games such as Microsoft hearts. Most games are presented with imperfect knowledge, this is mostly because it challenges the player more when he is required to hypothesize outcomes and this also brings in the element of surprise.

- Lateral-Thinking Challenges

Rollings and Adams also presents lateral-thinking challenges, where the player is required to use information from previous experience and knowledge to solve the challenge. The knowledge the player can use to solve this can be either extrinsic or intrinsic. Extrinsic knowledge can be given by the educator or gathered from various readings they have gone through, for example the knowledge that wood flows can help them solve the challenge. Intrinsic knowledge, on the other hand, is gained from within the game world, such as using a spell they haven't used before and figuring out what it does.

- Intelligence and Knowledge Challenges

Intelligence-based games mostly rely on the intelligence quotient of the player, while knowledge - based could easily fit within an educational context as it mostly relies on what the player knows about various topics. An example of a knowledge-based challenge is Trivial Pursuit, where the player progresses through the game by providing answers to questions from various categories

- Pattern-recognition Challenges

Some games can depend on the brain's ability to recognize patterns, such as Tetris does. In Tetris, the player must make the decision of where to place a specific block and this decisions must be quick. One attribute of pattern recognition challenges is the player's ability to focus on the entire playing area at once without considering individual elements.

- Spatial Awareness and Coordination Challenges

Spatial awareness games are usually represented by 3D games, some examples that pose this type of challenge are flight simulators and 3D combat games. Coordination challenges are closely tied with reflex and reaction time of the player, for example the ability to coordinate the character jumps within a game and accuracy of shots.

According to Rollings and Adams, not all challenges can easily be categorized and therefore hybrid challenges can emerge, for example a logic-based puzzle game with fast reaction time would represent a hybrid challenge.

Overall, a game's goal is to be fun but challenging at the same time. This can be achieved by following the elements presented by Crawford, however keeping in mind that the interaction is the strongest element that improves gamification. What is also to be kept in mind is that level design is an important element of game design and also includes elements that need to be considered when designing a game.

3.6 APPLICATION

The following section will describe the ideal design of the application. Firstly, the section will give an architecture overview of the specific components within the application and where each guideline is applied. Afterwards, the sections will represent in depth design of the application's functionalities and possibilities.

3.6.1 Architecture

In order to make it clear on which tasks the application will include, an architecture was created. The architecture is sustained by theories proven and presented in earlier sections and therefore will be visualized by the linear connections in Figure 15. The architecture presented in this figure will be designed to support an application on a mobile platform which helps and motivates educators to use gamification and game elements during lectures to teach students about a specific topic. This is intended by giving the educators a high range of possibilities and choices they can consider in order to adapt game elements to their lectures.

An important aspect to get the educators motivated to use technology and apply gamification to their lectures is by implementing user friendly graphical interface, to make it simple and easy as possible for educators to work with the application, therefore, the architecture presents *user interface* as a component point so to show the importance of the component. The application is split into two areas, one which focuses on the educator's needs and the other focusing on the students. The goal of the application is to motivate teachers to use gamification to improve their lecture while the students get more engaged in lectures by using interactivity. Gamification is an important aspect within this application as games can create engaging interactive situations, while the teachers

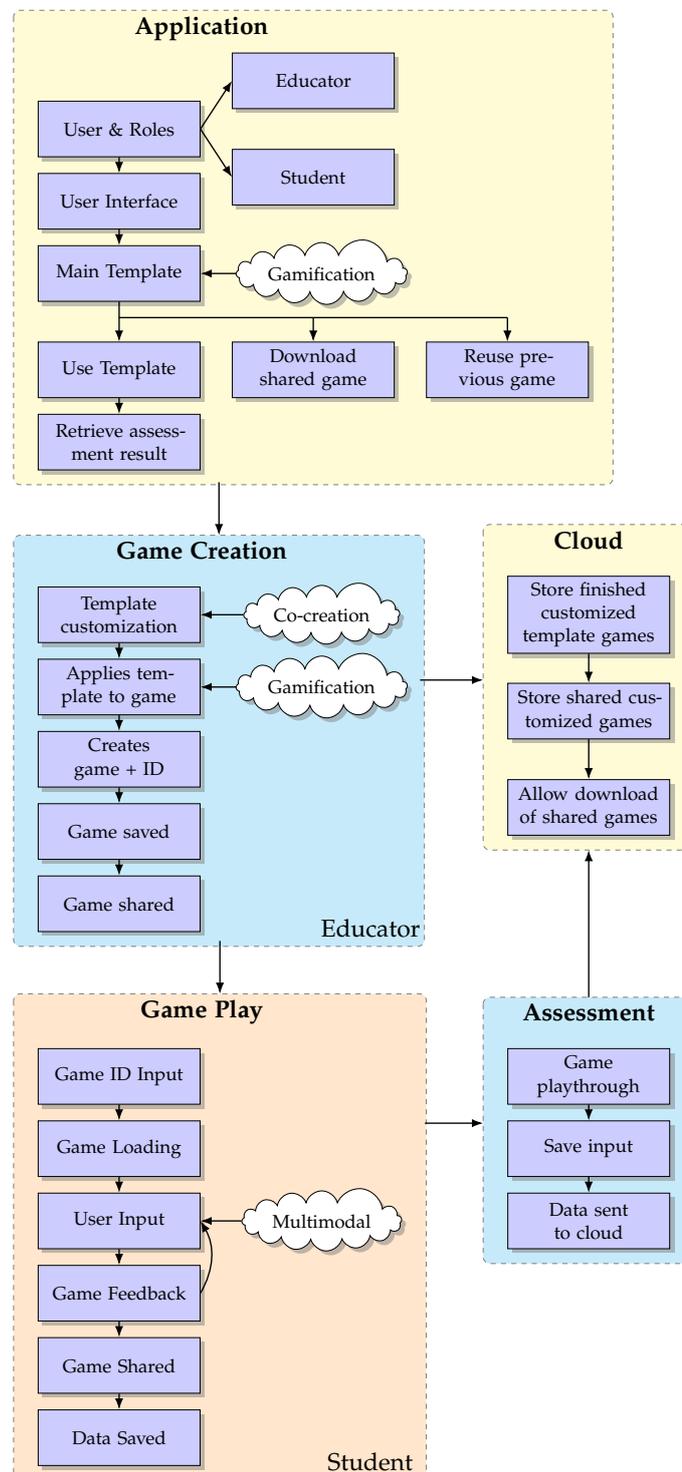


Figure 15: Architecture of the application and its functionalities

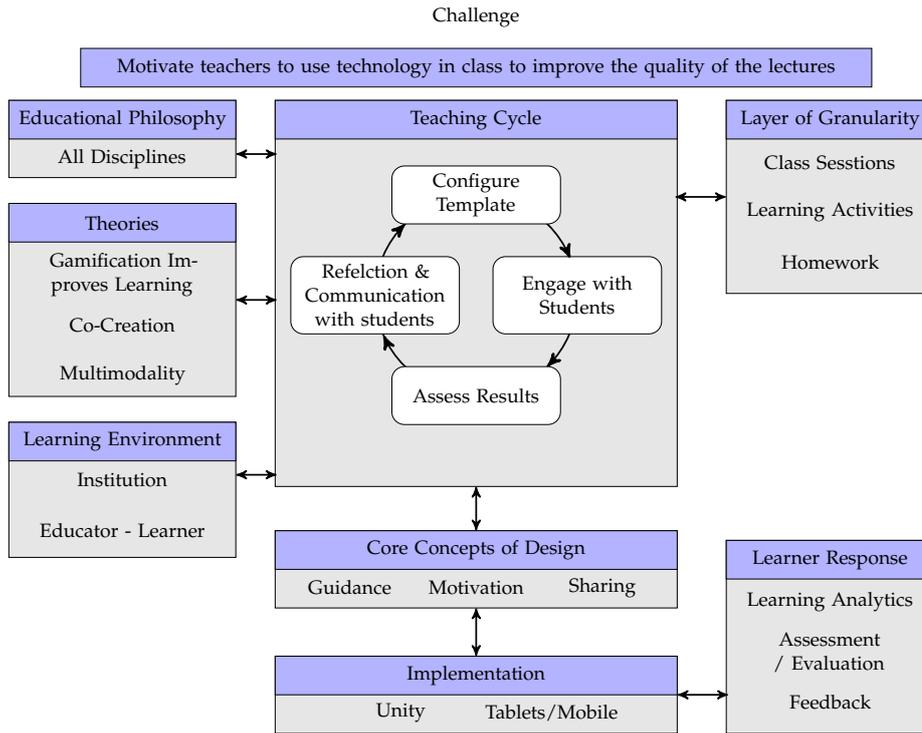


Figure 16: Applied Learning Design Conceptual map

can help the students reflect upon it [Prensky, 2001]. In order to motivate teachers, the option to add “*Templates*” as a component to the architecture and as functionality to the application, is considered, these templates can be used by giving the teacher a choice on whether they wish to create a new template of their own or download a template that other teachers have used and tested. This type of approach is supported and inspired by the idea of the “*Learning Design*” framework, which has great pedagogical and productivity benefits by decreasing the amount of time educators must spend to prepare a lecture (see Section 3.4 Learning Design). Therefore, educators can be motivated to implement gamification knowing that it is possible to save time and have the opportunity to make lectures more interesting to students.

There are two components represented by the color blue, which are functionalities aimed at the educators, these being the game creation and assessment. The game creation process involves the template customization, which allows the educator to apply game rules to information that they would like students to be given by the end of the lecture. In this component, co-creation plays an important role as it involves the teachers in the creation of the educational games, therefore personalizing the learning process and adapting it to their needs. The second educator component focuses on the process that occurs after the students have managed to fulfil their task of playing the game through. The assessment box includes the process of using data from the finished games, this data being saved on the cloud to be sent to the educator when this is requested.

The cloud component has an important connection to the game creation, which is the educator’s focus, since the templates are sent and stored on the cloud together with the assessment data from each student.

As mentioned in Section 3.4 Learning Design, the conceptual map supported by the Larnaca Declaration will be used in this case to adapt it to the requirements, needs

and theories that are considered in this research. The map can be seen in Figure 16 and presents the challenge of the report within the first part and the theories such as Gamification, Co-Creation and Multimodality. As the system within this research paper allows the activity to take place both for individual learning activities and sequence of activities for class sessions, the map presents the level of granularity of it. The teaching cycle represents the steps that will be followed for every learning session. Lastly, the map points out the core concepts and specifies the resources and tools to be considered within this design type.

3.6.2 Graphical User Interface

According to the architecture presented in the previous section, the application will involve various functionalities which the user, the educator in this case, will be allowed to use. These functionalities require to be placed in a common layout to create aesthetically pleasing design referred to as graphic design. Graphic design can be defined as a form of conveying a message to be sent to a specific group of users, this type of design can rely on creation and organization of visual elements and can have great impact on the meaning conveyed within the message. Through a graphic design, it is possible to persuade, motivate, inform, enhance, engage and organize users to perform a specific task [Landa, 2006]. Applied in different areas, graphic design can have various influence on users, graphic design can be aimed for advertising, branding, identity design, environmental, corporate design design, information design, interactive and experience design, etc. This application will mostly focus on areas such as information design as its goal is to take a large amount of information and design it into a clear representation to the user. Graphic is designed for a specific audience as the message should be shaped correspondingly to the type of user that will be receiving the message. This application conveys information for both educators and students, therefore it is important to make compromises when designing for both target groups.

One important aspect that is the focus during the graphical user interface designing process is user experience, when creating simple intuitive interfaces, it is important to acknowledge that the user must not feel frustrated, confused or find it difficult to use the system [Rogers et al., 2011, chp. 1]. Since one of the goals of this application is to motivate educators to use gamification within their lectures, user experience plays an important role, therefore they should be pleased when using it.

The first step to consider when designing is identifying the needs, functionalities and requirements the application needs to provide for a pleasant user experience, the following section will present the specific functionalities aimed at helping the educator in a mobile system, followed by the functionalities for the student.

Functionalities for educator:

- **Settings**, allows the user to change components of the application and of their own account, these settings are universal and can be noticed in various other apps, such as: username, email, language, sound volume, notifications, help.
- **Profile**, when accessing this functionality the user can see their current name and username, recent actions, such as new games created and achievements
- **New template creation**, when accessed it directs the user to the available templates that can be selected to create a gamified lecture
- **Assess Assignments**, the educator can here search for each student's results or get overall learning analytics of how the students have done throughout the quiz. This

area will give the educators information on whether the quizzes are too simple or too difficult.

- **Previous templates/ Gallery**, shows all the templates created before, completed or just started, this information would be saved therefore allowing the educator to pick up from where they left or reuse a quiz already finished. This “gallery” also contains all the downloaded templates from other educators.
- **Upload and Download template**, educators have the possibility of sharing their finished and tested templates with other educators, to help other educators save time when working with such a subject. They can therefore search for specific tags such as: quiz, story, mathematics and download the completed templates by other teachers and use those in their class.

Functionalities for student:

- **Settings**, involves the majority of the functionalities that educators can use: username, email, language, sound volume, notifications and help.
- **Profile**, this area for the student contains more game elements to motivate students, therefore the profile will show besides username and name, picture also their Achievements and Stars collected during playing the game.
- **Enter template ID**, the student’s possibility of accessing the game is represented by this. The educator provides the student with an ID number, which accesses the game created by the educator.
- **Previous templates/ Gallery**, the gallery is similar to the educators, however it involves only the games that had been accessed by the student by using the ID the educator gave them. The Gallery holds both the games that have been played before, marking them as played and giving but also games that aren’t just yet finished, using a sign to show this.
- **Results**, this area gives information to students on which areas of the game/quiz they have given wrong and which they have given good. It is a good idea to share the learning analytics to each student to give them a better idea of their performance and how much improvement they require.
- **Plug Ins**, gives a list of available plugins for the application and how to connect them to the device if the plugin is physical. Specific software for the plugins can also be downloaded from this section. These plug ins can also be multimodal, using the different multimodal approaches presented in Section 2.5.1.1 Examples of multimodality.

Figure 17 represents a sketch of the design including all the functionalities presented in the sections before. This sketch is a quick representation of the educator’s possibilities to create and assess templates. Figure 18 is representing the design of the student’s part of the application, which also includes the profile with more information regarding the gamified aspects. Lastly, Figure 19 shows an example of the result screen for the students, where they can see their different played games, with the information they gathered in each of these.

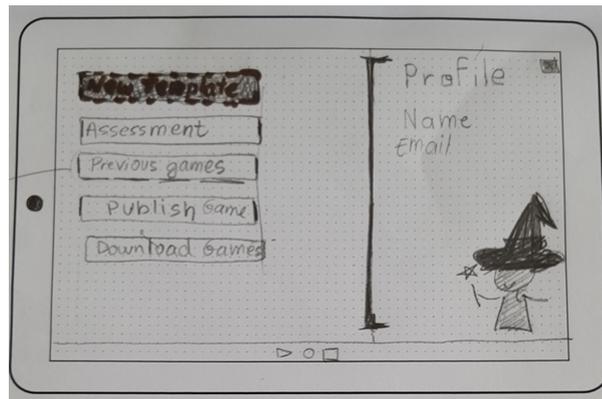


Figure 17: A sketch of the functionalities of the educator

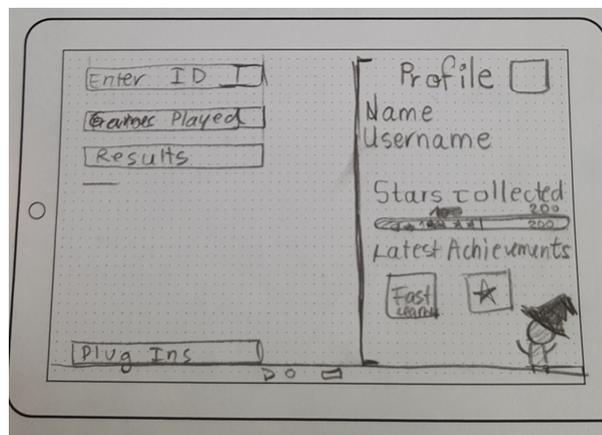


Figure 18: A sketch of the functionalities of the student

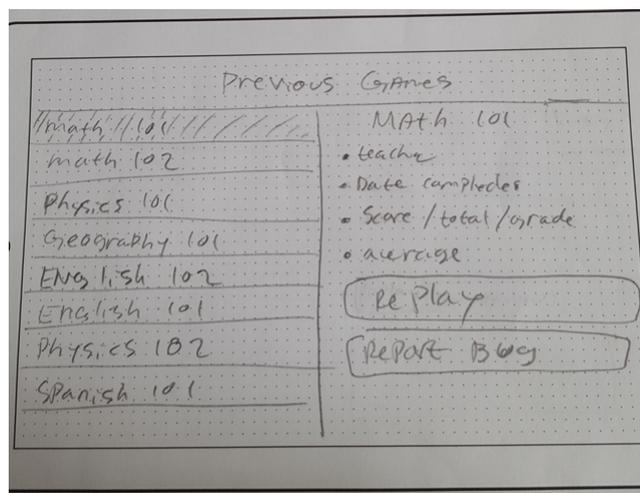


Figure 19: A sketch of the functionalities of the student

As mentioned in Section 3.3 User Experience, the system must be easy to learn and therefore it will focus on making clear functionalities, as presented in the sketches. In order to take most advantage of the screen space, a decision between focusing on landscape or portrait mode had to be considered. Using the knowledge gathered by Quinn et al. from the survey conducted regarding the usage between landscape and portrait mode, it was decided to focus on using a landscape direction for the application as it would give a better overview of the functionalities available and keep consistency throughout the system. Therefore, the system was designed so that the user does not require to remember any of the steps in order to perform a function, making clear buttons with what their functionalities can do. Memorability also plays an important role and was therefore decided to create relevant icons to the functionality and thus a survey was sent out.

3.6.2.1 Interface Survey

In order to get an input on the currently created icons which can be used to represent the functionalities to be added in the application, a survey was conducted. The survey was distributed on the internet forum www.reddit.com, more specifically under subforums aimed at students and teachers. The results come from 30 participants aged between 17 and 55, with an average of 24 years old. Responses vary on the occupation of the participants, however the majority are represented by students, results also vary country wise as the majority of responses are from participants living in the USA.

The survey was aimed at getting an understanding to whether users can recognize functionalities based on the icons created. In order to get this information, the survey included a numbered picture of all the icons while the participants were asked to connect various descriptions of functionalities to visual icons. Figure 20 presents the image with icons used within the survey.

From the survey it was discovered that the two most simple and intuitive icons are icons F and G, all participants of this survey have known that these buttons represent uploading and downloading a template. Two of the least understood icons are represented by D and E, which represent the gallery and assessment. This information was both gathered from the matching up of descriptions to pictures but also from asking participants which icons were the most difficult to understand where the majority stated D and E, however A was also often mentioned, while F and G were the easiest to understand. Therefore, due to this information it was decided to apply a change and simplify the difficult icons, A, D and E. These icons can be seen in Figure 21, where first one represents icon A, second icon E and last icon D.

To get an idea of whether participants would find it easier to connect the icons to their functionalities, if the icons are placed in the environment, the tablet in this case, an example of some icons in use was given to them. A picture applying the icons



Figure 20: Image of icons used within survey



Figure 21: Improved icons after the survey

according to the design was shown and participants were asked if it would be easier for them to understand the icons. The majority of the participants (44%) stated that it does not make a difference to them, however 31% believe it is easier to understand the icons in this setup (See Figure 22).

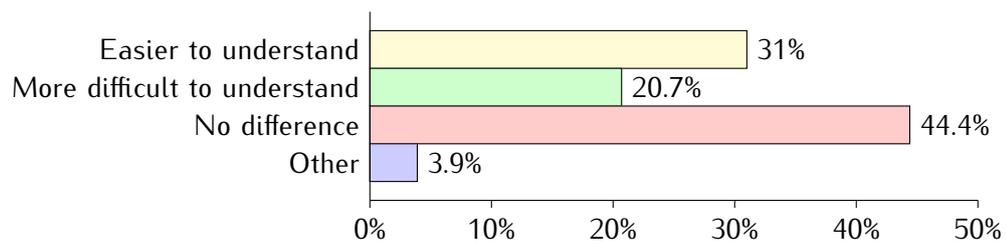


Figure 22: Do the icons become easier to understand when put in the interface setup?

3.6.2.2 User Interface Design

The user interface that the system will adapt is simple and straightforward such that it focuses on user friendly aspects and will be easy to work with, which is important to the educator and student. As presented before, there are different functionalities that the educator or student can access, therefore the application start screen requires for the user to choose their respective role which will access the functionalities they need to use. Figure 23 shows the design of the application's introduction page, where the educator is placed on the left side while student on the right. The ideal design will require the users to sign up/sign in to the system before being able to perform any actions that the application offers. This functionality is required as the system needs to save data, such as games, quizzes, results for specific users and quizzes will only be shown to the users who have signed in and created the quizzes in earlier usage.



Figure 23: Introduction screen of the application (User Interface).

Based on which button the users press, different scenes open up. When accessing the educator scene, the functionalities for the educator are opened up and respectively

for the student. Figure 24 shows the design of functionalities for both the educator and the student, which were kept with a similar design, as to not cause confusion and allowing the teacher to help the student if this needs help or feels confused to what they are supposed to do. As it can be seen, both student and educator are presented with the profile and settings options. In the student version, the icons represent a different functionality, for the educator the “Add template” icon shows various templates the educator can choose from to create a new template, while for the student, accessing this icon means they will be required to input a number, name, educator name or search through a database of games to access the games, quizzes or tests, that they need to fulfill for their class.

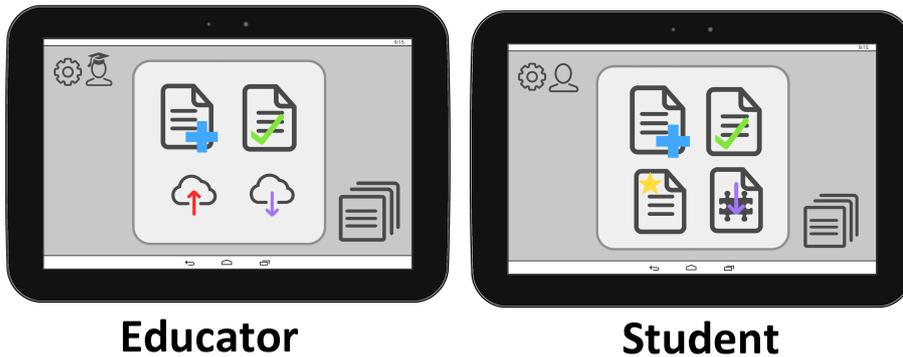


Figure 24: Educator and student interface

The educator’s functionality which involves assessment, represented by the icon with the green check mark, allows the educator to get information on the results from the student’s assignments. The assessment icon and the scene it opens when this is tapped can be seen in Figure 25. By accessing this scene, the educator will be shown with useful information regarding the games/quizzes the students played. The educator has either the possibility of vertically scrolling through a database of students or input the name of the students they wish to see the results from. The results can then include the amount of correct or wrong answers the students have performed when going through the quiz, the time each student required to finish the quiz and when the quiz was handed in. The educator also has the possibility of accessing the learning analytics by tapping the remaining icon in this scene. Similar to the EngAGe assessment tool (see Section 2.3.4.2 EngAGe Assessment Tool), the system should have the possibility of giving information to the educator on whether any part of the quiz or game is too difficult or too easy and thus see how many students had troubles with the quiz.

When returning to the main screen of the educator, there are other functionalities that the educator can access, one of these functionalities is the download possibility which can be seen in Figure 26. Accessing this area will allow the educator to search through multiple game quizzes or other types of games created by educators who also use this application to create games for their class. This scene allows the educator to search for a specific type of game in the database, tagged by either a teacher name, game genre or challenge type (eg. quiz) and once found, the cloud button will allow them to download the game to their device and will then be able to access the game through their gallery and share it with their own students. The main menu of the application also includes the icons/buttons of allowing the user to upload their own games and quizzes to share with other educators and students, when pressing this button, a very similar scene to downloading the game will appear, however instead of allowing the educator to search

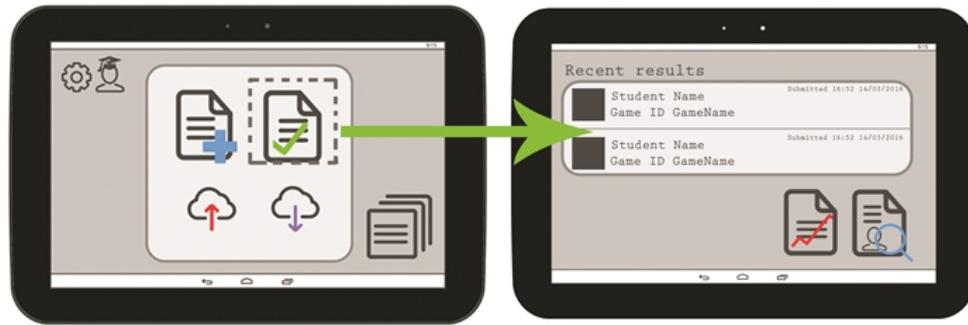


Figure 25: Assessment Functionality for Educator

through a database of online games, the educator will be able to search through their own personal quizzes from the device, select which they would like to share, add tags to it, such as name, genre and type and tap to upload it to the cloud.

In Section 2.4.2 Personalized Learning, Andersen explained her idea of implementing personalized learning to motivate students to go back to information. The goal of this system is to use these theories and findings such as *co-creation* and *personalized learning* to make a better system than the systems already available. Therefore using the knowledge gathered by Andersen, it was decided to apply personalized learning through the steps proposed by her, such as creating a new media, however aimed for educators. This will be achieved using the upload and download buttons, allowing educators to share knowledge with each other and therefore save time by reusing effective ideas from other educators. Through knowledge gathered from personalized learning theories and learning design theories described by Dalziel, the educator media is created and applied to the application. In this media, educators will have the opportunity to share information and experiences. This internet media can be referred to as the “educator cloud”, which could be accessed online and would adopt similar functionalities as “Facebook”, allowing educators to share ideas/quizzes/templates, like these ideas and comment on them. However, this paper will not focus on designing the internet media that could come with the application and will only focus on what the application can offer. The functionalities “uploading to cloud” and “downloading from cloud” will be available in the application and are connected to the “educator cloud”, where the templates are shared and downloaded from.

When taking a look at the student’s functionalities, it is possible to see that students cannot share games with other educators. The student is merely allowed to add new games to their own gallery, play them through and share their achievements within the game with other students. Looking at Figure 27 the interface for the student’s functionality of downloading a game can be seen. The student functionality is created to be simple and similar to the educator’s so that the educator can offer help to the students. As seen, the student can either click on the latest games which specific educators shared, ex. Biology or History, and the game will be downloaded to their gallery function. If they do not wish to scroll through the pictures, the students can tap to search for a specific game name, genre or teacher name, as the educators do when searching for games from other educators.

By looking at Figure 29 it is possible to get an overview of the connections and functionalities to the cloud. The educator should have the possibility of both uploading a game to the cloud and also downloading from a list of games who had been uploaded



Figure 26: Select to Download- Functionality and Download Functionality for Educator



Figure 27: Search and download game for Student

to the cloud by other educators. The educator is the allowed to play the game, share with their students and edit the game to their needs. On the other hand, the student can only download from the cloud and play the game. For both cases, the games are saved in the gallery and allows educators and students to add names, comments and notes to each game that can be seen inside the gallery. Games within the gallery can also be deleted by both educator and student, however the username and password will be asked for when deleting a game.

When accessing the results function for the student, the student is shown with the screen seen in Figure 28, with information such as a table with the most recent games they have played and results given to them, to the left the students and tap on the game or search for the game they wish to see the results for and their results will be displayed as the image to the right, giving them information on which were wrong and which were right. The interface can also show various information that teachers might consider useful, such as feedback and amount of points. What is also possible for

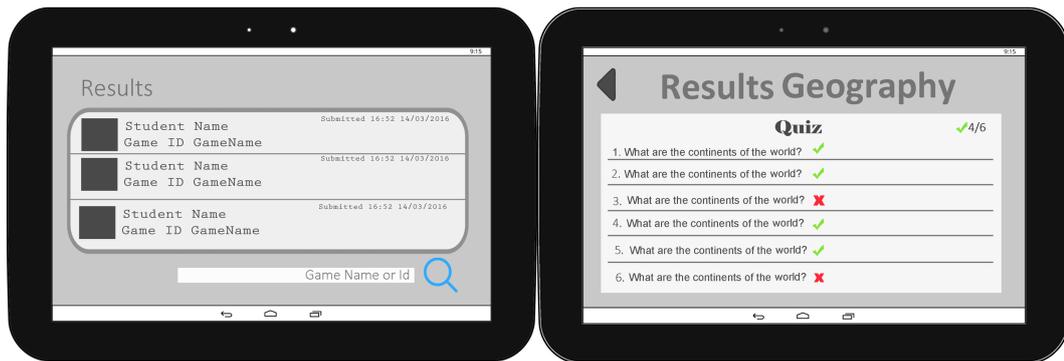


Figure 28: Results function for Student

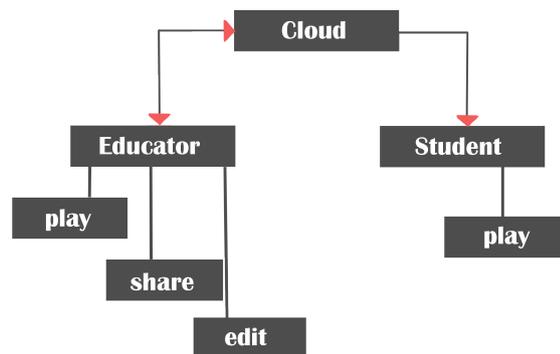


Figure 29: Cloud connections and functionality possibilities for both educator and student

the student, is to download multimodal plug ins which can be used for specific games. Such plug ins can be for example “*Vuforia plug ins*” which could allow the student to use augmented reality to play through the games. As mentioned in Section 2.5.1 Multimodal Systems, multimodality can be a lot of different types and just because it is available does not mean it has to be used. Multimodal input devices can be a wide range of types, such as:

- Speech
- Touch
- Joystick
 - Controller
 - Mouse
- Movement Tracking
 - Kinect
 - Leap Motion
 - Video Tracking
- AR/VR

When looking at the design aspects and the architecture (see Figure 15) a multimodal input method for this application could be speech. During the setup process when the educator has to input quiz questions or story elements, it could be a practical approach to use speech as an input method. Using speech would further improve the usability of the application and also increase the speed of input for the educators. During the

Investigation chapter it was mentioned that speech might not be ideal in a crowded classroom, this should not be a problem with the design described in this chapter as the educators should work on the quiz and content at home and not in the actual classroom. The same could be said for students wanting to use speech as a way of answering question at home. If the educator chooses to use the game as a homework, students can use the speech recognition at home to answer questions in an easier way. As the application is designed for a tablet, touch is an input method that is already there. Some people are not familiar with touch or does not have a lot of practise using touch, this problem can be overcome using an external controller such as a mouse or a game controller.



Figure 30: Example of a Leap Motion plug in.

Figure 30 shows how a Leap Motion could be implemented as a controller for the student playing the game of the application, represented by the *Game Play* component in the 15 architecture. The Leap Motion is a hand tracking device that can register movement and gestures. The example shows how the hand is used to track movement left and right to move the in-game character. The Leap Motion can also track up/down movement and a quick downwards hand movement could trigger a jump for the character. These modalities of controlling a character in game would be a possibility for students, however the educator is in charge to what type of games the lecture will include, such as quizzes using simple platformer games or adventure games to present a story or puzzle games to pose a problem solving challenge.

When using the “create a new template/game” functionality, the educator is provided with new functionalities and options that will be available to choose from in order to decide what type of game the students will play and what type of information the students will receive. These functionalities will be presented in the following section.

3.6.2.3 Educator Templates

This section of the design will describe two types of templates the educator can use, however ideally, templates can be added with updates to the application or by allowing the educator to download it from the server/cloud. This section will go in depth with the functionalities and interface the educator is presented when selecting a quiz or story template.

Figure 31 represents the interface that the educators will be faced with when trying to create a new game for their students. The educator can horizontally scroll through icons

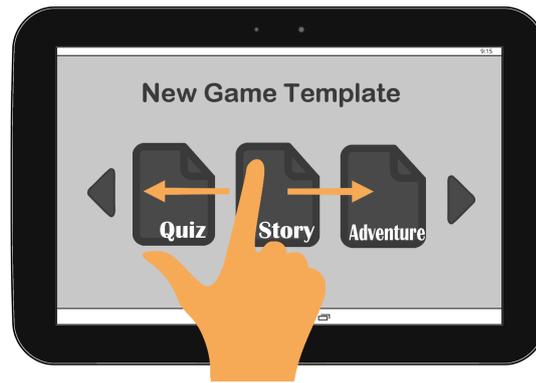


Figure 31: Templates examples

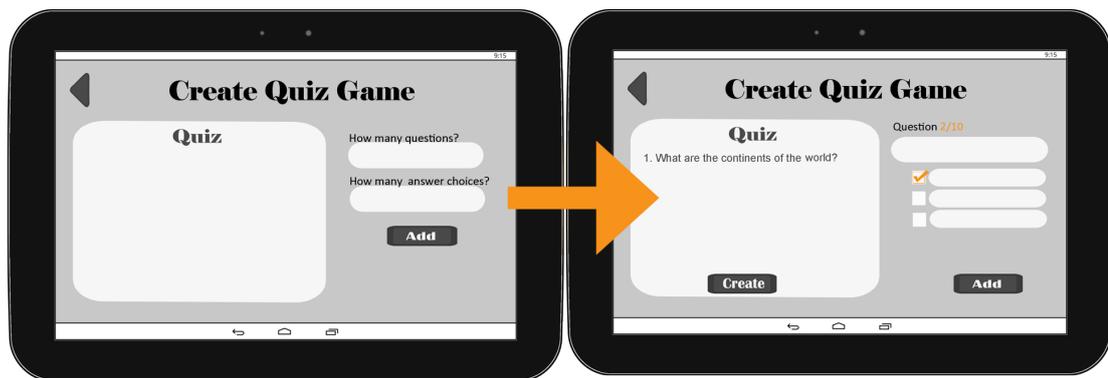


Figure 32: Quiz Template options

of templates, quizz, story or adventure, and then choose the specific type of template they wish to create. Based on what kind of skills the educators seek to test the students on, they can choose a template accordingly. For example, if the educator seeks to test the knowledge of a historical event, he can choose the *Story* template. Once they have chosen which template they would like to work with, another scene will open up with various options that can be chosen. Figure 32 shows an interface of the options which the educators are faced with when choosing to create a quiz. Firstly, the educator can choose how many questions they plan to add to the game/quiz and how many multiple choices each question should allow. Once this has been decided, the template continues and allows the educator to type in the questions within the text areas by tapping them and a keyboard popping up. They are also asked to select which of the multiple options of answers will be the correct one. If the educator forgets to choose the right answer, the application will pop up a reminder when the educator tries to add a new question. Once the 10 questions, or how many the educator planned to use, were created, the “Create” button will be clickable and therefore the questions added to the game. The educator can also personalize their game. After the questions are added, the educator is asked whether they would like to personalize the game or use a pre-made template. With this option, the educator has the opportunity to change specific colors, skins and themes of the game to match the subject they are testing.

The educator can choose to create a story as the template, Figure 33 represents the interface where the educator will be given the option to choose between various maps which have a game implemented for. Each of these maps show the course of action that the player will be going through when playing the game and therefore giving the

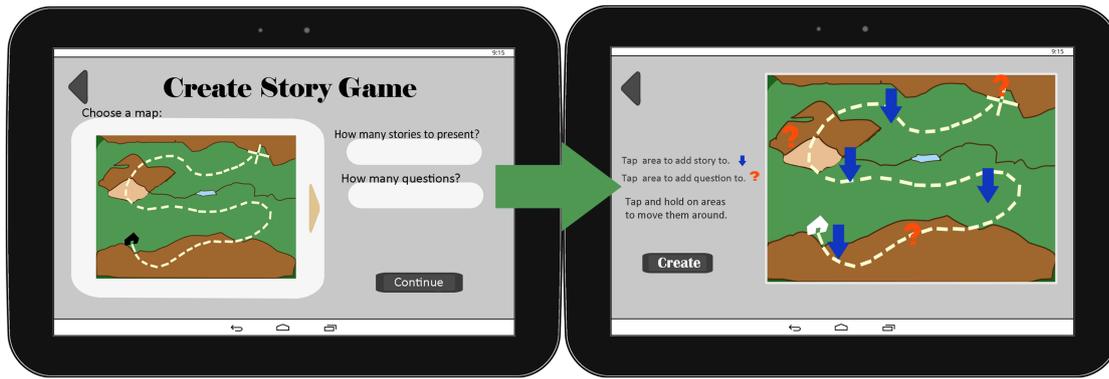


Figure 33: Story template

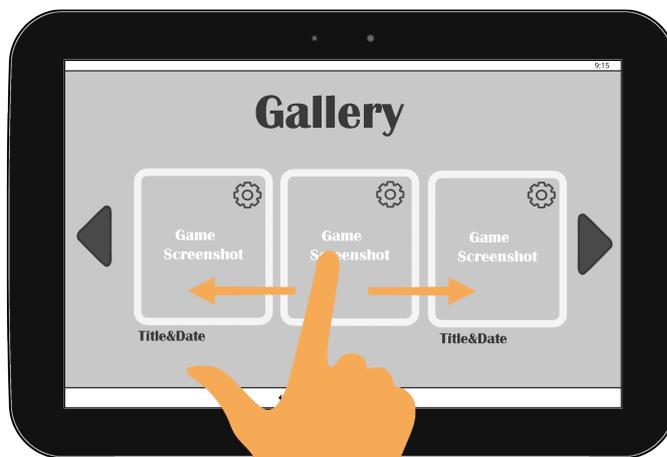


Figure 34: Gallery example for educator

educator an overview of how the game will evolve. Using this information, the educator can choose the type of map they would like the students to go through and input an amount of stories and questions that the students should face when playing through the map. Once they have chosen, they can press to continue to the next scene where they are faced with actually adding the stories to the map/game itself. The map will be interactive and allow the user to tap on the colored symbols to either; add a question or add story, respectively using the question mark and the arrow. For each symbol, a pop up window for text will show where they can input their desired information. Similar to Kahoot, these templates also allow the educator to use pictures, videos and sounds within their quizzes and stories. Once they finished adding the story for each component they also have the possibility of moving arrows and question marks around as they wish them to be displayed to the student. Lastly, when the educator feels that the story is complete and ready to be shared with students, they can create the game which will be added to their gallery. From the gallery, the users can decide what will happen with the games they have, the gallery can be seen in Figure 34. Each template saved within the gallery has their own settings button which will allow the educator to change the name of the file, share it with students or delete it.

Overall, there can be many types of templates in various combinations such as quizzes presented with an adventure style game and pattern recognizing challenges

player dies and needs to be resurrected. If they cannot answer right, they might not be able to continue playing. The goal should of course be for the student to want to play the game enough that they will prepare and do their homework, so the quizzes are just small delays in the game and not any big obstacles. As for the assessment information given back to the educator, this should not only be the answer the student gave, but also the time it took for the student to answer and how many times they have tried to reach the goal. A combination of these should give the educator a much better view of how the student is performing on the specified subject.

3.6.3.2 Adventure

Another style of game that would be useful to implement is an adventure style game. This style of game should be used by the educator to tell a story or teach a subject. This can be done through different types of adventures where the student needs to choose different paths in order to learn about different topics. The genre of adventure games is big and a template like this could either be very simple like the game *“The Oregon Trail”* or a more advanced game like *“The Secret of Monkey Island”* or *“Assassin’s Creed”*. These games all tell a story through the gameplay and offer options to the player to change or alter the story.



Figure 36: The Oregon Trail [MECC, 2012]

The Oregon Trail is a game from the 1971 that focuses on following the Oregon Trail in the US. As seen in Figure 36 the game uses simple graphics and at different points in the game offers options to the player for what they want to do.

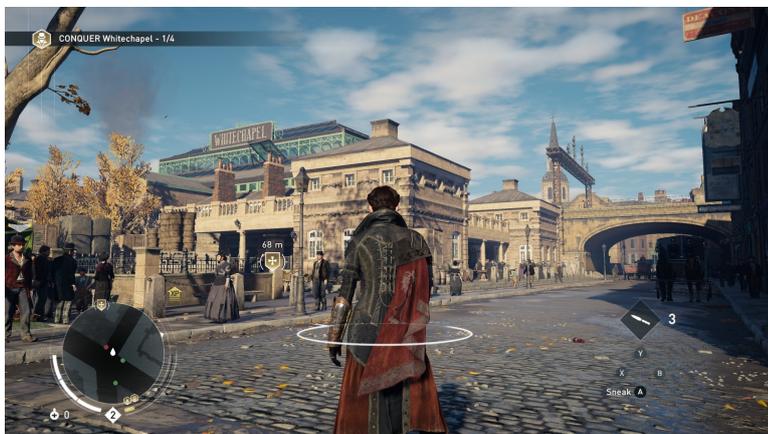


Figure 37: Assassin’s Creed [Dingman, 2015]

A much newer game is the Assassin's Creed series (see Figure 37) that has a huge focus on realistic graphics and tells the story of an assassin through various time periods such as the American civil war or late 15th Century in Florence, Italy. These games, while not historically correct, have a great deal of details and information from their time periods.

Implementing an adventure game like the above mentioned ones seems a good approach to engage students in a story and gameplay that will be interesting and fun at the same time. As the games should be adaptable to each educators needs, implementing an adventure game is one of the hardest genre to work with. These types of games often have very specific graphics and content to what story they are trying to tell. This is not like the previous example of a platformer where the gameplay does not necessarily have anything to do with the quiz content. The content/story could be told through Non Player Characters (NPCs) in the game and by walking up and talking to these NPCs the student will learn about a given topic.

3.6.3.3 Puzzle

After looking at two different styles of games where the students are controlling a player character in the game, this next game style is a bit different. It is possible to implement a game style where there is no playable character but instead the game consists of different puzzles. The student will have to answer questions as part of the game if they want a hint to how to solve a puzzle or before advancing to the next level.

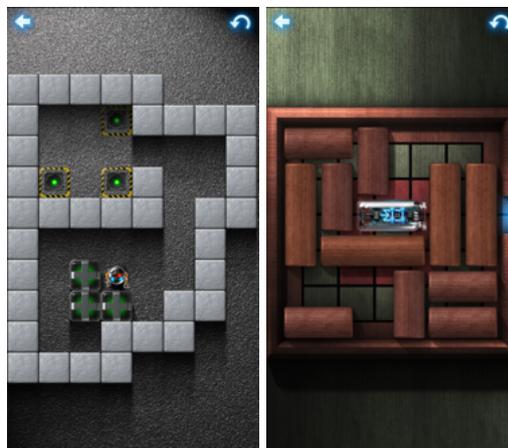


Figure 38: Two different puzzles from the game "The Heist" [tap tap tap LLC, 2013]

Figure 38 shows an example of two different types of puzzles from the iOS game "The Heist" [tap tap tap LLC, 2013]. These style of puzzle games can be incredibly hard but with just one or two hints, they can suddenly become easier. This will make for great games in a class room, if the students collaborate with each other as you really need to think about the solution. Hints can be incorporated into the game and be earned using quiz questions. Another way a quiz can be implemented into this style of game is to remove obstacles when a student has answered a quiz question correctly. Sometimes a puzzle can be near impossible but if a simple piece is removed it is suddenly a lot easier to complete.

3.6.3.4 *Story*

The last game style that will be discussed is a story based game, but not to be confused with the Adventure style. In this style of game the student will play the role of a writer and using in-game NPCs to guide to student and learn the topic.

The game should be a roleplaying game where the student is going through a story, it could be as a writer on a newspaper, and is tasked to write an article, letter or essay. The NPC in the game should be a kind of mentor and help with ideas and research while the student should write the text themselves. This might motivate students to work harder and better on a given assignment and the educator will be able to get the text from the student submitted online through the application.

Similar for all the style of games is that they need to be challenging and rewarding without promoting failure. Each of these genres have different aspects that can contribute to the educational scene when the goal is to create student friendly games.

3.7 CONCLUSION

During the Design chapter, various guidelines such as Interface Design, Learning Design and Game Design have been researched and applied within the design of the application. These guidelines have been used to create a set of design rules, which combined with the design requirements in Section 2.7 Conclusion, put focus on specific educational aspects presented in an architecture (see Section 3.6.1 Architecture). The architecture shows a clear overview of the application including which aspects are educator relevant, how these are interconnected, how the game should be created and how the users should interact with it. The design also focused on creating a full interface design of the application and the system connected to it. The overall design of the application can be seen in A Appendix, which uses arrows to connect specific buttons to their corresponding scenes, such as create new template or assessment functionality. The application is based on the winning factors presented in Chapter 2 Investigation and focuses on designing a user friendly, simple application that incorporates assessment functionalities and educational games for students.

A survey was also conducted during the Design chapter, which aimed to gauge the user's interest and understanding of various icons which were used for the design of the application. In the end of the chapter, a section about various game genres are presented. These genres are discussed in order to find interesting ways of creating educational templates for the application. These templates being the core of the application as it allows educators to use co-creation to personalize the games and the learning activities within their lectures to the types and genres of games each student likes to play. The design presented in this chapter is ideal, therefore the topics discussed in this chapter will be delimited in the following chapter to make it possible to test parts of the architecture and the goal of technology usage within educational aspects. Creating the application outlined in the architecture and the conceptual map is not within scope of possibilities for this project, due to lack of time and resources. Therefore a proof of concept needs to be made, which can limit the project to a more feasible application that can be tested and concluded upon.

4

PROOF OF CONCEPT

As the design and idea of involving gamification with education is a broad and large concept, it is wise to approach a specific part of the architecture and perform a pilot study on a smaller area. Therefore, it will be possible to test the preliminary idea and it will allow the continuity of the study for later research which will be thorough and on a larger scale. In this delimitation process, the focus that we would like to have is teachers, since it is clear that teachers do not get as much attention when it comes to technology and education. Educators play an important role regarding the possibility of students using technology to learn. Most research does not take in consideration the importance of the role that educators play when it comes to involving technology with education, educators can be the initiators of technology usage as they can be the core factor of educational change. [N. Bitner and J. Bitner, 2002] Through educators is the path of involving gamification in education and adapting new teaching methods to new generation's needs.

However, what has been noticed to be the problem with the evolution of this movement, is that educators have difficulty opening up to the usage of technology during class or as teaching methods. Another reason may be that change can seem an intimidating prospect and for some it might seem as though technology is unstable and unreliable, therefore one must think of ways of how to prove to educators that technology can be useful to them and it can be trusted to help them in the teaching process. Noel and Joe Bitner give various reasons which could be the issue to why educators are not likely to approach technology, such as the fear of change, lack of training with computers, personal use with technology, fear of failure, motivation to endure the process of change and lack of support in technical areas and curriculum [N. Bitner and J. Bitner, 2002].

Glenn A. Brand also presents issues to why it is difficult to implement technology in schools and one of the most important aspects of these is time. Brand believes that educators need to have a lot of time in order to be able to both prepare the curriculum required information and learn how to infuse this information with technology and do so too. Training and development is also dependent on time and is presented by Brand as an issue closely related to it. [Brand, 1997] However when looking through these problems mentioned, for example training, it can be said that this generation of teachers and educators have a better chance at understanding technology as it has become more common to use technology in daily life activities in this century, either using browsers, word documents or a smart phones. These daily activities have opened up for a better chance at the possibility of educators not being required to go through training of understanding technology in order to put it to use, we believe that educators do not need lengthy training but good guiding and simple straightforward interfaces to motivate them to spend more time with technology during their lectures. By making sure that the application answers to all the issues given by Noel and Joe Bitner and thus making sure that the application will give them a feeling of safety and avoid all chances of failure, motivating the educators by giving them good positive outcomes and

improvement to their tasks and making sure that educators will not require support for technical areas by making a friendly user interface.

Therefore, it is important to ask ourselves in what way we can break the barriers between educators and technology so that educators feel more motivated to use technology during their lectures. The pilot chosen will have this question as focus of evaluation of the proof of concept, as technology would be an important aspect to implement in an educational context and would greatly change the learning methods.

This question of breaking barriers between technology and motivating educators can be split into a short list of requirements, these being:

- User friendly application, create an application such that the educator does not require external help from developers to understand how to put the application in use or require training to feel safe and motivated to use during lecture.
- Time saving, create an application such that it does not take large amounts of time for the educators to prepare the information or quizzes for their lecture using technology. The involvement of technology during class should not require longer time to create as general teaching methods.
- Productivity increase, the application should show the importance of how technology can help both the educator and student in becoming more productive. This productivity can be achieved through learning in a better way or gathering more data in a shorter amount of time than usual.
- Assessment, by simplifying the assessment process for the educator it would increase the productivity of the application, make it quicker for educators to receive the results and give the educators feedback on what needs to be improved.

In order to approach these needs, the pilot was divided into the areas presented, such that each of these must be tested and see whether they can achieve the goal of breaking the barrier between educator and technology and motivate the educators to use technology as a teaching tool. This information leads to the supposition that, if the teacher finds the user interface easy to use, that it is more useful than using other learning methods and that it saves them time, it would be more likely to motivate teachers to use the application or technology in class.

The proof of concept will focus on two aspects of the architecture implementation in order to fulfill the four requirements presented above. These two aspects being the section which the educator will be requiring to navigate through and the section which gamifies the edited template into a personalized game for the educator. To be more specific, when looking at Section 3.6.1 Architecture, the project is divided in five areas that could be implemented to create the full ideal application, however from this point on, the paper will keep focus mostly on the educators and their needs, therefore the implementation will take in consideration the blue areas of the architecture representing the game creation and assessment. The two components of the architecture and the focus that they will have will be shortly described and separated into two areas, functionalities aimed at the educator and functionalities aimed at students created by educators.

4.1 EDUCATOR

In order to break the barriers between technology and educators using this application, the educator must be able to use the core functionalities offered.

Firstly, the educator will be allowed to create a quiz using the templates as this is an approach at creating a gamified experience for the students. The focus is placed on being able to create a quiz due to the assumption that every educator is familiar with using and creating quizzes for their students in class and will be able to understand what the rules to create a quiz are. Creating a quiz functionality will therefore not require extra guidelines for the educator and will be explicit to how to navigate through this functionality. A quiz is also chosen, as it allows the educator to have as much control over the assessment and knowledge testing as he would usually have when creating a paper quiz. Therefore, the educator will be allowed to choose how many questions they wish for the game to display and how many multiple choices the questions will have. Figure 32 on page 49 gives a visual representation of the components that will be focused on for the educator when choosing the quiz template.

The proof of concept will focus on allowing the educator to:

- Create a quiz
- Gamify the quiz
- Share the quiz with students
- Allow the students to play the quiz and send results
- Check results from the quiz
- Check Learning Analytics for the quiz results

Creating a quiz is connected to the educator choosing a template, as mentioned in the Design chapter, the educator can choose between various templates according to their needs of whether they wish to present a story to the students or test their knowledge through a test or a quiz. These templates can then be tailored to the educator's needs such as adding the story they wish to present or, in this case, the quiz questions they wish to test. Similar to the "*Collaborative Problem Solving Game*" system presented in Section 2.3 State of the Art, the game will be tailored according the educator's choice of questions and answers. However, in the situation that will be tested during the proof of concept phase, the educator can only change the amount of elements that trigger the questions within the game, as a quiz is not as complex compared to the mathematical problem solving game by [Al-Washmi et al.](#)

Once the educator is finished with adding the questions, he can continue to add the quiz to the game template and therefore creating the game, which he can share with specific class of students he teaches. Ideally, the students will have to play through the game to send data results to the educator and thus give meaning to the assessment functionality. The results open up a new functionality that will help the educator through the process of testing student's knowledge and therefore save time on collecting the results from quizzes, as the game will record the data of the amount of right and wrong answers for each student and give the educator the possibility of seeing this data. The design of this functionality can be seen in Figure 25 on page 45 and will represent the data for each student in a table where educator can tap or search for the specific student they wish to get better information about, information such as: amount of correct answers, wrong answers, time taken to complete the quiz, how many times it was completed and last time the results were submitted. Also in this part of the application, the educator can access the learning analytics which can help the educator see the how well the students perform and see whether the quiz is too difficult or too easy for the specific students. Similarly to the "*EngAGe Assessment Tool*" implemented by [Chaudy et al.](#), the assessment is separated from the game mechanics in order to be

able to support learning analytics. However, unlike the EngAGe tool, this application supports user friendly interface not requiring the educator to know coding language to be able to use the tool.

4.2 GAME

In order to fulfil the requirements set that the game should be generally approachable by any topic, it was decided to focus on a platformer styled game. The art style of the game could be dependent of the topic however in this case, the genre and play style should not be influenced by the topic as much. This is due to the fact, that the goal is for educators to be able to choose their own topics that they wish the quiz to approach and apply them to already existing template/games the application provides. Ideally, the application should have the possibility of always adding game templates, either by downloading them or updating the software as developers will focus on creating designs that could match any educational theme the educator might be in need of. Examples of such game templates can be seen in design chapter Figure 33 page 50. However, design templates of themes are usually represented by “skins” in games and other softwares. In this case “skins” can be topic specific for the educator. For example, in a scenario where the educator is a high school teacher for Biology and the topic of Photosynthesis is what he desires to quiz the students about, the teacher will choose the template that is most specific to this topic. Ideally, the educator would be offered a list of choices of what types of genres the games implemented allow him to create a quiz for his lecture. These choices can either be, for example, a platform game or a puzzle game (see Section 3.6.3 Game Genre). The educator may also choose a specific theme to the template he wishes to use for his lecture, in the case of Biology, the educator would be able to choose either: a color theme, a character specific to this subject, environment (background image, text on objects) or sounds, to suit the specific subject. All these components can be gathered under one setting which the teacher can choose, a setting named based on the subject area such as: Biology, Mathematics, Literature, etc. This setting being decided upon by the developers and designers, so that to make it less time consuming for teachers however still leaving it as a possibility for them.

4.2.1 Game Rules

Choosing a game genre and style that is very common, can bring the focus more on the educational part of that game rather than having fun with the game or understanding the rules. It has been chosen to use a platformer game as the proof of concept implementation, and to be more specific the platformer type of game will be Mario inspired and will include the majority of the rules Mario involves. This is due to making the game more general and to avoid having to give new information to the player and allow them to focus on answering the quizzes. The idea behind this game is that questions interrupt the game play when it is most convenient for the player so that the quizzes do not become too intrusive. A way to put the focus of the level in answering all the questions of the quiz, an achievement bar will always be available in the corner of the level as to remind the player to try to find and hit all the question boxes. (See Figure 39 for example)

To make the design more clear, a list of the available environment elements is made:

- Lives
 - Quizzes are activated when being killed by an enemy to allow the player to respawn at a closer location if the answer is correct, else start over.
- Enemies
 - Will cause player to respawn.
 - Are scattered all over through the level.
- Coins
 - Are given by Quiz Questions
 - Are given by Question Mark Blocks
- Blocks
 - Question Mark Blocks, can randomly trigger quiz questions.
 - Unbreakable blocks, who only block the player.
- Achievements
 - For gathering coins.
 - For answering the questions.

These elements combined should create a simple game, easy to understand by the student and also pose the questions which the educator have placed. In order to keep a general style to the game, the design must also be simple, however customizable. The game is inspired by a pattern recognition challenge, as the player is required to understand the moving platforms, calculate how far they are required to jump and decide which boxes their next goal will be. The game focuses on developing player skills such as timing, patience and precision all the while posing quiz questions which the educator presented within the template creation.

The proof of concept represents the design of the game as geometrical and only using shapes and patterns, keeping simplicity both in the design and the gameplay. Figure 41 represents the shapes and patterns that should be adapted within the game. The colors chosen are also simple and representative of the functions that each element is attached with. Overall, the theme of two main colors were chosen; orange and blue, these colors were chosen due to their symbolic representations as orange can stand for energy and excitement which are some of the feelings we intend the students to show when going through the game. Blue was chosen for two reasons, as a complementary color for orange thus creating aesthetically pleasing design and as it symbolizes trust and truth [Morton, 1997].



Figure 39: Example of how achievement information could be given to the student. Original image from the game "Mario Star Scramble 2".

The students are then faced with the challenge of jumping up against the boxes to trigger questions or coins which can be randomly placed by the developer or semi random, such that it can give some sort of control over the environment. Whenever a student jumps against a box within the level, there is a chance that it will trigger a question, this is a pop up with text and multiple choice answers, which pauses the game and giving the student time to read the questions and answer (see Figure 40). When a question from a box is answered, the head up display (HUD) will give feedback on whether this was correct or right. When a question triggered by character death, falling and by getting hit by enemies, the player has the chance to be revived back to their position if the answer is correct, however when this is wrong they are moved back at the start location and must jump through the full level. Therefore, it is wise to implement a hint system to wrong questions and avoid getting the player frustrated for reviving too many times at the start location. Players are thus also faced by the goal of reaching the end of the level without letting their character die. This is done by using simple joystick functionality placed at the bottom of the screen, allowing them to move left right and jump up. Currently, shooting the enemies functionality is not high priority and therefore will not be focused on.



Figure 40: Example of how questions will be given in game. Original image from Kongregate [Roger, 2010].

The level must pose a challenge and also create a balance between the difficulty of the level and such motivating the player to want to try again when failing to jump from platforms or walking into enemies. The game is designed using the information presented in Sections 2.4.1 Games in Education and 3.5 Game Design and therefore it promotes ego gratification and fun, as it has a rewarding system as coins and presents a constant reminder of the goal which motivates the player to keep going and find the end of the level. The level presents the components described by Ed Byrne [Byrne, 2004] and therefore the level begins at the left of the screen and ends on the right. The beginning is clear as it does not allow the player to move to the left and no platforms can be seen in that direction. The goal is made clear by presenting a HUD which is a reminder to the player of what the goal is, the HUD would show information of how many coins gathered and how close the player is to breaking all boxes within the game. The level design should be simple, however not too simple as to avoid getting the student to feel bored playing through the game.

4.3 CONCLUSION

The overall system is aimed to engage students in the learning environment, this project presented an approach of innovating the educational scene using technology. The sys-

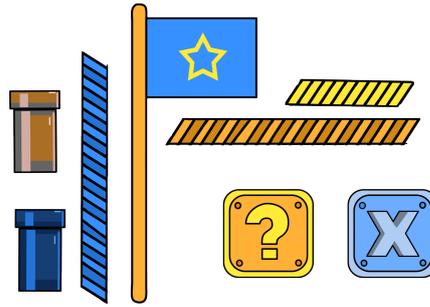


Figure 41: General design idea for elements within the game.

tem also aims to adapt to the new generation of learners who experience an abundance of technology in their daily life. Williams calls these generations *digital students* and describes them as students who present characteristics which have not yet been seen before in the youth generations. These characteristics involve the quick understanding of technology as they grew up with computers and mobile phones, being hypercommunicators, using various tools to communicate and multitaskers, who easily manage to do several things at once. Weller also discusses this concept in his book and points out the change that free access to journal articles, videos podcasts slideshows have brought to the educational environment. He also believes that students, in this age, have a better chance at approaching experts on the subjects they are researching into, through forums, social networks and blogs. Students are influenced by technology such that people can share their ideas and their work easily through technological means and thus Weller raises the question of whether the teaching methods used now are appropriate and whether education makes proper use of technology. [Weller, 2011].

Weller stresses the point, that blogs, social networks and content sharing sites are examples of approaches that emphasize learning and lecture participation compared to classroom presentations, for example. Therefore, it is ideal to use technology to create participatory classroom activities, which can connect students and educators and bring them into focused conversations over educational topics. Currently, when technology is used within class it is merely used as instructional tools to meet the learning objectives, however technology can be used for more than just as instructional process and can be adapted and bent to fit the personalized learning needs and requirements of students. Therefore, this system has placed the focus to be on educators as they have the possibility to enhance the digital students learning process by welcoming new technology and methods of using technology during lectures, homework or learning activates.

The system presented is large and presents many focus points that can be considered within this project, however, most approaches using technology as educational tool focus on the student's needs, this research will change this and put the focus on educators. Educators are the connection between students and knowledge and they can be the deciding factor of how this knowledge is presented to students.

To sum up, the proof of concept is only a small part of the full working application, this part will have as focus testing the four components which could motivate educators to implement technology for their lecture, the four components being user friendly, time saving, productivity increase and assessment process. By making sure the application is user friendly when navigating through the functionalities and the functionalities implemented are used for time saving activities, such as avoiding going correcting through every result and the game promotes learning by motivating the students. The components described in the Proof of Concept chapter have in focus the educator, however

the game genre and style is simple created ideally for a target group of students aged between 10 and 14 years old who attend grade-school and are able to read text and enjoy simple mobile games.

5 | IMPLEMENTATION

5.1 INTRODUCTION

The application is implemented in Unity using C# [Unity Technologies, 2016]. During the initial implementation stage various development tools were discussed. As the application is designed to be deployed on a tablet, two options seemed possible. Either the application should work on an Android tablet or on an iPad. In order to get native looking GUI elements the code should either be made in Java, C# for Android, Objective-C, Swift for the iPad. The developers have knowledge with Xamarin (C#), which has been used in courses to develop Android applications and Java has also previously been sparsely used for Android development. The developers do not have much experience with either Xamarin or Java for game development. For iOS one main concern was the lack of devices as resource to test and develop on. Android tablets were available to develop on whereas just an old outdated iPad was available, which would not be ideal to develop on. More so, developing naively in both Objective-C and Swift require a Mac, which is also not available. As the application should feature a game, the option of using the game engine Unity, was discussed. Likewise, the developers of the application have considerable experience with Unity and Unity also has multiple advantages such as a cross platform support. What Unity does not have however, is a native Android GUI that is easily implemented. Even without the native GUI, Unity was deemed the best choice. Later in the implementation section an example of how native pop up windows were implemented in Unity is shown.

5.2 APPLICATION

The program is build up using using approximately 25 scripts that each control various aspects of the application. Some scripts are used in each scene, such as changing scenes, controlling aspect ratio etc., and some scripts are very specific to control a single aspect of the game. During the implementation chapter, when code snippets are explained, the caption of the snippet will contain the script name in which the code is featured, in order to be able to find the complete script. The complete Unity project with all scenes, prefabs and scripts can be seen on Github at <https://github.com/drudoo/MED10>. The implementation follows the exact design presented in the previous chapter (see Section 3 Design), however, narrowed down to the proof of concept functionalities presented in Section 4 Proof of concept. Therefore, the goal of the implementation is to use the same icons and set up that the Design presents. During the design phase various icons were designed and tested as seen in Section 3.6.2.1 Interface Survey. The icons were implemented using the Canvas option in Unity by adding Button elements and attaching scripts to said buttons.

As many buttons are connected to different functionalities, a lot of the buttons are set up to simply change to a new scene. This is done by using the lines of code below in Code 1.

Code 1: Change Scene (ChangeScene.cs)

```

1 public void ChangeToScene (string sceneToChangeTo) {
2     SceneManager.LoadScene(sceneToChangeTo);
3 }

```

When the application first loads, the user is presented with a window that has three buttons that can be clicked on. One for the student, one for the educator and a sign in/sign up button. If the user presses the sign in button a pop up window shows where the user can input credentials. This sign in box should be connected to the cloud service as described in Section 3.6.1 Architecture. As this application is a proof of concept, the actual cloud service is not working and the mentioned sign in box does not do anything special than remember the username of the user who signed in for later use.

The educator button leads to a new window where the educator can check their profile and settings. They also have the option to create a new template, check assessment info from the students and upload and download from the cloud. If the educator pressed on the assessment button a new screen will be displayed with assessment info from each student in the educator's course. Pressing on a student name will display more detailed information about the student.

The overview of the students is created using a `BeginScrollView` function populated with `Labels` for the information and a `Button` for the name. A scrollview is a large view that has small on-screen area which the user can scroll in. The scrollview is an ideal way to represent a lot of data on the screen because the user can scroll through the table. On a computer the user can use the scroll bar to the side to drag up and down in the table but can also use the scroll wheel on the mouse to scroll. This, however, is not the case on Android. On Android the user can still use the scrollbar, though this is not as intuitive as it would be on a PC or laptop. In order to get some more native scroll feel on the Android using the game engine used to create the android application for the tablet, a custom touch scroll function is created called `TouchScrollView`.

Code 2: Scroll function (TableView.cs)

```

1 Vector2 TouchScrollView(Rect aScreenRect, Vector2 aScrollPos, Rect
  ↳ aContentRect, ref int aFingerID) {
2     aScrollPos = GUILayout.BeginScrollView(aScrollPos);
3     foreach (Touch T in Input.touches) {
4         if (T.phase == TouchPhase.Began) {
5             Vector2 pos = T.position;
6             if (aScreenRect.Contains(pos)) {
7                 aFingerID = T.fingerId;
8             }
9         } else if (aFingerID == T.fingerId) {
10            Vector2 delta = T.deltaPosition;
11            aScrollPos.y += delta.y;
12            aScrollPos.x -= delta.x;
13            if (T.phase == TouchPhase.Ended || T.phase == TouchPhase.
  ↳ Canceled) {
14                aFingerID = -1;
15            }
16        }
17        return aScrollPos;

```

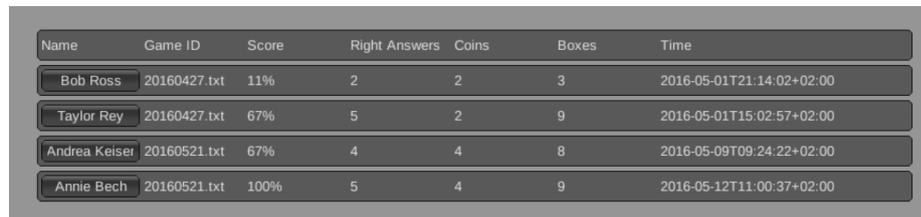
```

18     }
19     return aScrollPos;
20 }

```

Code 2 shows the custom scroll function. It takes the touch input if the finger is inside the assigned area, the scrollview in this case, and checks the finger ID and position. The position is then added to a Vector2 and returned. When the user then wants to scroll on Android it works more like native scrolling and the user can scroll anywhere in the scrollview and not just using the scroll bars.

Inside the scrollview there are rows of information about the students who took the quiz. An example of this can be seen in Figure 42. Here, four student's information is shown and the educator can press on their name to see more detailed information about their results and about the students.



Name	Game ID	Score	Right Answers	Coins	Boxes	Time
Bob Ross	20160427.txt	11%	2	2	3	2016-05-01T21:14:02+02:00
Taylor Rey	20160427.txt	67%	5	2	9	2016-05-01T15:02:57+02:00
Andrea Keiser	20160521.txt	67%	4	4	8	2016-05-09T09:24:22+02:00
Annie Bech	20160521.txt	100%	5	4	9	2016-05-12T11:00:37+02:00

Figure 42: Example of the tableview inside the ScrollView.

The tableview loads in the assessment information from the students by calling `ApplicationModel.assessment`, which is a string containing variables like name, correct answers, date and so on. These variable are separated by the non-visible character `\t` and each person's information is separated by `\n`. In order to display the information, the variables need be loaded into an array. This is done by first separating the lines using the `\n` character (see Code 3).

Code 3: Separate line using regular expression search

```

1 string[] lines = Regex.Split(scores, "[\n]");

```

Once the lines have been split up, each line has to be split again into separate words. Again a regular expression search can be made. Since there is an unknown number of lines (one for each student), a foreach loop can be used to iterate through the array.

Code 4: Separate lines info fields and display them horizontally

```

1 foreach (string _line in lines) {
2     string[] fields = Regex.Split(_line, "[\t]");
3     GUILayout.BeginHorizontal("Box");
4     if(GUILayout.Button(fields[0], GUILayout.Width(w1))) {
5         //display popup
6     }
7     GUILayout.Label(fields[1], GUILayout.Width(w2));
8     GUILayout.Label(fields[2], GUILayout.Width(w3));
9     GUILayout.Label(fields[3], GUILayout.Width(w3));
10    GUILayout.Label(fields[4], GUILayout.Width(w4));
11    GUILayout.Label(fields[5], GUILayout.Width(w5));
12    GUILayout.Label(fields[6], GUILayout.Width(w6));
13    GUILayout.EndHorizontal();

```

14 }

Code 4 shows how it is possible to split the array using `line` and saving it into the `fields` array and then each variable can be accessed using `fields[n]` command. First a button is created with a width of `w1`, then six labels are created and the process is repeated for each line in the array `line`. The length of each button and label is calculated based on the screen width.

When using the default Unity popup style, the design is not as appealing as a native style popup window. When working on Android, or iOS for that matter, there are specific design guidelines to follow when creating applications. These guidelines specify the look and feel of an application, but when using Unity, a lot of the UI elements don't follow these guidelines [Google, 2016] [Apple, 2016]. Because Unity is a cross-platform and supports so many devices, a lot of their code does not follow these guidelines. In order to create native looking popup windows, Android native code has to be used.

Creating a C# script in Unity, it is possible to use `#if UNITY_ANDROID` to define the start of a native Android function. Code 5 shows how an alert window is created.

Code 5: Native Android code for alert window (AlertPopup.cs)

```

1 #if UNITY_ANDROID
2
3 AndroidJavaClass unityPlayer = new AndroidJavaClass("com.unity3d.player.
   ↪ UnityPlayer");
4 AndroidJavaObject activity = unityPlayer.GetStatic<AndroidJavaObject>("
   ↪ currentActivity");
5
6 activity.Call("runOnUiThread", new AndroidJavaRunnable(() => {
7
8     AndroidJavaObject alertDialogBuilder = new AndroidJavaObject("android/
   ↪ app/AlertDialog$Builder", activity);
9
10    alertDialogBuilder.Call<AndroidJavaObject>("setTitle", mTitle);
11    alertDialogBuilder.Call<AndroidJavaObject>("setMessage", mMessage);
12    alertDialogBuilder.Call<AndroidJavaObject>("setCancelable", true);
13
14    if(answerA != "") {
15        alertDialogBuilder.Call<AndroidJavaObject>("setPositiveButton",
   ↪ answerA, new PositiveButtonListner(this));
16    }
17    alertDialogBuilder.Call<AndroidJavaObject>("setNegativeButton", answerB,
   ↪ new NegativeButtonListner(this));
18
19    AndroidJavaObject dialog = alertDialogBuilder.Call<AndroidJavaObject>("
   ↪ create");
20    dialog.Call("show");
21 }});
22 #endif

```

In the code, a new `com.unity3d.player.UnityPlayer` variable is defined and a new Java thread is started. This creates an object called `alertDialogBuilder` that can be used to set title, message and buttons of the pop up. Using `AndroidJavaObject`, it is possible

to get various functions from the default Android Java library and use those functions to create native interactions. This is used to create pop ups and better looking input fields. Pop ups are created for every student field input in the assessment table and will be used for other functionalities too, such as the quiz questions and error messages.

To change variables across the whole application a new script called `ApplicationModel` can be created. This script contains a public class called `ApplicationModel`, which does not extend `MonoBehaviour` as most other classes do. The `ApplicationModel` script contains public static variables that can be accessed from any script in the application. The educator scene shows a new button which allows the user to go to the settings. Inside the settings scene, there is a sound on/off toggle, which changes the global sound preference for the application. Inside the `ApplicationModel` a boolean is set for the settings scene which changes to true or false depending on the toggle and later on, the boolean state is retrieved to see if sound should be played or not in the game.

Moving on, the main screen of the educator allows other functionalities and one of them is choosing a template. When an educator wants to create a new quiz, they can access the *Create Quiz* interface as seen in Figure 43 and add in the questions for the students along with the answers.

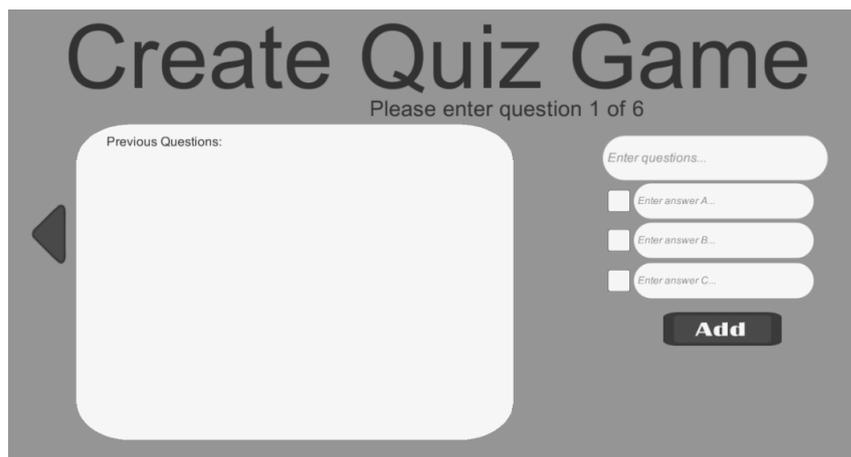


Figure 43: Interface for creating a new quiz game

These questions are saved in a file using date and time for filename. This is done using Code 6.

Code 6: Filename creation (`SaveQuestions.cs`)

```
1 string fileName = System.DateTime.Now.ToString("ddMMyyhhmm");
2 string filePath = Application.persistentDataPath + "/" + fileName + ".txt";
```

C# has a default library for getting the current date and time using Line 1 from Code 6. When saving the file, instead of hardcoding the specific file path, the application's data path is used. This can be done using `Application.persistentDataPath`, which returns the data path depending on the system. Each question is taken from the text boxes in Figure 43 and this is done using code 7. First, the gameobject called "*Question*" is found, then the text from the gameobject is added to a list. This is repeated for the three answers and once for the correct answer.

Code 7: Example of how text is grabbed from a textbox and saved.

```

1 GameObject question = GameObject.Find("Question");
2 _question = question.GetComponent<InputField>();
3 questions.Add(_question.text);

```

Afterwards, the five lists (questions, answer A, answer B, answer C and correct answer) are parsed to a new function called `saveEditor`. This function can be seen in [Code 8](#) and takes five `List<string>` inputs. The function then adds all the questions, answers and correct answers to a new list and writes them to a file.

Code 8: Save questions and answers to a file

```

1 private void saveEditor(List<string> q, List<string> a, List<string> b,
2   ↪ List<string> c, List<string> correct) {
3     try {
4       if (!File.Exists(filePath)) {
5         List<string> text = new List<string>();
6         for (int i = 0; i < q.Count; i++) {
7           text.Add(q[i]);
8           text.Add(a[i]);
9           text.Add(b[i]);
10          text.Add(c[i]);
11          text.Add(correct[i]);
12        }
13        File.WriteAllLines(filePath, text.ToArray());
14      }
15    } catch (System.Exception e) {
16      Debug.Log(e);
17    }

```

After the questions are created and saved, the game should be created. In [Section 3.5 Game Design](#), different game theories are explored and discussed, which were used to guide the implementation and design of the game. The game should have a start and an ending, in this case the start will be where the player spawns and the ending will be represented using a flag. The beginning of the level is placed to the left of the screen and the end is placed to the right. This way the player will have a natural progression from left to right when playing through the level. The goal of the level is represented using the mentioned flag as it is important for the player to have a clear goal to work towards. The level also incorporates different challenges, these challenges include moving platforms, enemies, doors and obstacles. In order to motivate the player to overcome these challenges rewards in form of coins or questions are given to players when they find boxes.

In the following section the game and the level design will be created. For this proof of concept implementation, a single level will be created using the game elements shown in [Figure 41](#) on page [61](#).

5.2.1 Game

The game is build using prefabs connected together to create platforms. These platforms are tiled together using the script seen in Code 9.

Code 9: Tiled texture to create platforms (TileTexture.cs)

```

1 while (yIndex < mapSizeY) {
2     xIndex = 0;
3     while (xIndex < mapSizeX) {
4         GameObject newTile = Instantiate(tilePrefab, new Vector3(
5             ↪ xIndex*0.55f, yIndex*0.5f, 0f), Quaternion.identity)
6             ↪ as GameObject;
7         tiles.Add(newTile.transform);
8
9         newTile.transform.parent = transform;
10        newTile.transform.name = "tile_"+i;
11        newTile.transform.position = newTile.transform.parent.
12            ↪ position+new Vector3(xIndex*0.55f,yIndex*0.55f,0);
13        i++;
14        xIndex++;
15    }
16    yIndex++;
17 }

```

The mapSizeY and mapSizeX is given in the inspector and can be seen in Figure 44. The script then instantiates a new game object and defines its position based on the size. The game object is then given a name tile_i where i is a number.

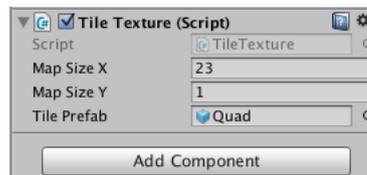


Figure 44: Define the platform size.

Since game objects are invisible in the Scene view in Unity, a new OnDrawGizmos function is created. This function draws a new cube where the gameobject should be. The code is similar to Code 9 and can be seen in Code 10.

Code 10: OnDrawGizmos function to display platforms (TileTexture.cs)

```

1 Gizmos.color = Color.green;
2 while (yIndex < mapSizeY) {
3     xIndex = 0;
4     while (xIndex < mapSizeX) {
5         Gizmos.DrawCube(transform.position+new Vector3(xIndex*0.55f
6             ↪ , yIndex*0.5f, 0f), new Vector3(1, 1, 1));
7         i++;
8         xIndex++;
9     }
10    yIndex++;

```

10 }
13

Instead of instantiating a new gamobject, a cube is drawn and will be shown in the game as seen in Figure 45.



Figure 45: Screenshot of platform in the Scene view

Also seen in Figure 45 is a question box. This yellow box has a Box Collider 2D attached and when the player hits it from below, a coin or a question will appear. Each box contains the same script that will load in the questions from a file, then randomly assigns the box to be either a question or a coin box. If the box is a coin box, then it will spawn a coin when hit and a counter in ApplicationModel will be incremented to reflect that the user collected a coin. On the other hand, if the box is a question box, then the first line of the file will be loaded in to a string variable, the second line will be loaded to another string variable for the answer A and so on. This can be seen in Code 11.

Code 11: Questions assigned to boxes (AskQuestion.cs)

```

1 void Start() {
2     if (Random.Range(0, 2) == 0 && coins < 5 && this.tag != "Player") {
3         coins++;
4         isCoin = true;
5     } else {
6         loadFile(); //test
7         mTitle = questions[0+count];
8         answerA = questions[1+count];
9         answerB = questions[2+count];
10        answerC = questions[3+count];
11        rightAnswer = questions[4+count];
12        count+=5;
13    }
14 }

```

Since each question box needs a new question from the file, a static integer called count is created. This variable will be incremented by 5 each time a new question box has been populated with a question. When the next question box then needs a question it will not take line 1, 2, 3 and so on, but instead line 6, 7, 8 and so on. Since a question is also presented when the player dies, the Player gameobject also contains the AskQuestion script. The questions are presented using the native Android code as seen previously in Code 5.

When the player has completed the game and reached the end (marked with a flag as seen in Figure 46), a score screen will be presented to the player.

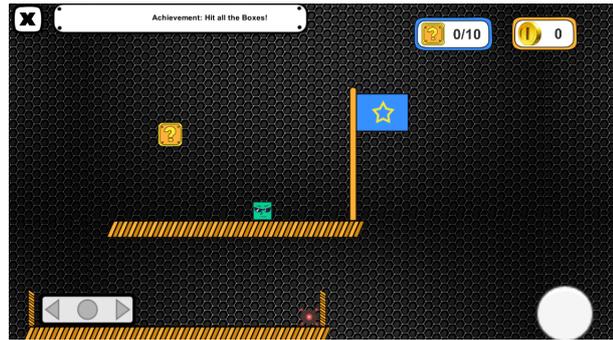


Figure 46: End of the game, marked with a flag

When touching the flag, the game ends and therefore, a score screen is presented with information that shows correct answers, wrong answers, coins, boxes and an overall score. (see Figure 47)

The score gives the player a good overall impression of their performance while not just focusing on the questions.

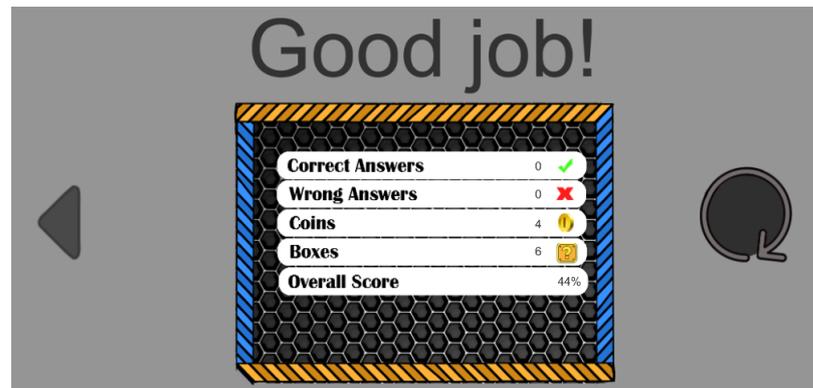


Figure 47: Example of the score screen.

Unity has built-in functions for player behaviour and collision detection which uses rigidbody, however, these default methods are not the best to use. Therefore, a new script called `Controller2D.cs` was created in order to create proper collision detection using raycasting. A *struct* is created for each object that contains the `controller2D` script. This struct holds public booleans that can be checked to see if the object (player or enemy) is colliding with something above, below, left or right. Four rays are created on two sides at a time, in the direction the object is moving horizontally and the direction the object is moving vertically. The object has a fictional skin width, in order to not get stuck inside other objects, so the rays are cast from the border of the object minus the skin width to the outside of the object at skin width length.

Code 12: Raycasting (`Controller2D.cs`)

```

1 const float skinWidth = .015f;
2 float directionY = Mathf.Sign (velocity.y);
3 float rayLength = Mathf.Abs (velocity.y) + skinWidth;
4 Vector2 rayOrigin = (directionY == -1)?raycastOrigins.bottomLeft:
   ↪ raycastOrigins.topLeft;
5 rayOrigin += Vector2.right * (verticalRaySpacing * i + velocity.x);

```

```
6 RaycastHit2D hit = Physics2D.Raycast (rayOrigin, Vector2.up * directionY,
    ↪ rayLength, collisionMask);
```

Code 12 shows how vertical rays are calculated. The variable `hit` can then be used to check if the object (with the `collision2D` script) collides with something else, if it does, `hit` can be used to check for tags as seen in Code 13.

Code 13: Collision between Collision2D object and tag (Controller2D.cs)

```
1 if (hit.collider.tag == "Through") {
2     //Do something
3 }
```

This command can then be used to check whether a player should be able to go through a platform.

5.3 CONCLUSION

Overall the implementation process of the application went well and, the implementation phase was completed in time for the testing process. The implementation was made in Unity using C# and Android native code for popup windows. Problems were encountered using native Android popup windows and inputs, which limited some of the functionality and user interface design. Specifically, a native popup window with an input field was created, the native Java code would not allow for saving the input text to a C# variable in Unity. For example in the application when user input is requested in a popup window for a quiz name or loading a specific quiz it was not possible to save the input text.

The ideal way of storing the data files would have been online, however, for unknown reasons the C#'s FTP upload method using `FtpWebRequest` would not work in Unity. This limited the user to only be able to work with the device's storage using `Application.persistentDataPath`, which is not optimal if multiple users should use the same quiz on different devices.

Using the design and guidelines gathered in the previous sections, the game development was completed successfully except for a few unknown bugs. When a user loads a quiz from the *Gallery* scene, the application encounters errors and is unable to load the questions into the game. This was a recurring problem, yet not one that happened all the time. This was especially a problem if the user died when the questions would be shown to resurrect the player. If the questions were not loaded, the user could not answer the question and would get stuck.

During the implementation, various bugs and problems arose, as mentioned above, however, these were taken as points to consider in future iterations and would have been solved if more time had been available.

6 | EVALUATION

This chapter will cover the evaluation process of the proof of concept developed and described during the implementation chapter. As presented in the implementation, the goal of the prototype is to break the barriers between educator and technology and thus achieve an ideal teaching environment where students can use their everyday knowledge and love of technology for learning. Therefore, the goal of the test is to evaluate whether this application covers the needs of the educator when it comes to using technology in class. By reaching the needs presented in Section 4 Proof of Concept, of creating an user friendly, time saving application which allows the increase of productivity through making an easier assessment process for the educator, it is possible to achieve this goal. Therefore the goal of the test involves gathering a sufficient amount of participant to give feedback on whether these certain needs are fulfilled.

As mentioned, the application implements a user friendly interface for both the educator and the student, the application allows the educator to gather assessment data from the students' results given in the quizzes they can easily create. Since the application allows the educator to create a quiz by simply preparing questions he would use for a paper quiz, it can be assumed that by using this application, the educator will save time for the quiz preparation while also involving technology. Other approaches, such as Kahoot, allow creating quizzes, however, our application also gives the opportunity of gathering individual data from the results of quizzes and implement the quizzes in a complete mobile game.

The test presumes that by creating an application that fulfils the needs presented (user friendly and time saving application, that also increase productivity) the educator will be more motivated to use technology when teaching, during class or as homework.

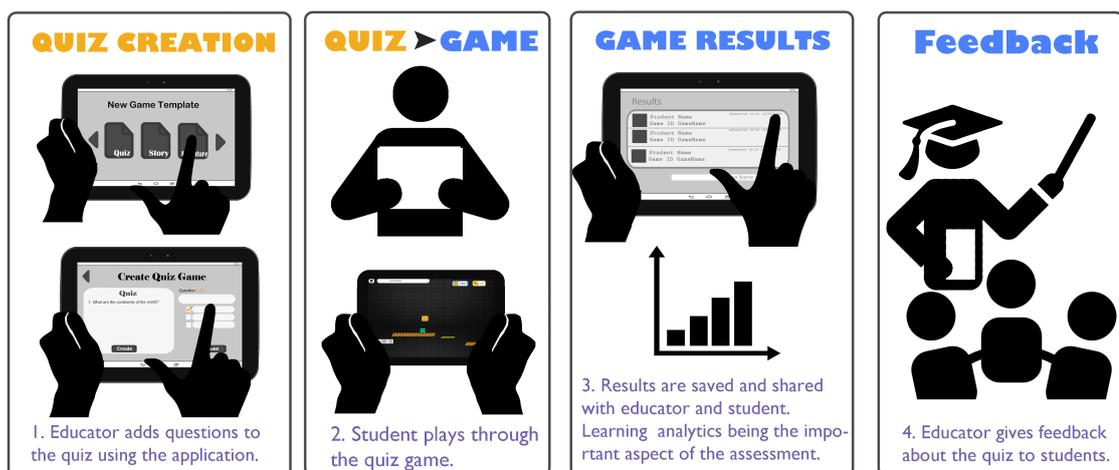


Figure 48: The process of the working system

Figure 48 is a step by step representation of how the system works and how a test in an ideal scenario would be performed. The first step representing the educator related functionality of creating the quiz, the second step no longer involves the educator once

this has released the quiz. The student will then play the game and answer the quiz created in the first step, lastly the educator will be able to use the results gathered from the students to get information regarding the quiz and the student's performance and therefore give written or verbal feedback to the students using this information. The last step of the system is optional, as the educator can use the information gathered to improve the quiz or the quizzes to come and avoid giving specific feedback to students.

The application can be used in different scenarios as it does not have a limitation on neither the subject in which it can be used nor the activity. Since the application supports a general approach to fit a wide range of educators and activities, the system can be applied in a classroom as a form of teaching a specific subject, or applied as a class exercise where the educator can stand by and offer help whenever students are in doubt of certain questions. The application is also designed to work from home and would ideally be also an option to use the quizzes created by the educators as homework, since the educator can check the data, results and struggles students encounter, online.

6.1 TARGET GROUP

The goal of the test is to evaluate the impact of the application on the educator's decision to use technology to teach and educate students about a certain subject. As data collection plays an important role on the analysis of the findings, it is important to define the target group in charge of giving such information, therefore a persona of an ideal test participant is given. The persona in charge of this decision is presented below in Figure 49 and gives an overview of the skills and personality traits a test participant would ideally require to possess. These traits are grouped by demographic, geographic and behavioural. These educators have limited knowledge with technology and therefore do not use many technical tools either at home or in class. As the goal of the test is to motivate educators to accept technology when teaching, the target group is represented by educators who are in charge of students, more specifically this application is aimed at educators who teach grade-school students who can read and who enjoy simple mobile games.

Participants are chosen according to a specific criteria; they must be educators, such that they have taught various classes on a specific topic multiple times. The target group participants have little knowledge with technology and have used simple programs such as Microsoft Word and know about websites like Facebook.

The persona chosen represents the majority of the characteristics that will be considered when gathering participants, therefore it is chosen that the sampling method that will be used for the testing is quota sampling. Quota sampling is a non probability sampling technique where participants are gathered according to specific characteristics, either gender, age or education, attributes who are relevant to the research question [Bjørner, 2015, p. 57]. In this case, the characteristics relevant are the demographic, geographic and certain behavioural aspects, such as limited technology knowledge. As the testing aims to get feedback from students as well, it is required to divide the participants in two sample groups, educators and students, the sampling technique that will be used is cluster sampling. Cluster sampling requires the researchers to select large groups of the population and then randomly sample individuals from these clusters. [Bjørner, 2015, p. 60].

Target Audience | Persona

John Doe

Age	Profession	Location
37	14 years of teaching Biology	Copenhagen, Denmark

Profile/Digital Habits

John frequently uses Office Tools such as Microsoft Word and Power Point to create presentations and quizzes for his students. He also has a Facebook account where he keeps in touch with his friends and family, he likes to upload pictures whenever he is on vacation. Due to these activities, John has an understanding of technology and using simple application so that functionalities as saving and creating new documents is a simple task for him.

Figure 49: A persona of the target audience for testing

6.2 TESTING METHODS

The test is going to be build up upon qualitative interviews and quantitative questionnaires. [J. W. Creswell](#) describes in his book *Research Design* three mixed methods for data gathering.

1. Convergent parallel mixed methods: qualitative and quantitative data gathering in parallel.
2. Explanatory sequential mixed methods: quantitative data is gathered and analyzed then qualitative data is gathered and analyzed.
3. Exploratory sequential mixed methods: Opposite of Explanatory, here qualitative data is gathered and analyzed first, then quantitative data is gathered and analyzed. [[Bjørner, 2015](#), p. 21] [[J. W. Creswell, 2004](#), p. 200].

For this project's test, the convergent parallel mixed method is going to be used. Qualitative and quantitative data is gathered during the same test where the test participant first is asked to answer a questionnaire then provide feedback in form of an interview. The two sets of data are then analyzed individually before their conclusions are combined to give an overall representation of the feedback. Qualitative research has been chosen because it is the most often used technique as it solves practical issues when working with small sample sizes.

Qualitative research is generally seen to have three main "problems":

1. Lack of statistical reliability and validity.
2. Cannot be used to disprove a hypothesis.
3. Are not representative and cannot be generalized.

These criticisms of qualitative research does not suggest that it is useless or less reliable than quantitative methods. If the research study is designed and evaluated with these concerns in mind, then a qualitative study can be just as reliable and valid, if not more, as a quantitative study. [[Bjørner, 2015](#), p. 22].

The qualitative interview that will be conducted is an "in-depth" interview. The specific type of "in-depth" interview that will be used is a "key-informant" interview, which

uses experts (“*key-informants*”) to get knowledge about the topic at hand [Lazar et al., 2010, p. 190] [Bjørner, 2015, p. 70-71]. The interviewer has a list of key topics and themes to ask the interviewee but it does not matter what order the questions are asked in. This way of conducting an interview is referred to as “*semi-structured*” and it helps the interviewer be more flexible in the interview. Additional questions can also be added in the interview based on the interviewer and interviewee’s conversation. [Bjørner, 2015, p. 87].

Observations are another form of qualitative data collection that will be considered for this evaluation. The goal of observations is to also get feedback and information about the application through facial expressions, body language and actions the users perform. The observations can be categorized in participant and non participant observations and mechanical or human. This evaluation will focus on over participant observations, which refer to the situation where test participants are aware that the researcher is present for the research. The researcher will be having short interactions with the user and the users are aware they are being observed. [Bjørner, 2015, p. 63]. Lastly, the observations will not be mechanical, recorded by a system or camera but will be human, observed and collected by the researchers.

The ideal approach at testing the application implemented is a diary documentation, as this can have a better chance at representing the motivation increase or decrease in usage of the application for the classroom. A diary is a document that records daily activities and relevant information about an individual’s life. A time diary can be more specific in regards of how much time participants spend using a specific software and through this type of information data can be analyzed [Lazar et al., 2010, p. 126]. Using this type of method can overall increase the validity of the results when used in conjunction with interviews and questionnaires. Since our goal is to get subjective information from teachers and learn how they perceived their experience with the application, how it impacted their day and how much time they spent on creating it, and lastly to see whether they feel motivated to use it, diaries as test method would give most relevant feedback for this type of research. Even though, diaries can be an ideal approach at testing this application, it also presents various disadvantages such as removing the possibility of having controlled time recording and thus not being as accurate. Another disadvantage could be that participants would forget to record in their diaries the information of using the application or how they felt using it. [Lazar et al., 2010, p. 130].

Lastly, a big disadvantage is the fact that it is a difficult approach finding participants to test this intrusive testing method as diary tests span over a larger time period, which would then require giving the application to the participants in good time to test. However, due to time limit and restrictions it will not be possible to use this testing method.

6.2.1 Test Scenario

Keeping in mind the persona presented, it is possible to create a test scenario based on this information and such present the steps to be followed when testing the application. Since the application does not focus on a specific subject to be taught and generalizes the subjects that can be used, the scenario will focus on the subject which the persona, John Doe, educates in and thus the questions would be Biology related.

The experiment investigates how educators interact with the application user interface, how they create their quizzes using the application and whether they make use

of the assessment functionality. The test can be split into two parts, a part where the quiz creation is tested and the part where the assessment functionality can be in focus. Firstly, the educator will be allowed to navigate and create a quiz. The first test will focus on getting information on creating the quiz, the interface and whether this makes sense to the user.

First test steps:

1. The user is presented with information regarding the testing process such as: What will happen, what is required of the user and how long this will last.
2. The user is given the tablet with the application open and notified which area to focus on and which areas are not fully functional.
3. The user is allowed to navigate through the application while being observed, the researcher will note down every mistake and issues the user encounters. The participant can opt to write a quiz, in this case about biology questions.
4. Once the user has finished going through the application (approximately 15 minutes of trying out), he will answer a short questionnaire.

The second test will then be performed after 2 or 3 potential students (or the developers) go through the quiz created by the participant, the focus will then be placed on testing the assessment functionalities. Second test steps:

1. Students will play the game and answer the quiz.
2. The educator is returned the application and allowed to navigate through new functionalities, such as the assessment.
3. The educator is allowed to navigate through the application while being observed, the researcher will note down every mistake and issues the user encounters.
4. Once the educator has finished going through the assessment functionalities and feels he has understood it (approximately 5 minutes of trying out), he will answer a short questionnaire.

Once these two processes are completed, an overall interview of the two steps will be conducted and questions regarding the assessment, quiz and game will be asked.

6.3 EVALUATION RESULTS

The test was performed on four educators and five students participated in the two test cases presented. The educators were seen as key-informants as described previously in 6.2 Testing Methods and gave feedback and subjective opinions on the usage of the application in the lecture. Each participant was allowed to navigate through the application for 5-10 minutes, asked to answer questionnaires and a semi structured interview was conducted.

6.3.1 Questionnaires

During the test, the participants were asked to answer a questionnaire. This questionnaire was largely identical when testing on both educators and students. It starts out with basic demographic questions such as age and gender. Since all tests were conducted in Denmark, it was not necessary to gather information about their country.

Below is a list of the first four questions asked. These questions are there to get a grasp about how technology savvy each participant is and how receptive to new technology they are.

1. *Do you use or have used a smartphone before?*
2. *On a scale from 1 - 7 how interested are you in using more technology in class?*
3. *On a scale from 1 - 7 how interested are you in using games in class?*
4. *Can you navigate through Facebook and create Word documents?*

Afterwards the participants are asked questions related to the application. These questions are there to see how well the participants understood different aspects of the application.

1. *On a scale from 1 to 7, how easy was it to navigate around this application?*
2. *Do you understand the assessment functionality?*
3. *On a scale from 1 to 7, how useful do you find the learning analytics functionality?*
4. *On a scale from 1 to 7, how much do you enjoy going through the results of the student's quiz?*

Next, is a series of multiple choice questions where the participant can select as many options they want. These questions are gathered from an article by [A. M. Lund](#) that talks about measuring usability. Measuring usability can be scaled down to Usefulness, Satisfaction and Ease of Use (USE), these three core components were developed after many questionnaires where users were asked to rate statements on a seven point Likert scale. The USE questions can be used to gather usability information about a given product and the questions can be seen in Appendix B [[A. M. Lund, 2001](#)]. These questions were given to the educators and students in order to gather usability information about the application.

The last three questions are yes/no questions about specific options in the application. These questions are there to help identify if the focus points of the application would be useful and used by the educators.

1. *Would you share your quizzes with other educators?*
2. *Do you believe using this application would save time on creating quizzes for your students and correcting them?*
3. *If you would have the opportunity to use this application for quizzes in class instead of traditional paper, would you use it?*

The above three questions were only asked by the educators. For the students, their last question was:

1. *Would you support the idea of using an application like this in the classroom?*

This question is a general question about the idea of having an application like this for the classroom. The goal with this question is to see if the students would even like to use this type of application.

6.3.1.1 Educators

The four educators were aged 24, 39, 46 and 47, which gave a broad variety of ages as to include both younger and older teachers. The educators taught various different subjects such as Math, Physics, Danish, Biology and Chemistry and three out of four had previously used a smartphone. When asked how interested they were to use more technology in class, the three participants that previously had used a smartphone had an average grade of 5.66 whereas the educator that had not used a smartphone before answered a neutral 4 (see Figure 50). On using games in class, the average was 6 (see Figure 51) and average of ease of navigating the application was 5.75.

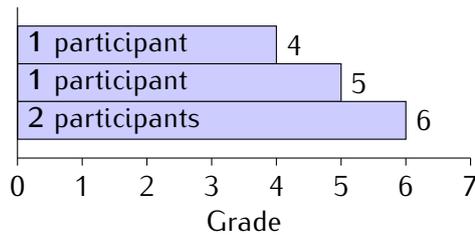


Figure 50: On a scale from 1–7 how interested are you in using more technology in class? (total participants = 4)

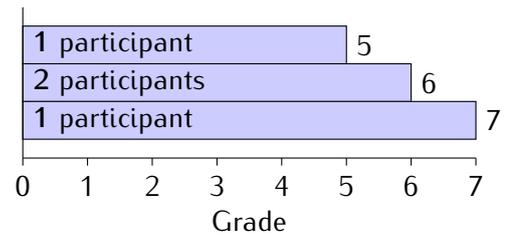


Figure 51: On a scale from 1–7 how interested are you in using games in class? (total participants = 4)

The same three that had previously used a smartphone also answered “yes” to being able to understand the assessment functionality whereas the one that had not previously used a smartphone answered “Don’t know”. The average grade of how useful the participants found the assessment functionality was 5 (see Figure 52). When asked how enjoyable it was to go through the students results the average grade was 4.25 (see Figure 53).

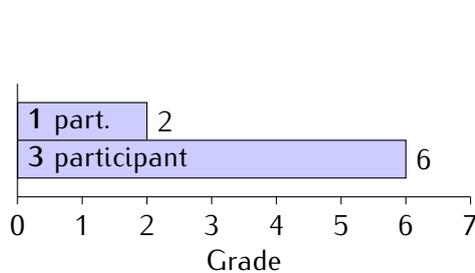


Figure 52: On a scale from 1 to 7, how useful do you find the learning analytics functionality? (total participants = 4)

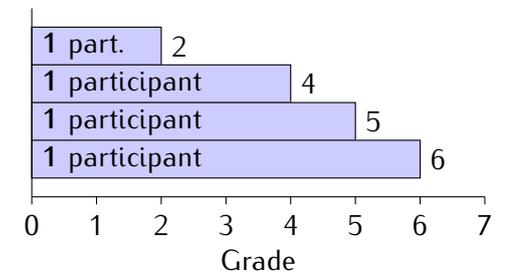


Figure 53: On a scale from 1 to 7, how much do you enjoy going through the results of the student’s quiz? (total participants = 4)

As mentioned earlier, assessment of the usability can be done using the USE principle [A. M. Lund, 2001]. This was done on the four educators and their individual answers can be seen in Table 3, 4, 5 and 6 on Page 108 in Appendix B Test.

When looking at the usefulness (Table 3 on page 108) all four participants agreed that the application was “useful” and “time saving”. Three participants also thought it would help them be more “effective” and that the application meets their needs. For Ease of Use (Table 4 on Page 108), the participants did not all agree on a single statement, but three of them did say it was “Easy to use” and that it would be “usable without written instructions”. When it comes to Ease of Learning (Table 5, on Page 108), three participants said it was “easy to remember how to use it” and that it was “easy to learn to

use it". Lastly the Satisfaction (Table 6 on page 108) has three participants answering that they would "recommend it", that it was "fun to use" and that it was "pleasant to use".

When asked if they would share their quizzes with other educators, all four educators said "yes". The same is the case for the questions regarding "time saving" and using the application "instead of paper", where all four participants answered "yes".

6.3.1.2 Students

As previously mentioned, the students are asked almost the same questions as the educators. All the students, aged between 21 and 20, had previously used a smartphone and they all understood the assessment functionality. When asked how interested they are in using technology in class the average grade was 6 (see Figure 54) and as for using games in class their average grade was 5.8 (see Figure 55).

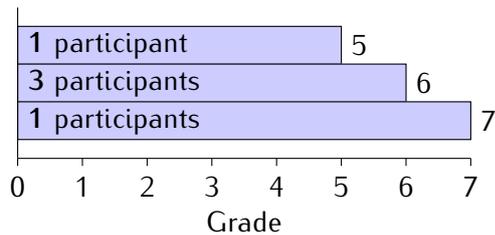


Figure 54: On a scale from 1–7 how interested are you in using more technology in class? (total participants = 5)

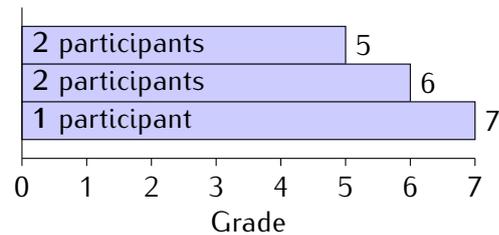


Figure 55: On a scale from 1–7 how interested are you in using games in class? (total participants = 5)

The students were also asked to rate how easy it was to navigate the application where the average grade was 5.6. The next two questions regarding usefulness of the learning analytics and how enjoyable it was to go through the results, the students average grade were 4.6 (see Figure 56) and 4.2 (see Figure 57) respectively.

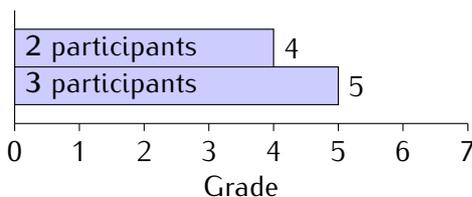


Figure 56: On a scale from 1 to 7, how useful do you find the learning analytics functionality? (total participants = 5)

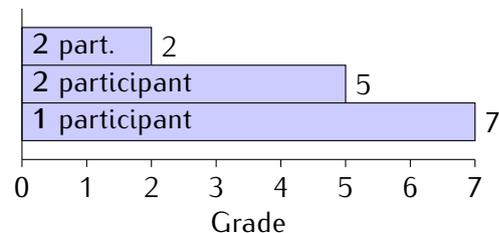


Figure 57: On a scale from 1 to 7, how much do you enjoy going through the results of the student's quiz? (total participants = 5)

One of the points of testing on students was to get feedback on the interface. Four out of five student said that the interface was confusing at some point. Their reasoning why the interface could be confusing was:

- "A little in the beginning, but I quickly got used to it. But for the "older" generation, text would probably be an advantage."
- "When making the questions, I did not know that they saved the previous questions, when you went out and in again, they are not displayed together with the new questions I make, so I made the same question multiple times. I did not remember to check of the right answer. I only thought about it when the test conductor said something about it."

- *“That I got into the student profile after having played one of the games through the Gallery as the teacher.”*

Looking at the comments, the students found the interface a little confusing when it comes to creating questions and moving through scenes as it bugged when required to show the data saved beforehand from the quiz. One student believed that using text as buttons would be an advantage for the older generation, however as the application is aimed for the target group who has little knowledge about technology and would be able to understand simple icons, such as profile and settings, this was not considered. According to further student feedback, more information around the creation of the quizzes would be useful. Another student also noticed a bug where the game is played as the teacher, but when exiting the user is displayed as a student. This sort of bugs can bias the test and cause confusion when it comes to usability experience.

The students were also asked if there were any functionalities missing:

- *“Naming the quizzes. See the total amount of right and wrong answers in respect to the total quick view guide of the game. I firstly noticed some of the states late in the session. Make the answer options to the question like buttons. That’ll make it easier to choose. Make them Highlight in the correct or incorrect color when answered. So the feedback is more direct and less subtle like the small text up in the left corner. I barely noticed it.”*
- *“Ability to edit quizzes.”*
- *“The teacher should be able to grade the students based on their test score, so the students would be able to check it on their own profile - not sure if it is there, but I didn’t see it. When making the questions, maybe have the go back button another place, I thought it was your way to see previous questions. Maybe have a copy question functions in cases where only small changes are made for the question. Edit function would be nice as well.”*

One student asked for the possibility to name a quiz. This feature was initially going to be implemented but because of difficulties using native Android code it was put aside for the proof of concept phase. Multiple students also mentioned the ability to edit quizzes or suggested improvement to the quiz interface, especially the toggle box that marks a correct answer, when creating a question was overlooked a lot during the test. As for the game, one student said that more direct feedback when answering questions would be helpful, such as the boxes changing color accordingly to the right and wrong answers from a question.

Four out of five students also said that the Upload/Download button was clear to them and that they would support the idea of using an application like this in the classroom.

When asked if the students would support the idea of using this type of application in the classroom, all five participants said yes.

6.3.2 Interviews and Observations

As mentioned, the test was performed on four educators who gave their professional input on the application while two of the educators have had as classes the target group students, and therefore have had spent time teaching 4th grade students and 3rd grade students, who have also stated that this type of application would be gladly accepted by these in class. Feedback from these teachers was welcome as it was aimed to

improve the application in a scenario where this would be focused on teaching 4th grade students, as the game is simple and easy to play. The remaining two educators tested on have stated they were in charge of university students and adults and therefore could not give feedback as specific to the type of game implemented, however their feedback regarding the overall application is not influenced by the age of the students they teach. During the test, both the educators and students were observed and interviewed for extra information that could be useful to improve the application implemented and get an insight of the idea of using this application as an educational tool.

The majority of the educator participants had limited knowledge with technology as intended of the target group, therefore proper feedback was gathered from both the observations and their comments throughout the testing. At the beginning of the test, the participants were asked to give input on the interface and it was noted that the majority of the educators had no problems understanding the buttons and their functionalities, however the cloud download and upload buttons seemed to confuse a few of the educators as they did not have much knowledge of the cloud term. On the other hand, one educator had guessed correctly the functionality of the cloud as she stated she had heard of it in the news and was able to understand it. Student participants asked about the interface, proved to be clear on what the button's functionalities were and managed to understand the interface solely by looking at it.

From the observations, none of the educators encountered any problems when attempting to create a quiz as the button that offered this functionality seemed clear to them. However, both the majority of the educators and students forgot to tap the multiple choice box for the correct answer after finishing typing in the question and answers. This could be solved by having a reminder written before allowing the educator to add a new question to the quiz, thus avoiding having users forget selecting the correct answer and requiring them to return to their previous question.

Few stated they would not trust using the application as homework since they did not believe that students have tablets at home and would not expect them to be able to use the application in that type of situation. They also believed they would require more time using the application in class so that students have a good grip on how to use the application and avoid encountering any problems with the application at home. After a while using the application in class together with the students, the educators would also have more trust in giving homework through the application for students.

6.3.2.1 *Feedback*

Throughout the testing, participants gave various feedback regarding additional features the application could involve and feedback regarding currently implemented features that they believed faulty or well working. Some of the educator participants specified that they would like to know what the game will allow the students to do before choosing to create a quiz, Therefore, it could be a good approach in making a trailer available for what type of games the educators can use as quizzes, which the educator can play beforehand to get an idea or another approach could be to have a short summary of the game when selecting the quiz.

One educator proposes to not involve the students into getting the game ID and just have the students assigned to the teacher receive the game in their gallery and allow them to press on the image which will lead to the game. She believed this would be easier for both the student and the teacher as she would not be required to spend time trying to help students through sharing an ID in class and avoid troubles where

students would not understand or misspell the game ID. In order to avoid troubling students to type in the ID, it could be a good approach having the educator perform the action of sharing the specific game and replace the create button for the student's interface with the gallery itself as seen in Figure 58. With this approach, students would not have to be confused about the ID they would have to type in. This type of situation would most likely occur with lower grade classes, however older students would not have troubles with typing in an ID, therefore the target group must be taken in consideration when using this application in an educational environment. Overall, there are various solutions that can be approached to solve an issue occurring with educators sharing their games with the students, such as using a QR code to share the game with the students and therefore making it simpler to scan the code and access the game.

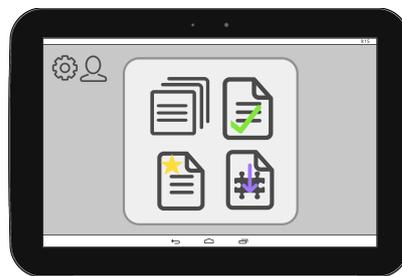


Figure 58: Improving the student feature by letting the educator control the sharing.

Feedback was also given for the assessment functionality, making it more specific about what type of results they wish to see from the quizzes and the majority of the educators want to be able to see, for each student, which answers they got wrong and which they got right. This can be achieved by representing the data for each student when tapping the specific student in the assessment table or when searching for that student. Another educator suggested other functionalities that could be useful for the pop up specific to the students in the assessment table, such as being able to message the students and see their absence history. Educators believe that the coins and boxes criteria in the assessment table is not relevant to them and were confused as to what it means to them as educators. Students did not show to be confused or bothered by this information, however as this information is not as important to the educators as it is to students, it is suggested to place the achievement results of the students as a lower priority in the representation for the educators. When it comes to the coins in game, educators have suggested to have the possibility to value the questions they create by setting a specific amount of coins that students can achieve by answering, harder or easier, questions when playing the game. This could motivate students to learn more and answer questions right so that to beat the highscore.

Another educator states that the application would have great success amongst her 4th grade students, however she points out that the current game would present a greater interest for the boys rather than the girls and it would be harder to adjust the games to fit both genders.

Overall, the majority of the participants believed there should be no restrictions when creating quizzes and educator should freely decide how many questions and answers there should be for each quiz.

6.4 LITERATURE COMPARISON

This section will compare the implemented functionalities of the system to research conducted within the educational field and other relevant papers that prove similar theories as the ones aimed to test within this paper.

6.4.1 User Friendly Interface

When thinking of interface design, we can include all the functionalities, features and methods of allowing the user to communicate with the system and the information system which aims to support the user in the activity. The goal of an interface is to enable communication between the user and the system and can impact the widespread and long term usage of a system. A user interface which is considered good and intuitive can predict whether the system will be accepted in a long term or will fail to be continuously used. Vincent Cho, T.C. Edwin Cheng, W.M. Jennifer Lai investigated the importance of perceived user-interface design (PUID) on continuous usage of e-learning tools [Cho et al., 2009]. E learning tools refer to programmes offered to students online to allow them to self-assess, whether at home, a café or library. These tools offer information about a specific course topic and mechanisms for self-evaluation, such as quizzes and tests for assessment.

Through the information gathered within this research, it is possible to assess various components of the educator system tested, one component being user interface. Since the goal of the test and system is to promote technological acceptance within educational environments it is possible to use information gathered by Cho, Cheng and Lai to point to the specific areas that should be taken in consideration when evaluating intention of continued usage of the system. As many user interfaces use menus and icons to enhance the ease of use and usefulness of a system and its different functions, the educator application also adapts the usage of big icons and menus to ease the usage of the system. [Cho et al., 2009].

Davis states that functionality of the interface should be related to factors as *“work more quickly”*, *“accomplish more work”* and *“make job easier”*, if the system manages to effectively enable users to achieve these goals the perceived usefulness of the system would be greatly enhanced [Davis, 1989]. Our application has precisely this goal and thus it was implemented as such that it should take a shortcut through areas as education, technology and games and combine them into a single application which will spare the educator the time to learn about technology which can be used in class and only requiring the educator to have basic knowledge of touchscreens and document creation. This application allows the educator to work more effectively by merging various functionalities and areas into a single process of creating a quiz.

Erik G. Nilsson’s research goes in depth with problems that are encountered when designing and creating mobile user interfaces and divides the problems into three areas: utilizing screen space, interaction mechanisms and design at large scale [Nilsson, 2009]. The paper not only points out the problems that can be encountered but also gives solutions for these problems. Based on these problems and solutions, an evaluation of the educator system implemented can be performed. One of these problems when designing for mobiles, is creating finger friendly menu choices, such as lists, buttons menus. According to Nilsson, standard button sizes are small for mobiles and he believes that bigger button sizes are better for finger use, the same goes with TextBox sizes and increasing the size of it will make it easier for the user to navigate the system.

Our system implements big sizes buttons and therefore makes use of the screen space. Another solution to finger friendly menu choices are checkboxes, which are also implemented within the educator system to allow the selection of the right answer when creating the quiz. Another aspect and problem to be considered and stated by Nilsson is long lasting processes need to be clear to the user that they are in progress, else the lack of feedback during waiting for loading a scene can cause the user to become impatient [Nilsson, 2009]. Therefore, our system implemented a loading bar for each action that required the educator to wait for a scene to load and therefore giving feedback on how much time this will take. The loading bars are implemented within each gallery when loading a game, as the games require more processing power and will take longer to start up.

6.4.2 Assessment and Quizzes

This section will use literature knowledge to draw attention to the importance of assessment in general and its connection to the usage of the implemented application. In his paper, Felix Kwan compared the importance of “one minute” papers to daily quizzes and concluded that daily quizzes provides a focused review of the topics presented in class. Quizzes play an important role in learning as researchers stated that responding to quizzes trigger learning since it pushes the student to the point of recalling information. Quizzes and testing students, are not just a means of helping the educators, but at the same time it is a way to helps the students during the learning process by motivating them to put greater effort in learning [Kwan, 2011]. The paper by Felix Kwan points out the importance of using quizzes as it promotes learning and states that students themselves confirmed the importance of quizzes, therefore the application puts a big focus on assessment and using quizzes as learning activities. These quizzes would be applicable both at home and in class, as it also aims to entertain students by using the gamification, students would then be more likely to enjoy to spend time on quizzes and therefore motivate them to study frequently. The paper also presents the time educators spend to create the the quiz and assess the quiz. He states that educators took about 15 to 20 minutes to grade quizzes handed by 30 students as these quizzes were more specific and was not required to read more focused questions and grade them. [Kwan, 2011].

Therefore, by considering the functionalities of the application, the educator would not be required to go through every result to check whether this is right or wrong and instead scroll through a table of 30 students while taking a look at a single table criteria (right answers) or use the learning analytics functionality to get an overview of the results. Instead of the action to grade 30 quizzes taking 20 minutes, the action could take far less time to get the overview and be ready to give feedback to students.

As presented in Section 2.3 State of the Art, the i>clicker also promotes the assessing functionality within quizzes and helps the educator save time when going through the results. Similar to Felix Kwan’s results that the quizzes promote student learning, the i>clicker studies also shown that using the quizzes lead to higher average grades amongst students.

Due to practicality of the assessment functionality, the i>clicker ended up being widely used within the US and has therefore changed the system of technological usage within class for 2 million students. Having this knowledge in mind and knowledge that the application implemented during this research also provides a practical assessment

tool by recording the data and allowing the educators to use this data, it can be said that the application would have the potential of greatly impacting the educational scene when it comes to usage of technology in class. However, when thinking budget wise, i>clicker is a multimodal system that requires the purchase of specific components in order to function. An advantage is that the application implemented within this paper requires a mobile tool such as tablets that can have other functions and does therefore not hinder the budget requiring the school to buy a component which cannot be used in other situations.

6.4.3 Systems Comparisons

The system implemented has focused on a small range of functionalities, which were compared and presented previously, however, the goal of the overall system is to offer functionalities which adapt theories for improving learning and theories improving workload for educators through the usage of technology. These functionalities can be analyzed and compared with systems researched in Chapter 2 Investigation. Nine systems were presented and their advantages and disadvantages in an educational environment were clarified. These advantages and disadvantages were based on the pretext of using technology for the learning process.

When comparing the game implemented with the described games; Space Chef, Motion Math and Angry Birds, it is possible to see that it was aimed for the implemented game to succeed where the described games showed disadvantages. Therefore, the implementation's goal was to be easy to understand so that the game adapted a common game genre and avoided using complex or new game rules which the player needs to understand. The game involves the teacher through the obstacles as the educator will be the one giving the students the possibility to reach achievements by creating quizzes. Unlike *Motion Math*, the game implemented is not limited to a specific educational topic, such as Mathematics, and quizzes created by educators can be fit to most topics. The overall system idea also supports a variety of game genres that can be adaptable to all types of educational topics, presented in the idea that the educator can download new game templates which will be generalized. For example there is a possibility of a *Story* template described in Chapter 3 Design, which can be used in scenarios where the topic requires more literature review.

When comparing the system with the i>clicker and ConcertStudeo, multimodal aspects have also been considered, however not for assessment process of gathering results from quizzes as i>clicker does. The system is designed to be an open architecture and to accept various multimodal inputs to engage students in the process of playing through the educational game. Examples such as Leap Motion for character movement was given, however multimodal inputs can be used for specific educational topics too, such as Vuforia for geometry theories and mathematical exercises.

Kahoot is the application with most similarities to the system that is designed in this study as it promotes gamified elements and reduces the workload for teachers through saving data results for quizzes. It is interactive as it allows students to vote on their own devices the correct answer for the questions, however, the system designed offers this functionality in a different approach, allowing the students to play a game while also answering the quiz. A drawback for Kahoot is that the application is limited to only creating quizzes while the system designed allows educators to give information to students through various different methods, such as story telling, quizzes, puzzle

aspects. Duolingo also uses gamified elements to motivate learners, as the system implemented is designed to do too. Similar to Duolingo, the designed system in this study supports the inclusion of achievements, making it possible for students compare their scores and show off achievements amongst each other. A disadvantage for Duolingo is that the assessment is not connected to the educators at all, so that educators have no impact on the learning process which is offered by the Duolingo application. The system implemented by [Al-Washmi et al.](#) was an inspirational system whose advantage allowed educators to edit the game which inspired the design of the concept for the system to allowing educators to edit the game they are going to use for quizzes. Lastly, the EngAGe tool provided an approach of how to develop the assessment functionality but unlike this tool, our system is user friendly and does not require coding knowledge to apply.

6.5 CONCLUSION

The results from both the questionnaires and interviews show that the application is considered to be user-friendly and useful. The application also appeals to all the participating educators and students, however due to bugs, participants expressed confusion at various moments during the evaluation. With a wide range of subjects taught by the teachers, the results also show that the application can be applicable in more than just a single subject. Overall, the educators were interested in using more technology in class and were definitely interested in using games and tablets with it. The educators also found the assessment useful, however, not so enjoyable in its current form. The students were more interested in using both technology and games in class, compared to the educators, however, educators also expressed positive ideas regarding the application. As for how easy it was to navigate, the average consensus was positive, although the students disliked the assessment system more than the educators, as they could probably not have seen how these can be used in a productive situation. If changes were to be made to the assessment system, and the overall application would follow the architecture, a new evaluation could be conducted and overall satisfaction towards the system might increase, this can be also seen through the literature used to evaluate the system in Section 6.4 Literature Comparison. Later on, the discussion of interviews, observations and biases will be thoroughly explained. Through the feedback from educators, it will be possible to note down points to be considered when working towards a complete version of the system, therefore, future aspects of how the application can be improved will be presented.

7

DISCUSSION

During the project, various technologies and theories have been applied and researched into. In Chapter 2 Investigation, multiple educational topics such as Games in Education, Personalized Learning and Mobile Technology have been researched. These topics led towards the Design Requirements in Section 2.7 Conclusion. The design requirements state that the application should incorporate co-creation, STEAM and gamification. When taking a look at these requirements, it is possible to see that the system designed and implemented fulfills the majority of these, since the application incorporates co-creation through the approach of allowing educators to be in charge of the creation of the quizzes and games for students to use as learning activity. Both the evaluation performed on the participants and the evaluation information gathered from research proved that the system adapts an user friendly interface which is simple and easy to understand. The requirements also state that educators should have access to every student's assessment results which was achieved both in the ideal system and the implemented proof of concept. The game approached in the proof of concept is general and fits any educational topic and it is not fully academized as it promotes entertainment. The learning session of the proof of concept is the same as the time taken to finish the level of the game, since the game can be completed in maximum 15 minutes, the requirement of creating short learning sessions is fulfilled. However, feedback received from the educators put a focus on missing functionalities of allowing them to have more control on editing the game. Another requirement that the proof of concept missed is to make the students reflect on their choices, though the game was not the main focus within the proof of concept implementation. Lastly, the application was also implemented on a mobile interface for an Android tablet. The educators also have easy access to assessment information from the students which is a major focus point in the design requirements. Overall the design requirements were implemented as possible in the allotted time.

Some of the first information mentioned in Chapter 2 Investigation is regarding the keywords used to define this project. These keywords are Gamification, Co-Creation, STEAM and Multimodal. When looking over the project, both gamification and co-creation have played an important role, as the application implements a game as well as tries to gamify educational elements, such as quizzes and homework. Co-creation is especially notable in the game creation where educators can customize their games to each individual course. Multimodal aspects are both discussed in Section 2.5.1 Multimodal Systems and will be discussed later in the discussion about future aspects. Multimodal plugins for an open architecture was deemed too ambitious for the scope of this project, as it would be very time consuming to develop and create a user friendly API to support the open architecture. STEAM, as mentioned in Section 2.2.2 STEAM and Section 2.3.1 STEAM, is a very broad concept, that is not explicitly implemented in the application, but instead just used as theoretical guidance when developing the application. Since the application is general and not limited to a specific topic, the STEAM elements can be implemented either by the developers or by the educators. These differ-

ent theories give a broad platform for educators to use and work with in the developed proof of concept.

The important aspects of the implementation were to focus on the educator. Due to lack of time and resources, the proof of concept evaluation did not allow for a long testing phase that focuses on both the needs of the students and the educators, the testing phase was limited on focusing on the educators and receiving feedback from qualified educators. As mentioned in Section 4 Proof of Concept, the application should be “*user friendly*”, “*time saving*” and “*increase productivity*”. As an important aspect of the application is user friendliness, this aspect of the application was one of the main focus points evaluated. The questionnaire used measured the usability experience of the participants by posing the question of how they would regard the application according to the usefulness, ease of use and ease of learning. Based on the answers, it is safe to assume that educators consider the application easy to use while both educators and students consider it useful. In order to make the application time saving for the educator, it was important to give the educators an incentive to use this application. This was done by making assessment functionalities and a simple approach at creating gamified knowledge. After the students play a game, their scores, correct and wrong answers and time will automatically be added to the educators profile. This will greatly decrease the time the educators need to assess the students after a quiz and should be a motivator for the educators. Therefore, by being time saving it will also increase productivity.

The proof of concept implemented contains functions for the educator to create a new quiz, play through a game, and see assessment information from each student as well as overall assessment information on all the students that took the quiz. As for the student, they only have the possibility of playing the quiz created by the educator and are currently unable to create games themselves. However, it can be a good approach at allowing students to create quizzes and games using this application for themselves or their fellow students. Such that, students might feel more motivated to learn by trying to solve a quiz created by their friend who has had a better understanding of the subject at hand. This approach would give the possibility of implementing co creation within this application, however this might lead to causing confusion in the simplicity of the current interface of the system. An example of how confusion could be caused is mistaking quizzes created by other students with quizzes created by educator as young learners might not pay as much attention to the difference. Therefore, in order for this functionality to be a possibility, a new interface design for the students would require to be approached.

In Section 3.6.2.1 Interface Survey, nine different icons were created and 30 participants were asked their input on how they perceived these icons. Most participants found the icons easy to recognize and especially the cloud upload and download icons were considered to be the easiest to understand (see F and G in Figure 20 on page 42). Although this was not the case for the survey, when evaluating the project in Section 6.3.2 Interviews and Observations, three of the participating educators did not know what the cloud buttons should do. Due to the initial survey it was believed that most people would find specifically the cloud icons the easiest to understand, but the combination of less technological knowledge and upcoming technological terms made us realize that using the cloud icons might not be the ideal way of showing upload and download functionalities to educators with little technical knowledge.

During the evaluation with the educators, multiple elements mentioned in Section 6.3.2 Interviews and Observations were taken into consideration. Especially observa-

tions about how the participants used the interface were interesting. The majority of the participants did not use the multiple choice buttons to mark and select the correct answer, which resulted in them not being able to choose the correct answer and therefore getting a wrong answer on the majority of the questions when playing the game. This puts focus on the importance of designing a clear interface which would make sense to the user. During the design phase, this possibility was considered and a design solution was offered, such that it would not allow the user to continue to the question before reminding them to choose the right answer.

The evaluation brought up various bugs that had not been noticed beforehand. Bugs cause biases that can affect the overall acceptance of the system and bring fear of failure to the educator's mind and be less prone to give an accepting opinion of using technology in the class. The interviews pose the question of whether they would use a system as such in their class and the majority of the participants are positive about this approach, however when asked whether they would use this as homework they were not as open to the idea, which can also be due to not trusting the system because of bugs. A bug was also encountered when trying to reopen a game. When loading the game, the application looks for a corresponding text file that contains the questions and answers to be shown in the game. This is done using a static variable for each box that is incremented whenever a question is assigned to the box. The static variable works well when trying the game for the first time but as soon as the player replays the game, since the variable is static it stays the same, the questions are not reset and when the player wants to play another level or use a new quiz the game thinks no questions were assigned to the boxes. During the test, multiple participants rejoined the game which caused problems when they wanted to test the questions. This bug could cause the educator or student to think there is not any questions saved and they might try and write the same questions again or waste time trying to figure out what the problem is. Therefore, a bug as such could bias the results in the way that the participant could assume the system is confusing or not working properly and therefore change their view on accepting the system in an educational environment. Another bug discovered was that when leaving the quiz creation after creating few questions and returning to it, the system does not visualize the the questions anymore, however remembers them and numbers "new" questions incorrectly. Therefore, this type of bug can cause the educator to be confused with the functionalities of the application and feel less prone to use it.

7.1 FUTURE ASPECTS

This section will present various points discussed to be considered in a future perspective of the system and application. These aspects were gathered with the help of the literature research and feedback received during the evaluation process.

7.1.1 Game Personalization

As mentioned in Section 4.2 Game it is also possible to implement the idea of "skins" in a future version. This way educators could theme the application to a specific topic. This could change the complete appearance of the application and the game elements. When looking at the game elements designed in Figure 41 on page 61 the design, colors

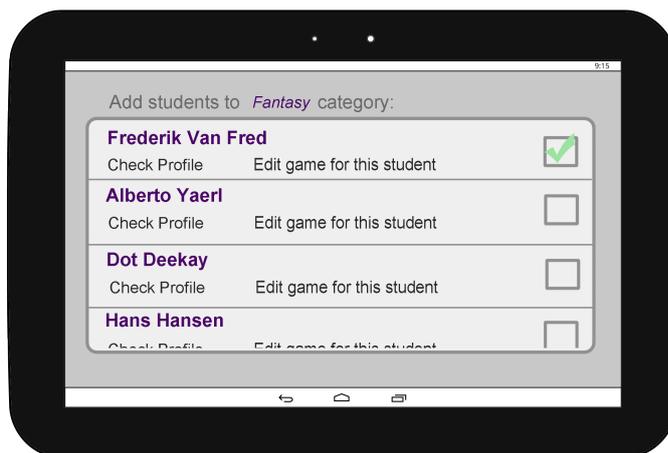


Figure 59: Example of Interface to allow game personalization

and shapes are very neutral in regards to subjects taught in school. This could be changed by changing the shape of the boxes to look like atoms in chemistry or make the platforms have letters or numbers on them in language or math class respectively. This would not change the functionalities of the game but it would change the perception of the game and allow for the students to see something different depending on the subject of the lecture. This type of approach can also be considered when thinking of personalized learning. The educator can use personalized information from each student to edit the game accordingly for the student they are sending the game to.

For example, this approach can be improved by having a field/functionality for students to add information to the system about themselves, such as favorite color or movie or book and similar, which can help the educator to personalize the game accordingly. In a case where a student enjoys fantasy books, the educator could personalize the game to use fantasy elements such as dragons, castles and treasures instead of geometrical and simple colors of graphical interface. Of course this would take more time for the educator to do so, however this can be clustered based on color, genre or other and categorize students accordingly, this type of information can be then be selected by the educator when releasing the quiz to the students. Figure 59 is an example of how the functionality of categorizing students can be placed in an interface in the full system. In this scenario, the buttons can be replaced with corresponding icons, such as, visit profile for student icon or edit game icon. The categorization can also be done automatically, instead of having the educator organize the students themselves.

7.1.2 Connect Students to Educators

In regards to other aspects of the design for the application, an important change would be the implementation of cloud infrastructure that would allow for educators to connect better with their students. As mentioned by one educator, it would be useful to be able to add students to the educator account and that way the educator would push games to the students accounts instead of having the students download the games themselves. This would allow less freedom for the students, but would help the educators greatly as it would give them more control of what content is accessible to the students, especially for young learners.



Figure 60: Example of i>clicker's live result system [i>clicker, 2016].

7.1.3 Live Results Updating

An aspect from the Section 2.3 State of the Art that would be useful to implement and a point one of the educators asked about, is live updating of results from the students. The SRSs i>clicker and Kahoot are based on live results from the whole class streamed directly to the educators account. One educator in the evaluation asked if this would be possible to implement, as it would help her see how far each student was and would be able to use the time when students are playing through the game on other productive activities and not require the educator to become a strict supervisor. Often, when students work on their own the educator can sit and correct old assignments or read paper but if the educator got direct assessment information from the application, they would not need to correct assignments. Instead, if the educator can follow along in the game progress then they should also be able to see which students has problems with what questions and prepare for what topics should be discussed later in class.

Figure 60 gives an example of how i>clicker implements their live results system. The educator has a list of all students on their device and as soon as a question has been answered the result is logged and the educator can see how many students answered what. The system implemented can approach this aspect similarly and give the educator a new functionality to access through a button which gives them live feedback of the quiz process.

7.1.4 Open Architecture

As mentioned in Section 2.5.3 Open Architecture the application should be an OAP. The scope of the project did not allow for a proper open architecture to be implemented. This section will however describe how it would be possible to implement. Examples of two types of plug-ins that can be made for the use case are:

- Game Controller: Creating another input method for the game.
- File handling: Developing a new way to save files in the application.

As it is, the application is made for a tablet and the controls are done from touch input on the tablet. The input is simple as seen in Code 14, the user can either give input from the keyboard when playing the game in the editor (this is also the case for standalone Windows and Mac application) or on a tablet where `dirH` and `dirV` corresponds to the touch buttons.

Code 14: Input method

```

1 #if UNITY_EDITOR
2     input = new Vector2 (Input.GetAxisRaw ("Horizontal"), Input.
        ↪ GetAxisRaw ("Vertical"));
3 #elif UNITY_ANDROID
4     input = new Vector2 (dirH, dirV);
5 #endif

```

If a developer wants to change the input method to an Xbox controller, there is a get/set function for these inputs (see Code 15).

Code 15: Input get/set function

```

1 public Vector2 getInput() {
2     return input;
3 }
4 public void setInput(Vector 2 _input) {
5     input = _input;
6 }

```

The function for setting the input just needs to be called whenever the input changes. The same can be done using physical buttons, leap motion or kinect, the only information that the developer needs to keep in mind is that the Vector2 needs to contain values from -1 to 1 . If a constant speed is needed in either direction then 1 is a fine value, but if something like a bend sensor or a potentiometer is used for the input values, then the raw analog value of these sensors can be used as the direct input into the vector.

The developed proof of concept uses a predefined scene to write down the questions in a text file, that is then saved on the tablet. This can also be customized by a developer if he or she chooses to create a plug-in for better accessibility.

Code 8 on page 68 shows how the questions are saved in to a file. The filePath variable is a string that uses the application's data path and a file name (`Application.persistentDataPath + "/" + fileName;`). By changing the function from private to public the plug-in developer can call this function, which is part of the API, and give it five Lists of strings that contain the questions, answer a, b and c and the correct answers. The application will then check for the filename and save all the questions and answers in the text file. The developer could develop a webinterface, using this API, for creating questions or create a scanner plug-in that would read a paper of questions and add them to the application. There are a lot of different possibilities when working with an open architecture that has an API to integrate new plug-ins with. The above mentioned examples are just two out of many that would be possible to implemented in a future version of the product.

Overall, the future aspects section gives a few of the main points to be considered in an iterative process of this study. These aspects were encountered from feedback, research and iterative processes and are both presented in regards of the design and the functionalities that would improve the overall system.

8

CONCLUSION

The thesis inspected a technological approach to cause change in the educational environment. Therefore, the goal was guided by the question of: *How can we use technology to improve the educational environment and make learning more engaging for students?*

The Investigation chapter used these points to present relevant keywords to narrow down the issue and researched into existing systems and described research approaches, which aimed to include technology as an educational tool. This chapter also investigated Education and Technology as guiding terms and described relevant theoretical aspects within the educational field. Lastly, the Investigation presented a survey with contemporary information regarding usage of technology in education and concluded on a list of requirements for the design of the system, which could become the solution to the issue stated.

The design chapter continued by presenting the idea of the full system which aimed to engage students and motivate educators to use technology. Therefore, the chapter is split into two main topics relevant to achieving the design of the application: Guidelines and Application. The first topic approaches relevant theoretical protocols to the design of simple applications and entertaining games, which are later used in the Application section. This section presents an overall architecture of the system, splitting relevant functionalities into components relevant to educators and students. It later designs an ideal interface which the system could adapt in the developing process.

As the system presents a broad idea and can be approached in many different ways, by focusing on various theories and target users, the thesis selected a feasible part of the architecture to be implemented and evaluated as a proof of concept within the time limit. The proof of concept chosen was based on research regarding barriers between educators and technology. [N. Bitner and J. Bitner](#) investigated and presented the reasons why usage of technology in class can seem an intimidating process, such as training, fear of change or lack of motivation to endure change.

The thesis approached these issues with the goal of bringing solutions to these intimidating prospects that hinder the usage of technology in class and therefore the issue was narrowed down to the question of: *How can we help and motivate educators to use technology as a learning method during class?*

Therefore, requirements selected to be implemented for the proof of concept were to create a simple user-friendly application, so that it allows educators to use the application without need of training or external help. It was also decided to add functionalities that help the educator by decreasing the workload they must perform when assessing quizzes and thus rendering the application to be productive. The implementation of the concept was then based on the theoretical guidelines and design created within the Design chapter. In the Evaluation chapter, the proof of concept was set as focus and therefore evaluated on qualified educators and on students, however, the full system was not ignored as the conducted questionnaires and interviews presented the idea to the participants and gathered their opinions regarding it.

The results and evaluation of this thesis corroborate with the theoretical aspects presented, therefore it is possible to assume that the system is capable of impacting the edu-

cational scene and help educators decrease workload when working with daily quizzes. However, based on the evaluation performed, it is not possible to conclude on which way the system will achieve that and how long it will take to impact the educational scene. Therefore and improvement of the system is required and more tests need to be conducted.

BIBLIOGRAPHY

BOOKS

Bjørner, Thomas

2015 *Qualitative Methods For Consumer Research*, Hans Reitzels, ISBN: 978-87-412-5853-9.

Byrne, Ed

2004 *Game Level Design (Game Development Series)*, Charles River Media, Inc., Rockland, MA, USA, ISBN: 1584503696.

Caschera, Maria Chiara, Arianna D'Ulizia, Fernando Ferri, and Patrizia Grifoni

2013 *On the Move to Meaningful Internet Systems: OTM 2013 Workshops*, Springer Berlin Heidelberg, chap. Multimodal Interaction in Gaming, pp. 694-703, ISBN: 978-3-642-41033-8.

Craft, Brock, Marcelo Maina, and Yishay Mor

2015 *The Art & Science of Learning Design*, SensePublishers, ISBN: 9789463001014.

Crawford, Chris

1984 *The Art of Computer Game Design*, Osborne/McGraw-Hill, ISBN: 0881341177.

Greenberg, Jerald

2011 *Behavior in Organizations, 10th Edition*, Pearson, ISBN: 978-0136090274.

Hammer, Tonya R.

2011 *Encyclopedia of Child Behavior and Development*, ed. by Sam Goldstein and Jack A. Naglieri, Springer, chap. Motivation, pp. 978-979, ISBN: 978-0-387-79061-9.

J. W. Creswell

2004 *Research Design: Qualitative, quantitative and mixed methods approaches*, 4th, Thousand Oaks, ISBN: 978-1452226101.

Kosturko, Lucy, Jennifer Sabourin, Jamie McQuiggan, and Scott McQuiggan

2015 *Mobile Learning: A Handbook for Developers, Educators, and Learners*, John Wiley & Sons, ISBN: 978-1-118-89430-9.

Landa, Robin

2006 *Graphic design solutions*, Clark Baxter, ISBN: 978-1401881542.

Lazar, Jonathan, Jinjuan Heidi Feng, and Harry Hochheiser

2010 *Research Methods - In Human-Computer Interaction*, 1st, Wiley, ISBN: 978-0-470-72337-1.

McClelland, David C.

1987 *Human Motivation*, Cambridge University Press, ISBN: 978-0521369510.

Miliband, David

2006 *Choice and Voice in Personalised Learning*, Personalising Education, chap. 1, pp. 21-30, ISBN: 92-64-03659-8.

Morton, Jill

1997 *A Guide to Colour Symbolism*, p. 79.

Müller-Brockmann, Josef

2010 *Grid Systems*, 7th, Niggli, ISBN: 978-3-7212-0145-1.

Prensky, Marc

2001 *Digital Game Based Learning*, Visionary book on instructional design and game design, McGraw-Hill Trade, ISBN: 0071363440.

Rogers, Yvonne, Helen Sharp, and Jenny Preece

2011 *Interaction Design - Beyond Human-Computer Interaction*, 3rd, Wiley, ISBN: 978-0-470-66576-3.

Rollings, Andrew and Ernest Adams

2003 *Andrew Rollings and Ernest Adams on Game Design*, New Riders Games, ISBN: 1592730019.

Rotter, Julian B

1973 *Social learning and clinical psychology*, Johnson Reprint Corp, ISBN: 9780384521605.

Schell, Jesse

2008 *The Art of Game Design: A Book of Lenses*, Morgan Kaufmann Publishers Inc., ISBN: 0-12-369496-5.

Weller, Martin

2011 *The Digital Scholar: How Technology Is Transforming Scholarly Practice*, Bloomsbury Academic, pp. 80-95, ISBN: 9781849666268.

Williams, P. John

2012 *Technology Education for Teachers*, SensePublishers, p. 270, ISBN: 9789462091603.

ARTICLES

A. M. Lund

2001 "Measuring usability with the USE questionnaire," *Usability Interface*, 8, 2, pp. 3-6.

Alavi, Maryam

1994 "Computer-Mediated Collaborative Learning: An Empirical Evaluation," *MIS Quarterly*, 18, 2, pp. 159-174.

Altintas, Y. and W.K. Munasinghe

1994 "A Hierarchical Open-Architecture CNC System for Machine Tools," *CIRP Annals - Manufacturing Technology*, 43, 1, pp. 349-354.

Andersen, Maria H.

2011 "The World Is My School: Welcome to the Era of Personalized Learning," *The Futurist*, 12.

Annetta, Leonard A.

2010 "The 'I's' have it: A framework for serious educational game design." English, 14, p. 105.

Betz, Joseph A.

1996 "Computer Games: Increase Learning in an Interactive Multidisciplinary Environment." English, 24, pp. 195-205, ISSN: 0047-2395.

Bitner, Noel and Joe Bitner

2002 "Integrating Technology into the Classroom: Eight Keys to Success," *Journal of Technology and Teacher Education*, 10, 1, pp. 95-100.

Brand, Glenn A.

1997 "Training Teachers for Using Technology," 19, 1.

Chaudy, Yaelle, Thomas M. Connolly, and Thomas Hainey

2014 "EngAGe: A link between educational games developers and educators," 2014 6th International Conference on Games and Virtual Worlds for Serious Applications, VS-GAMES 2014.

Cho, Vincent, T. C Edwin Cheng, and W. M Jennifer Lai

2009 "The role of perceived user-interface design in continued usage intention of self-paced e-learning tools," *Computers and Education*, 53, 2, pp. 216-227.

Christopoulos, D. and A. Gaitatzes

2009 "Multimodal Interfaces for Educational Virtual Environments" (Sept. 2009), pp. 197-201.

Dalziel, James

2015 "The Art & Science of Learning Design," ed. by Marcelo Maina, Brock Craft, and Yishay Mor, pp. 3-14.

Davis, Fred D.

1989 "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," *MIS Quarterly*, 13, 3, pp. 319-340.

Dawabi, Peter, Martin Wessner, and Erich Neuhold

2003 "Using mobile devices for the classroom of the future," *Learning with Mobile Devices*, 41, pp. 1-5.

Dewey, John

1910 "Science as Subject-Matter and as Method," *Science*, 31, 787, pp. 121-127.

Fisch, Shalom M

2005 "Making educational computer games "educational"," *Proceeding of the 2005 conference on Interaction design and children IDC 05*, 1, pp. 56-61.

Fitts, Paul M.

1954 "The Information Capacity of the Human Motor System in Controlling the Amplitude of Movement," *Journal of Experimental Psychology*, 47, 6, pp. 381-391.

Fujita, Masahiro and Koji Kageyama

1997 "An Open Architecture for Robot Entertainment," *Proceedings of the First International Conference on Autonomous Agents*, pp. 435-442.

Gong, Jun and Peter Tarasewich

2004 "Guidelines for handheld mobile device interface design."

Huotari, Kai and Juho Hamari

2012 "Defining gamification: a service marketing perspective," *Proceeding of the 16th International Academic MindTrek Conference*, pp. 17-22.

Kanehiro, Fumio, Hirohisa Hirukawa, and Shuuji Kajita

2004 "OpenHRP: Open Architecture Humanoid Robotics Platform," *The International Journal of Robotics Research*, 23, 2, pp. 155-165.

- Koren, Y., S.J. Hu, Peihua Gu, and M. Shpitalni
2013 "Open-architecture products," *{CIRP} Annals - Manufacturing Technology*, 62, 2, pp. 719-729.
- Koren, Y. and S. Kota
1999 "Reconfigurable machine tool," US Patent 5,943,750, <https://www.google.com/patents/US5943750>.
- Kwan, Felix
2011 "Formative assessment: the one-minute paper vs. the daily quiz," *Journal of Instructional Pedagogies*, pp. 1-8, <http://www.w.aabri.com/manuscripts/10717.pdf>.
- Laurillard, Diana
2008 "Technology Enhanced Learning as a Tool for Pedagogical Innovation," *Journal of Philosophy of Education*, pp. 521-533.
- LSE Enterprise
2009 "Co-creation : New pathways to value An overview," *Promise Corporation*, p. 22, <http://personal.lse.ac.uk/samsona/cocreation/report.pdf>.
- Moreno-Ger, Pablo, Daniel Burgos, Ivan Martinez-Ortiz, Jose Luis Sierra, and Baltasar Fernandez-Manjoo
2008 "Educational game design for online education," *Computers in Human Behavior*, 24, 6, Including the Special Issue: Electronic Games and Personalized eLearning Processes, pp. 2530-2540.
- Naumann, Anja B., Ina Wechsung, and Jörn Hurtienne
2009 "Multimodal Interaction: Intuitive, Robust, and Preferred?" *INTERACT '09*, pp. 93-96.
- Nilsson, Erik G.
2009 "Design patterns for user interface for mobile applications," *Advances in Engineering Software*, 40, 12, pp. 1318-1328.
- Oviatt, Sharon
1999 "Ten Myths of Multimodal Interaction," *Commun. ACM*, 42, 11 (Nov. 1999), pp. 74-81.
2002 "Multimodal Interfaces," *Handbook of Human-Computer Interaction*, pp. 1-22.
- Polsani, Pithamber
2006 "Use and Abuse of Reusable Learning Objects," *Journal of Digital Information*, 3, 4.
- Quinn, Jeffrey M., Justin Eddings, and Tony Stewart
2013 "Portrait versus Landscape: Task and hardware determine users mobile phone orientation behavior," *IDSA 2013 Education Symposium*.
- Ray, Nancy L.
1992 "Motivation in Education," <http://files.eric.ed.gov/fulltext/ED349298.pdf>.
- Rico, Julie and Stephen Brewster
2010 "Gesture and Voice Prototyping for Early Evaluations of Social Acceptability in Multimodal Interfaces," 16:1-16:9.

Van Eck, Richard

- 2006 "Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless," *Educause Review*, 41, pp. 16-30.

Vesselinov, Roumen and John Grego

- 2012 "Duolingo Effectiveness Study," December 2012, pp. 1-25, http://static.duolingo.com/s3/DuolingoReport%5C_Final.pdf.

Al-Washmi, Reem, Peter Blanchfield, Matthew Baines, S Organ, and Gail Hopkins

- 2015 "Mathematics Problem Solving Through Collaboration : Game Design and Adventure," October 2014, ISSN: 20490992.

Wessner, M and P Dawabi

- 2004 "Interaktionsunterstützung für die Präsenzlehre - Szenarien und Design," *DeLFI 2004*, pp. 175-186.

Whitehead, Christopher and Lydia Ray

- 2009 "Using the iclicker classroom response system to enhance student involvement and learning," *Journal of Education, Informatics and Cybernetics*, 1, 1, pp. 18-22.

Zhang, Jian, Deyi Xue, and Peihua Gu

- 2015 "Adaptable design of open architecture products with robust performance," *Journal of Engineering Design*, 26, 1-3, pp. 1-23.

WEBSITES

2D BOY

- 2015 *World of Goo*, [Accessed 2016-02-18], <http://worldofgoo.com>.

Apple

- 2011 *iOS - Siri*, [Accessed 2016-02-24], <http://www.apple.com/ios/siri/>.
 2016 *iOS Human Interface Guidelines*, [Accessed 2016-04-15], <https://developer.apple.com/library/ios/documentation/UserExperience/Conceptual/MobileHIG/index.html>.

Dingman, Hayden

- 2015 *Assassin's Creed Syndicate*, [Accessed 2016-03-30], <http://www.pcworld.com/article/3008718/software-games/assassins-creed-syndicate-review-one-of-the-best-but-its-still-just-assassins-creed.html>.

EducationCloset

- 2015 *STEAM Portal - STEAM Resources for Any Classroom*, [Accessed 2016-02-16], <http://educationcloset.com/steam/steam-resources-for-any-classroom/>.

Elias, Tanya

- 2011 *Learning Analytics: Definitions, Processes and Potential*, [Accessed 2016-05-19], <http://learninganalytics.net/LearningAnalyticsDefinitionsProcessesPotential.pdf>.

Google

- n.d. *Voice Driven Web Apps*, [Accessed 2016-02-24], <https://developers.google.com/web/updates/2013/01/Voice-Driven-Web-Apps-Introduction-to-the-Web-Speech-API?hl=en>.

Google

- 2012 *Google Now*, [Accessed 2016-02-24], <https://www.google.com/landing/now/>.
- 2016 *Android Design*, [Accessed 2016-04-15], <http://developer.android.com/design/index.html>.

i>clicker

- 2016 *i>clicker*, [Accessed 2016-02-16], <https://www.iclicker.com>.

Intelligent Voice

- 2013 *New Poll: Apple has oversold Siri say 46% of Americans*, [Accessed 2016-02-25], <http://www.intelligentvoice.com/assets/pressreleaseSiri17102013.pdf>.

Jolly, Anne

- 2014a *Six Characteristics of a Great STEM Lesson*, [Accessed 2016-02-13], http://www.edweek.org/tm/articles/2014/06/17/ctq_jolly_stem.html.
- 2014b *STEM vs. STEAM*, [Accessed 2016-02-13], <http://www.edweek.org/tm/articles/2014/11/18/ctq-jolly-stem-vs-steam.html>.

Leap Motion

- 2016a *Leap Motion*, [Accessed 2016-02-24], <https://developer.leapmotion.com/orion>.
- 2016b *Leap Motion*, [Accessed 2016-05-21], <https://www.leapmotion.com>.

MECC

- 2012 *The Oregon Trail (Video Game)*, [Accessed 2016-03-30], <https://en.wikipedia.org/wiki/File:OregonTrailScreenshot.png>.

Microsoft

- 2014 *What is Cortana?* [Accessed 2016-02-24], <http://windows.microsoft.com/en-us/windows-10/getstarted-what-is-cortana>.
- 2016 *Kinect - Windows app development*, [Accessed 2016-05-21], <https://developer.microsoft.com/en-us/windows/kinect>.

Motion Math

- 2016 *Motion Math - games that let kids play with numbers*, [Accessed 2016-02-18], <http://motionmathgames.com>.

npm

- n.d. *google-speech-api*, [Accessed 2016-02-24], <https://www.npmjs.com/package/google-speech-api>.

Oculus VR

- 2016 *Oculus*, [Accessed 2016-05-21], <https://www.oculus.com>.

Plante, Chris

- 2015 *When was Super Mario Bros. released in the US? Nobody knows!* [Accessed 2016-03-30], <http://www.theverge.com/2015/9/14/9324833/super-mario-brothers-30th-anniversary-date>.

Roger, Adam

- 2010 *Kongregate*, [Accessed 2016-05-19], <http://www.kongregate.com/forums/5-the-arts/topics/91065-make-me-a-wallpaper>.

Rovio

- 2016 *Angry Birds*, [Accessed 2016-02-18], <https://www.angrybirds.com>.

STEAM Education

2015 *STEAM - About Us*, [Accessed 2016-02-13], <http://steamedu.com/about-us/>.

tap tap tap LLC

2013 *The Heist*, [Accessed 2016-03-31], <https://macheist.com>.

Unity Technologies

2016 *Unity - Game Engine*, [Accessed 2016-05-23], <http://unity3d.com>.

University of California

2015 *How To Smile*, [Accessed 2016-02-16], <https://www.howtosmile.org>.

Vuforia

2016 *Vuforia*, [Accessed 2016-05-21], <https://www.vuforia.com>.

Waters, John

2014 *Adaptive Learning: Are We There Yet?* [Accessed 2016-02-04], <https://thejournal.com/articles/2014/05/14/adaptive-learning-are-we-there-yet.aspx>.

A

OVERALL APPLICATION

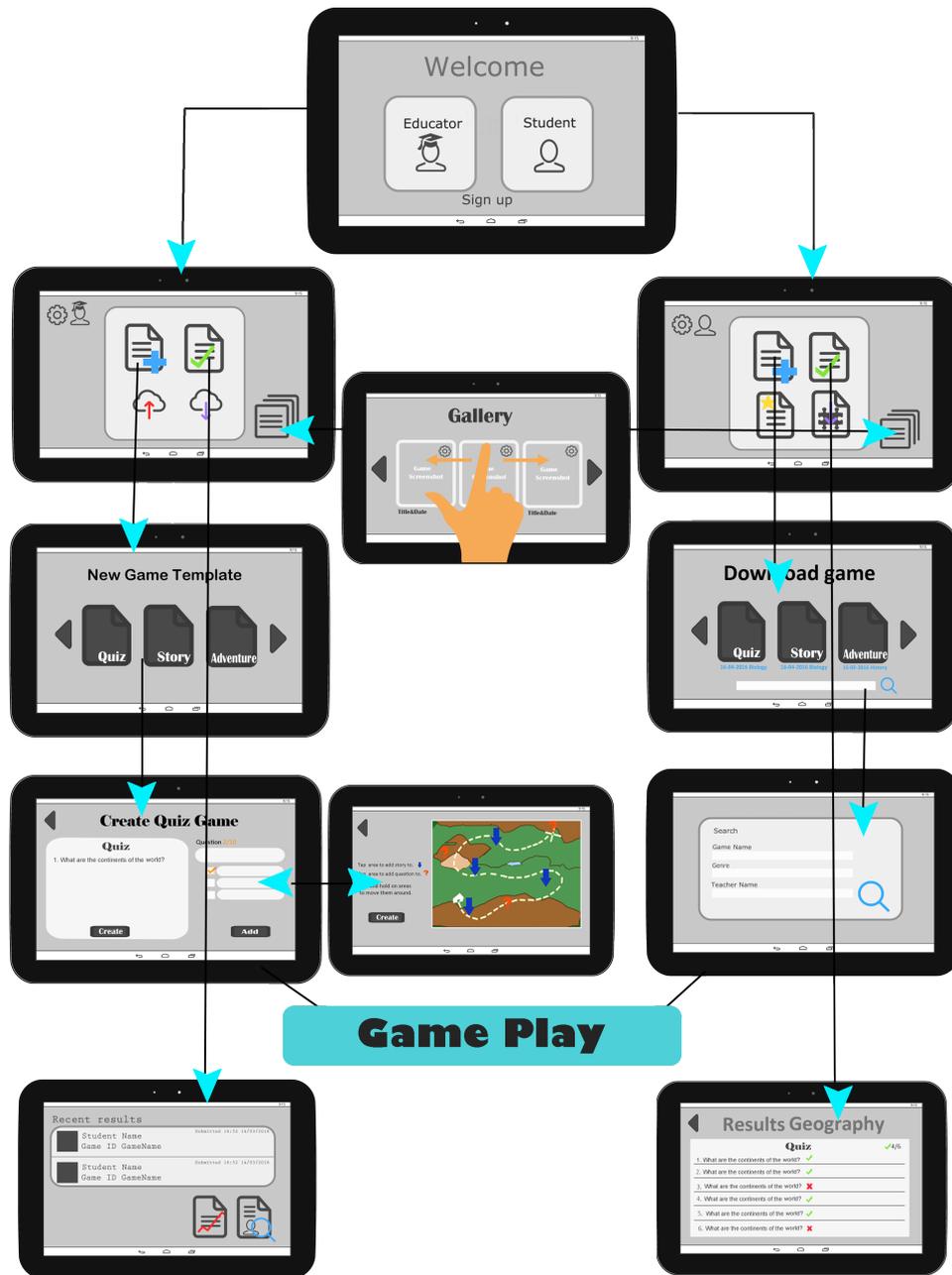


Figure 61: An overview of the application Design.

B | TEST

1. Usefulness

- It helps me be more effective.
- It helps me be more productive.
- It is useful.
- It gives me more control over the activities in my life.
- It makes the things I want to accomplish easier to get done.
- It saves me time when I use it.
- It meets my needs.
- It does everything I would expect it to do.

2. Ease of Use

- It is easy to use.
- It is simple to use.
- It is user friendly.
- It requires the fewest steps possible to accomplish what I want to do with it.
- It is flexible. Using it is effortless.
- I can use it without written instructions.
- I don't notice any inconsistencies as I use it.
- Both occasional and regular users would like it.
- I can recover from mistakes quickly and easily.
- I can use it successfully every time.

3. Ease of Learning

- I learned to use it quickly.
- I easily remember how to use it.
- It is easy to learn to use it.
- I quickly became skillful with it.

4. Satisfaction

- I am satisfied with it.
- I would recommend it to a friend.
- It is fun to use.
- It works the way I want it to work.
- It is wonderful.
- I feel I need to have it.
- It is pleasant to use.

B.1 EDUCATORS

Participant number:	#1	#2	#3	#4
It helps me be more effective.	✓	✓	✗	✓
It helps me be more productive.	✗	✗	✗	✗
It is useful.	✓	✓	✓	✓
It gives me more control over the activities in my life.	✗	✗	✗	✗
It makes the things I want to accomplish easier to get done.	✓	✓	✗	✗
It saves me time when I use it.	✓	✓	✓	✓
It meets my needs.	✗	✓	✓	✓
It does everything I would expect it to do.	✗	✓	✓	✗

Table 3: Usefulness

Participant number:	#1	#2	#3	#4
It is easy to use.	✓	✓	✓	✗
It is simple to use.	✗	✓	✗	✓
It is user friendly	✗	✓	✓	✗
It requires the fewest steps possible to accomplish what I want to do with it.	✓	✗	✓	✗
It is flexible	✗	✗	✗	✗
Using it is effortless	✗	✗	✗	✗
I can use it without written instructions.	✓	✓	✗	✓
I don't notice any inconsistencies as I use it.	✗	✗	✗	✓
Both occasional and regular users would like it.	✓	✓	✗	✗
I can recover from mistakes quickly and easily.	✗	✗	✗	✗
I can use it successfully every time.	✗	✗	✗	✗

Table 4: Ease of Use

Participant number:	#1	#2	#3	#4
I learned to use it quickly.	✓	✓	✗	✗
I easily remember how to use it.	✓	✓	✓	✗
It is easy to learn to use it.	✓	✗	✓	✓
I quickly became skillful with it.	✗	✓	✗	✗

Table 5: Ease of Learning

Participant number:	#1	#2	#3	#4
I am satisfied with it.	✓	✗	✓	✗
I would recommend it to a friend.	✓	✓	✗	✓
It is fun to use.	✓	✓	✓	✗
It works the way I want it to work.	✗	✗	✗	✗
It is wonderful.	✗	✗	✗	✗
I feel I need to have it.	✗	✗	✗	✗
It is pleasant to use.	✓	✗	✓	✓

Table 6: Satisfaction

B.2 STUDENTS

Participant number:	#1	#2	#3	#4	#5
It helps me be more effective.	X	X	✓	X	X
It helps me be more productive.	X	X	✓	X	X
It is useful.	✓	✓	✓	X	✓
It gives me more control over the activities in my life.	X	X	X	X	X
It makes the things I want to accomplish easier to get done.	X	X	✓	X	X
It saves me time when I use it.	X	X	✓	X	X
It meets my needs.	X	X	X	X	X
It does everything I would expect it to do.	X	✓	X	X	X

Table 7: Usefulness

Participant number:	#1	#2	#3	#4	#5
It is easy to use.	✓	X	X	✓	✓
It is simple to use.	✓	✓	✓	✓	✓
It is user friendly	✓	X	X	✓	✓
It requires the fewest steps possible to accomplish what I want to do with it.	X	✓	✓	X	X
It is flexible	X	✓	✓	X	✓
Using it is effortless	X	X	X	X	✓
I can use it without written instructions.	X	✓	X	✓	✓
I don't notice any inconsistencies as I use it.	X	✓	X	X	✓
Both occasional and regular users would like it.	✓	X	X	X	✓
I can recover from mistakes quickly and easily.	X	✓	X	X	✓
I can use it successfully every time.	X	✓	X	X	X

Table 8: Ease of Use

Participant number:	#1	#2	#3	#4	#5
I learned to use it quickly.	✓	✓	✓	✓	✓
I easily remember how to use it.	✓	✓	✓	✓	✓
It is easy to learn to use it.	✓	✓	✓	✓	✓
I quickly became skillful with it.	✓	✓	✓	✓	✓

Table 9: Ease of Learning

Participant number:	#1	#2	#3	#4	#5
I am satisfied with it.	✓	✓	✓	✓	✓
I would recommend it to a friend.	✓	✓	✓	✓	✓
It is fun to use.	✓	✓	✓	✓	✓
It works the way I want it to work.	✓	✓	✓	✓	✓
It is wonderful.	✓	✓	✓	✓	✓
I feel I need to have it.	✓	✓	✓	✓	✓
It is pleasant to use.	✓	✓	✓	✓	✓

Table 10: Satisfaction