My Teaching Assistant: Bridging the gap between realism and mechanism in educational games.

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Abstract

A “serious game” is not a term commonly known. At first glance one might quickly be inclined to think about something related to games as they are known today, games which are played solely for the purpose of entertainment or having fun. Although this is partly correct, in this case however the term “serious game” refers to this particular game’s role in actually teaching something of importance to the user. A serious game can come in many different forms and can be used in many fields ranging from education, health care to even defence. In this thesis we will focus on the field of education.

In the field of education when creating a serious educational game there are two aspects that need to be considered, namely mechanism (theory behind the subject) and realism (the application of the theory in real life situations). Striking a balance between these two aspects is crucial and an important step when developing such a game.

In order to find this balance we will first research how a serious educational game can be developed. A game which is both fun to play for children and at the same can teach them about various subjects one can come across in class. We feel that after we know the finer points of developing such a game we will have a better understanding on how to balance mechanism and realism within the game.

To this end we are developing a mobile game called “My Teaching Assistant” with the help of our findings on how to develop such a serious game aimed at children. We hope that this can also serve as an example on how a serious educational game can be made.

Preface

The idea that started everything began with the course Serious Games given by Prof.dr. Anton Eliens. During the course we were challenged in making a serious game, we chose to make a serious teaching game focusing on mathematics. After the course we continued our research into serious teaching games and what really defines them. We returned to this specific subject during the course Seminar in which again Prof.dr. Anton Eliens guided us. Now we decided to put our knowledge to the test and also into our game which we've expanded greatly since it's debut in the course Serious Games. We will present all of our findings in this document.

Christian & Erik

"Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand." - Albert Einstein

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1 Introduction

1.1 Research question

In this thesis we will write about the teaching aspects mechanism and realism. Much like “serious games” they are both terms not generally known. However when delving in the world of serious educational games it becomes hard not to notice their influence. In an educational setting they both share a similar goal as both aspects aim at teaching the player relevant study material. Mechanism and realism differ in their approach in teaching but both of these aspects are essential in an educational setting. The challenge however is how to utilize these aspects within the same setting or in this case a educational game. This brings us to our research question *“How can an educational game bridge the gap between realism and mechanism?”*.

In order to answer this question we will discuss realism and mechanism in-depth and why they are important in a serious educational game. As an additional aid to help us answer our research question we will also research how to develop an serious educational game which is fun to play for children and at the same time can also teach them about relevant school subjects. This ties with our own learning goal after having become immensely interested in serious games.

1.2 Learning goal

When researching how a serious educational game can be created we will be looking at the important design decisions that are needed when making a educational game like this as well as some of the core segments which are present in such a game that can help children learn something by playing the game. We believe that by doing this it will help us have a much better understanding on how realism and mechanism factor into an educational game and how they can be utilized.

Everything that we learn during this research will be put to good use in our own mobile educational game called “My Teaching Assistant” developed for the Android operating system. It is a serious educational game which is part of our own learning goal to see how a game like this is created, how we can utilize everything that we have learned since we started researching serious educational games and namely, how we can utilize what we have learned during this

research. With the help of this game we want to experience first hand how the research answer can be answered and also how we can use our own developed game to help us define the problems of an serious educational game. Beyond that we will use My Teaching Assistant as a tool to see how children react to different kinds of ways to play educational games as well as how they react to other tools an educational game can utilize to make it more attractive to them.

1.3 Timeline

As previously stated in the preface, the idea to make a serious game in the first place came from the course serious games. It was there that we decided on developing a serious math game. Being the topic math it did not make it programmatically complex to create a game in which the player had to solve math problems and it also gave us enough time to create an appropriate theme and some visuals.

In the course seminar we delved deeper into researching serious math games and if they in any way can act as a replacement to more traditional teaching methods. We learned about successful serious games and how most of them accomplished what they set out to do. We will highlight a few of these serious games further in this thesis.

After the course we began brainstorming on how we could improve My Teaching Assistant in order to make it a full fledged serious game. We began with small expansions until we decided to approach Prof.dr. Anton Eliens about our master project proposal in which we wanted to even further expand My Teaching Assistant. It is expanded according to ideas he gave us and what we learned during our research.

1.4 Overview

Before delving further into the research question and our own research we will first start by looking into the origin of serious games, discuss realism and mechanism in-depth and why it is so important in an educational game. We will discuss them in detail, look at the proposed gap between these two aspects and the other relevant questions regarding them.

Afterwards we will take a look at multiple serious games concerning education that are available at the moment and what we, and other developers interested in developing an educational game, can learn from these games.

Following the relevant games one can find today we will then discuss our design methodology and go in-depth into our thought process during the development of various aspects in our game. We will also give a technical analysis of the techniques we used during the development of My Teaching Assistant and what other options are possible.

We will then discuss the encountered problems during development and evaluate the results of our gathered impressions with the target audience. We will discuss on how these results combined with the results of our research helped us find an answer to our research question and how to develop a good serious educational game with the right balance between being fun and educational.

After evaluating the results of our tests we will give a general reflection on the whole project and discuss the future of serious games.

Finally we will conclude this paper by giving a short summary about how you can find a good balance between realism and mechanism in an educational game and what some of the important steps are developers need to take in order to develop a good serious educational game.

2. Background

2.1 Origin of serious games

As previously stated the term "serious games" is not a well known term. This is not really surprising, games as they appear in the present media are all heavily emphasized for their entertainment value rather than for other purposes. But as we will discuss shortly, serious games are a lot more than merely entertainment tools.

The origins of serious games can be traced back to 1970 when it was first discussed by Clark Abt in his book titled "Serious games". In his book he discussed various computer games which he designed because one of his goals was to use games for training and education[1]. It is also in his book in which Abt lists a number of "non-digital" serious games from which most are,

[1] Abt, C. C. (1970). Serious Games. Viking Press.

surprisingly, math related games to be used in school[2]. Up until now serious games have been associated with digital games which are to be played on a certain platform, but it is important to note that a serious game need not be digital at all. A well-known non-digital serious game teaches people about US politics and the reason why this game is non-digital in the first place is because the author believed that in order to teach politics this could only effectively be done via human interaction with each other[3]. This game is explained in the book *"The New Alexandria Simulation: A Serious Game of State and Local Politics"*.

When the first game that embraced commercial success (Pong which was released in 1972) there were already a number of other digital games designed for serious purposes instead of entertainment. The only reason we didn't hear much about these kinds of games at that time (and of the term) is because most of them were non-commercial and not widespread. Serious games has had applications in the military (the study of cold war conflict on a worldwide scale), healthcare (how to manage certain illnesses) and of course education (the teaching of certain subjects)[4].

The first successful serious game that gained public awareness was "america's army" which was released in 2002[5]. This was big news because most of the games (if not all) at that time were purely designed for entertainment and it was these kinds of games which dominated the market. Sadly it was also exactly these games designed for entertainment which sometime suffered from bad reputation. This bad reputation usually came in the form of violence or inappropriate content in the video games, how it impacted children is what led developers to think of a new label for their game in order to show that their game was different from the games designed for entertainment. This was one of the main reasons for using the term "serious games" but of course this time in a much more widespread setting[6].

With the public having become a bit more accepting towards games in the present day it would seem that this is one of the better times for serious games to make themselves known and this is something seen in certain games that have been released. Nowadays with the arrival of smartphones, tablets, laptops it has become easier than ever to make serious games much more reachable. It remains to be seen if it can also become a well known term.

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[2] Abt, C. C. (1970). Serious Games. Viking Press.
[3] Djaouti, D. Alvarez, J. Jessel,J-P. Rampnoux,O. (2011). Origins of Serious Games. In Ma.M & Oikonomou.A & Jain.L (Eds.)*, Serious Games and Edutainment Applications* (pp. 25-43). London, Springer.
[4] Ibid.
[5] Ibid.
[6] Ibid.

2.2 Our game philosophy

It is clear that gaming today is already vastly different than it was a few years ago. Nowadays game advertisements can be seen nearly everywhere and games are found on almost any platform whereas a few years ago it used to be only on dedicated game consoles. With the new wave of electronics such as tablets, smartphones, smartwatches it became possible to make mobile games which are easily accessible to the general public. This led to mobile games in general becoming much more mainstream as the cost of developing them far outweighed the cost of developing them on other devices[7]. As a result of this not only has their exposure increased dramatically but inadvertently also that of games available for other devices. Because of this the general public has become much more lenient and accepting of games in general. It's not only games focused on entertainment but also serious games in all shapes and forms.

Our belief is that games first and foremost should be fun, lighthearted and entertaining. The context of the game can change the scope of it but we believe that it should retain these three core elements. When extending this to a serious game however there are some other elements that need to be included because the goal of a serious game is to teach and it is important that this is not lost when developing one. It is because of this that we believe that there needs to be a fine balance between a serious game being fun but also engaging and deep enough so the player can actually learn from it. Games are a lot more accessible today which makes it possible to reach a much wider audience and thus more people can benefit from what serious games can bring to the table.

2.3 Realism and mechanism

Realism and mechanism are two very important concepts regarding serious educational games. "Realism", strictly speaking, is a term which is relevant when discussing any type of game and it is not necessarily limited to serious or educational games. "Mechanism" on the other hand is a

[7] Waldron,V.L. (2014, August 25) . *The Rise of Mobile Games: Factors Contributing to Their Success.* Retrieved from http://www.lib.umich.edu/blogs/eaten-grue/rise-mobile-games-factors-contributing-their-success

term which is mainly relevant when discussing education and methods for which education is brought to the students. However for an educational game, both of these terms are very important to understand and consider when developing such a game.

2.3.1 Realism

Realism is a well known term in computer games as game developers are often trying to make their games more realistic. When we are discussing realism in computer games we are mainly considering how realistic the games are and how players can use the game to relate to the real world. The most well known way to bring realism in computer games is by making them look good. Detailed visuals/graphics that closely resemble how our own world looks will make a game feel a lot more realistic.

However visuals are not the only important aspect in making a game realistic. Another key aspect is how actions are conceived by a player[8]. If a player can interact with all different kinds of objects, no matter how insignificant, it will vastly improve the realism in a game. This also includes how the player his or her own character reacts to inputs they give via their controller or other input methods.

For serious games realism is equally as important. Making a player feel like they are in a real world scenario instead of a game will improve how well they can later re-use what they have learned during the game. Having good visuals and interactions with objects in a serious game will do the same thing as it will do for normal computer games, namely make the game feel more immersive and relatable.

In serious games there is another way to give the games more realism; by having how the game works mimic how it would work in the real world. For certain serious games this is more obvious than for other games. For example, a well developed serious game designed for fire-fighters could help them train by simulating how it could be like when entering a burning building; the

[8] Low,G.S.(2001). *Understanding Realism in Computer Games through Phenomenology*. Term paper, Stanford University, Stanford.

realism in this is naturally the entering of a burning building and it is this relatable real life situation which can give the idea of how it would be in real life. When looking however at a simple math game where a monkey catches falling coconuts and the player needs to count how many coconuts have been caught, it is not nearly that realistic (even though it still might be fun for the children) nor relatable to a real world situation, although it certainly contains real-life elements.

Having seen the advantages that realism can bring to the table it is also important to note that too much realism is not always something to strive for in any game, including serious games. The main factor being that people play games because they are fun and by making games more and more realistic it won't always benefit how fun a game is to play. This is also the case for serious games. While they are usually meant to learn something or get better at a certain skill, it is still important that people actually want to play these games. If people do not want to play a serious game they will also not benefit from it.

2.3.2 Mechanism

As we already said the term mechanism is mainly associated with education. When we look at how mechanism works in an serious educational game we look at the underlying methods that are being used to teach the players. For instance let's take a mathematical game from which the main gameplay functions involve giving equations to the player that he/she needs to solve. It is these equations that are called the mechanism behind this particular type of mathematics; mechanism is the very concept behind how two numbers can be added,subtracted,divided and multiplied with each other in order to create a new number. The term mechanism is exceptionally strong within the mathematical field of education, but we also use it to in other categories. In geography for example we mainly see it as learning about all the countries and their attributes such as their location and capital. For the English category the term mechanism applies mainly to correct spelling, grammar and word knowledge of the language.

Teaching children study material by having strong mechanisms is a very good way to teach them how the actual material they need to learn works. It thus comes as no surprise that understanding the mechanism of the material is the first step in understanding the material itself. However teaching children by teaching them purely the mechanisms of a subject can have the

adverse effect that it is not an entertaining way to learn this material. This can lead to the children having less interest in the material itself and consequently will learn less.

Alternatively however if the mechanisms are not thought well enough you risk the children not having a deep enough understanding of how the material actually works. So striking a good balance here into how much mechanism is incorporated in educational games is also very important.

While we mainly looked at educational games, the term mechanism also holds true in other serious games. Not always in the same extent as for the educational games, but players of these games often need to learn something on a certain topic. It will always be very important that the topic is perfectly understood by the player, meaning they have to learn the mechanisms behind this topic. For some serious games this is more obvious than for others, but it will always play some kind of role.

2.4 The gap between realism and mechanism

We have repeatedly mentioned how both realism and mechanism can be very important to a serious game. If a game has too much realism it becomes less focused on the mechanisms behind the concepts it is trying to teach. If the opposite is true and there is too large of a focus on the mechanisms it becomes more of a tool to study these mechanisms, instead of learning them through a fun game players can relate to.

Games with not enough realism have the danger that they do not teach enough to the players while games with too much mechanism are not fun to play and will feel more like work or studying than like a game.

The gap between realism and mechanism as described in our research question specifically refers to the difference between these two concepts and how often having realism in a game takes away from the mechanism and vice versa.

In this thesis we will focus on how these two different aspects work in a serious educational game and what the challenges are for both these aspects. We will do this by looking at multiple small mini-games. During development we will look at the difficulties of incorporating realism in such a manner that it still tries to be educational and on the other side implement mechanism

without the games getting to theoretical. Furthermore we will study which of these mini-games are more fun to play and how good the learning curve in these games is.

3. Serious games

3.1 Existing relevant games

There are many different games currently available and with a little bit of searching serious educational games can also be found. Before we start delving into the development of our own game we will first take a look at various serious educational games that we came across during our research and during our own history of playing games. We will dissect each of these games in order to get a better understanding on what kind of gameplay and mechanics they employed in order to teach their players the study material in a fun manner. These are but a few games that we came across.

3.1.1 DimensionM

Description

This is a serious math game which was available on pc. Currently it has been replaced by a new series of games called DimensionU, but DimensionM has been a great success when first released, which is why we decided to include it[9]. It is a sci-fi role-playing game in which the player moves an “avatar” through a 3-dimensional world. The game features a story and the goal is to find a missing person, in order to progress through the story the player requires quick math skills during various sections in the game[10]. There are single player modes as well as multiplayer modes, in which students have to either work together or compete with each other. The game has also been used as supplement material to math curriculum in schools. Most students agree that it is a well-designed game and that the questions are fun and creative.

[9] DimensionM. previously available at http://www.dimensionu.com/dimu/Home/DimUContent.aspx?MainNav=AboutUs

[10] Offenholley, Kathleen H. (2012). Gaming Your Mathematics Course: The Theory and Practice of Games for Learning. In *Journal of Humanistic Mathematics: Vol. 2: Iss. 2* (pp. 79-92).

Figure 1: Gameplay of DimensionM

Gameplay/mechanics

The game has an expansive story which is what drives the player to play. The study material is integrated seamlessly into the gameplay; math related questions turn up during various points in the game and are part of the game world. The visuals themselves are colorful and the world is detailed well enough and lend part to the realism. Answering questions correctly will earn the player points and this quickly becomes competitive as they will compete for points when playing with other players in the multiplayer modes. While a sci-fi setting is not really relatable to our world it still feels realistic because of the very creative implementation of math within the game world and part of story. It is important to note that, the game is not for deep knowledge creation or learning while playing - it is all about practice as the player must already be familiar with the type of questions asked[11]. In this game realism and mechanism are balanced very well as neither of them overshadow the other.

3.1.2 DimensionU Meltdown

Description

From the same people who created DimensionM now comes a game part of a new line-up of educational games[12]. This game is available on both PC, iOS and Android. This time however there is no expansive story like in DimensionM. There are both single player and multiplayer

[11] Offenholley, Kathleen H. (2012). Gaming Your Mathematics Course: The Theory and Practice of Games for Learning. In *Journal of Humanistic Mathematics: Vol. 2: Iss. 2* (pp. 79-92).
[12] DimensionU Meltdown. available at http://www.dimensionu.com/dimu/home/games.aspx?ref=top%20menu%20dimu

modes but the game is primarily aimed at multiplayer. The main goal in the game is to collect spheres and with these spheres the player unlocks math or literacy related questions which open up more parts and customization in the game.

Figure 2: DimensionU Meltdown gameplay

Gameplay/mechanics

Much like DimensionM the sci-fi setting is retained and one can again create an avatar which is used to move around the world. The gameplay revolves around the collection of spheres which unlock math and literacy questions. The more spheres the player manages to collect the more answers are present when questions are unlocked. Correctly answering these will net points and with these points the player can unlock customization options for their avatar or earn in-game boosts. It is primarily geared at playing against other people so it becomes a race to who can get the most points in any given level. there are daily and weekly challenges which also net points and motivate the player to try different things. This time however the questions are not cleverly integrated in the game world, it is clear that the focus here was more on gameplay but fortunately the questions do not detract from the immersion. Much like DimensionM the game retains its vibrant colors and visuals on both the PC and mobile versions.

The overall realism takes a bit of a backseat (sans the visuals) as the questions aren't really integrated within the game world but the mechanism aspect in this game is integrated well enough.

3.1.3 Math workout

Description

This game is called "Math Workout", it is a serious educational game available on both Android and IOS with over five million downloads in the Android google play store alone[13]. It's main goal is "to keep your mind healthy", it does this by giving a number of exercises that can be played. These exercises are also divided into daily challenges.

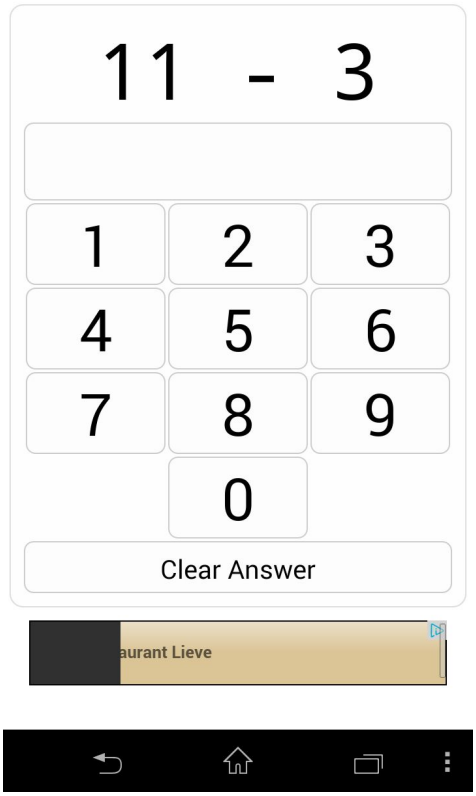


Figure 3: One of the mini-games in Math workout

Gameplay/mechanics

The gameplay revolves around different modes and in each of these the player is tested in either "addition & subtraction" or "multiplication & division" and simple problems have to be

[13] Math Workout. available at http://www.mathsworkout.net/

answered in quick succession. This is done in a variety of ways. There is also a mode in which it begins with a number and the player is tasked with multiplying it, dividing it, subtracting it or other equations with a random number. This needs to be done in quick succession. This game is also geared at practice and players can compare scores. It is a very bland game and the design is basic in which colors are used very sparingly, in this game it is all about the material. There is sadly no realism aspect to it as nothing except for the material is related to real world situations, it is clear that the mechanism aspect is very prevalent here.

3.1.4 Where in the World is Carmen Sandiego?

Description

The Carmen Sandiego franchise is a long running series based on geographical questions. Although not traditionally a serious game we believe it can be considered one as it teaches about geographical locations in a fun way while this is not explicitly it's intention. The series has been around since 1985 with its first installment on the Commodore 64. Since then it has seen numerous sequels and re-releases. Children today can still play the game on Facebook or in the iOS app store[14].

Figure 4: Solving a case in Where in the World is Carmen Sandiego?

[14] Carmen Sandiego Returns for iOS. available at https://itunes.apple.com/us/app/carmen-sandiego-returns/id1038376578?mt=8

Gameplay/mechanics

In these geographical games the player is tasked to travel the world to find and arrest evil villains working for Carmen Sandiego, ultimately also capturing her. The player is given numerous hints on where they should travel to find the criminals, each referencing some characteristic of a country, city or it's people. through these hints players will learn where countries and cities are located as well as what defines them. Every game was very vibrant and had some very nice visuals of the various different countries whether created by hand in the old versions or the realistic pictures in the newer versions . With later versions came the ability to play against other people and earn various kinds of rewards. There has always been a progression system in which the player moves through different ranks of an up-and coming detective. There is a fine balance between realism and mechanism present here. The real-world locations and nice visuals help with the realism while the characteristics about the locations offer sufficient mechanism.

3.1.5 Lumosity

Description

Lumosity is an online brain training program originally launched in 2007 on pc and since than also ported to Android and iOS[15]. Lumosity promotes itself as being a helpful way of increasing the player's cognitive performances. It consists of multiple cognitive tasks dressed as games which are created by a team of game developers and designers as well as neurological scientists. The scientists come up with different neurological tasks which are aimed to train the brain, which are then translated to fun games by the designers

[15] Lumosity. available at http://http://www.lumosity.com

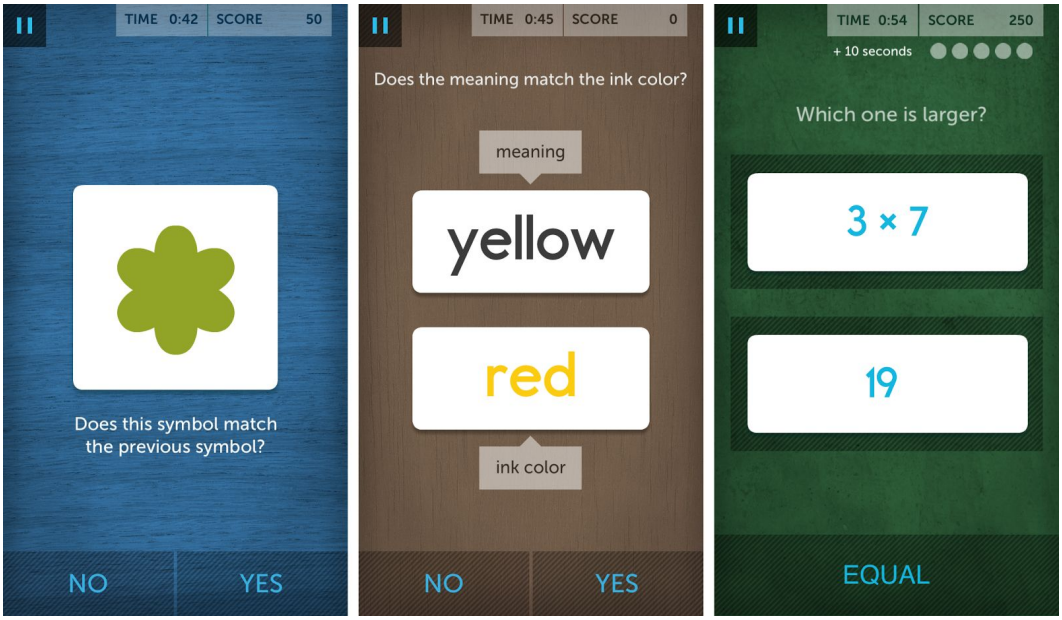


Figure 5: Some of the game types in Lumosity

Gameplay/mechanics

Lumosity consist of many different mini-games. Each day players can only play a few of the different types of games, which are being rotated the next day, except for paying players. The different areas of a player's brain such as memory, problem solving or speed of processing are all monitored by how players perform in the different games. Depending on their scores different difficulties of the games are presented. Many of these games either focus on mathematics or english, while others focus on memory, logical thinking or quick responsiveness. While the game does not promote itself as a learning tool, it does try to train a person's mind. Many of the games are based on realism, containing many different real-life elements such as trains, birds or stories about persons. The mechanisms of the content is never fully pushed back however, since the game's main purpose is to train the cognitive performances of the player.

Figure 6: A player's brain scores in Lumosity

3.2 Game overview

Below we have compiled all the relevant information from the games in a table. All of the games were successful in their own right so it is interesting to see that although different there are no decisive factors for a successful game. It shows that different factors can also still lead to a well received game.

	Dedicated serious game	Single / Multiplayer	Gameplay / Mechanics	Subject(s)	Realism / Mechanism	Platform
DimensionM	Yes	Both	3d-movement, progressive story, study material integrated in world	Math	Both	PC
Meltdown	Yes	Both, with focus on multiplayer	3d-movement, robust reward system, questions regarding study material	Math, Literacy	Both	PC, Android & IOS
Math workout	No	Both with focus on single player	Different game modes relating to study material	Math	Mechanism	Android & IOS
Carmen sandiego	No	Most games are single player	Narrative based adventure game, incorporates geography characteristics, reward system	Geography	Both, with a large focus on realism	PC, Android & IOS
Lumosity	No	Single player	Different mini-games related to improving cognitive performances	Math, Literacy, Memory, Logic and more	Both	PC, Android & IOS

Table 1: Overview of some existing serious games

4. Design decisions

4.1 Design methodology

We have so far discussed serious games, realism, mechanism and have shown existing serious games. In the beginning we stated that in order to better answer our research question we would be also investigating how a serious educational game can be built. This is tied with our own learning goal which involves the development of our own serious educational game My Teaching Assistant. Our design methodology can at best be compared to a bottom-up design as our beginning foundation was the game we built during the course Serious Games and we have been continually developing it towards the desired solution with everything we've learned since we began work on this thesis.

There are a number of development phases we went through when developing My Teaching Assistant. We will discuss each of these phases in order to give a detailed look into our design decisions and how these phases correspond with a bottom-up design methodology.

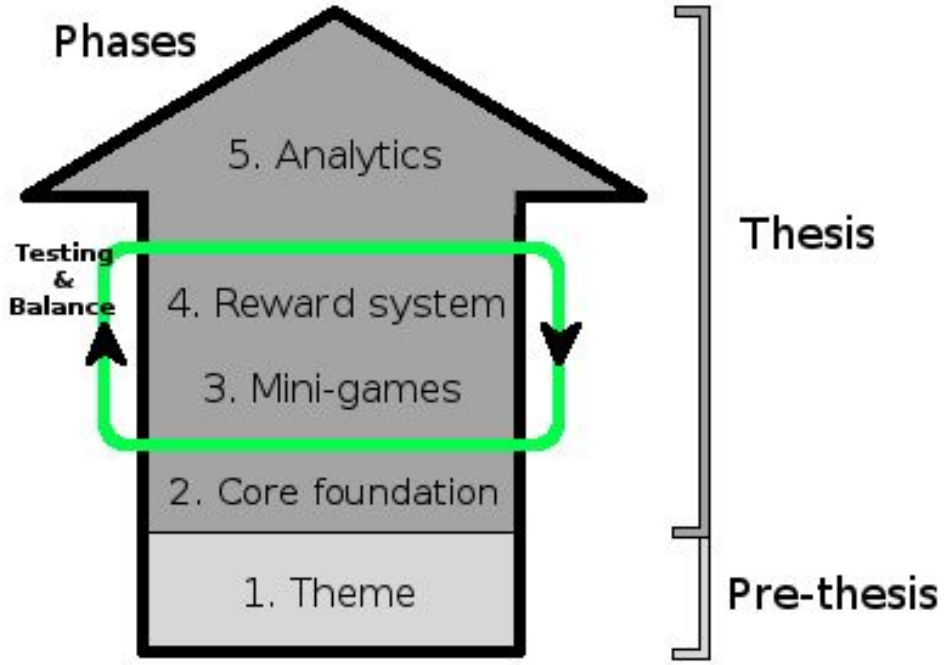


Figure 7: The bottom-up design methodology used in My Teaching Assistant

We will first start by discussing the theme and afterwards we will move upwards and discuss the remaining phases in detail. What is not listed here is the design of the user-interface (UI), we purposely left this out because the UI has changed constantly across all development phases and so it could not be given it's own phase.

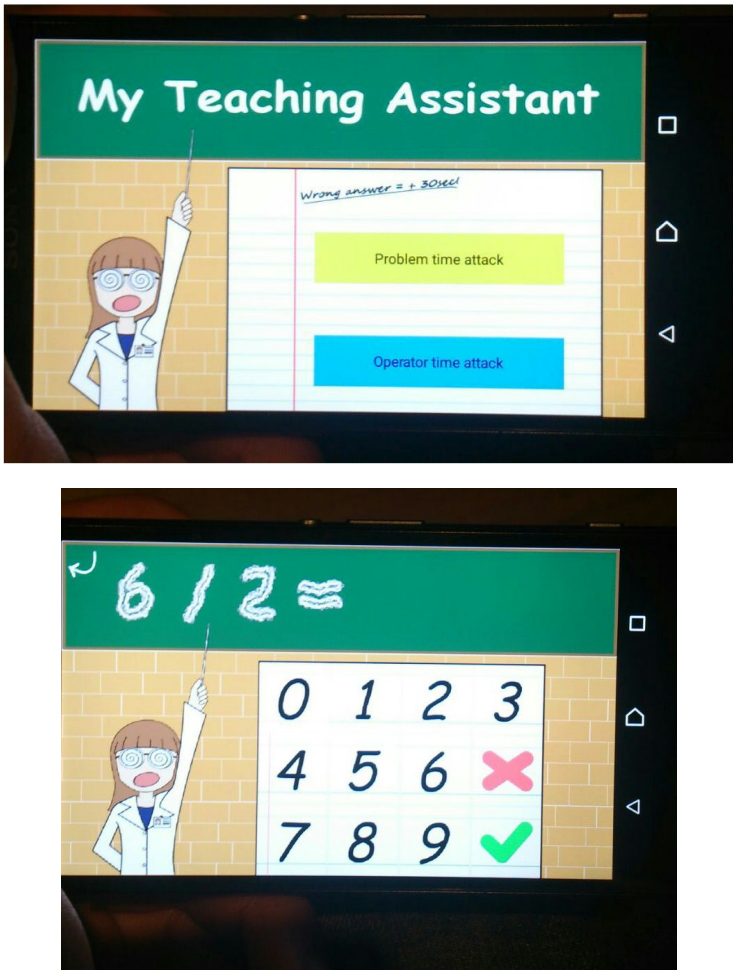
4.1.1 Phase 1 - Theme

The start of the development phases in My Teaching Assistant started off with the theme. While this was largely decided and developed before we began work on our thesis, it is still very integral to our game and to help understand how it shaped everything else.

Because we were expanding on the game we built during serious games we also didn't want to stray too far away from the original theme which we used in the old version. We both agreed that certain elements had to be kept going forward. The theme that we decided on was that of a classroom. Admittedly it is not a unique theme but we were confident that we could give it a unique spin with our design and make it appealing.

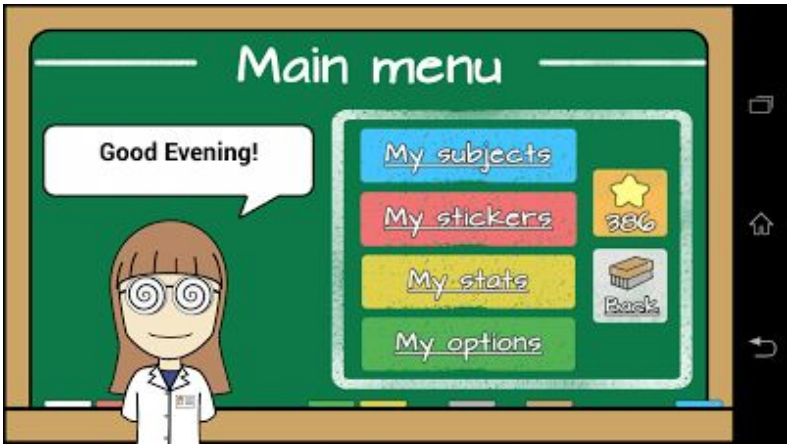
For us the theme was important as the whole game get's it's identity from the theme. We believe it is an important factor contributing to the immersion the user can experience when playing the game. If the overall design is likable we think the player will be at least be a bit more inclined to give the game a chance as a opposed to a game with next to no visual elements. We really wanted to make it visually appealing to the target audience and other people playing it so this was one of our first goals.

Figures 8 and 9 detail the classroom as it was in the old version of the game.



Figures 8 & 9: The old version of My Teaching Assistant

When we decided to update the game we made the UI more colorful, used less sharp edges and really tried to give it a sort of goofy personality while still retaining elements from our old design. We believed that by doing it like this it would be more recognisable and funny. The teacher also received an overhaul to a more simpler design which enabled us to easily redraw her in different moods. We felt that these elements had to be kept as they were integral with the idea of the serious educational game that we had in mind. Everything was done in order to give the game it's lighthearted feel.



Figures 10 & 11: The new more light-hearted look of My Teaching Assistant

All relevant information such as the exercises, menu and results are presented on the blackboard with the teacher on the right side of the screen, interacting with the player. Nothing overlaps and we tried to give every element it's own space in order to keep everything orderly.

4.1.1.1 Teacher

We wanted to have another element besides only the classroom in which the game takes place and at the same time we also wanted some kind of mascot character with which the game could be easily identified with. This led us to the decision of bringing the teacher which already could be seen in the old game(there she was part of the background) back in the new game but with a more active role this time. The original idea was to give her a simple AI and a mind of her own, she would then talk during random times when playing the game but we decided that this would become annoying faster than actually being fun and helpful (what a teacher is supposed to be).

Instead we opted for her to only give relevant information and help the user through the menus, by doing it like this we felt her presence had more meaning. She also serves as the indicator of seeing whether answers are right or wrong. When the game starts she has a randomized greeting and six different poses based on what is being said at any time. She might also give a unique response if the player decides to tap on her at certain times.

4.1.1.2 The six different poses

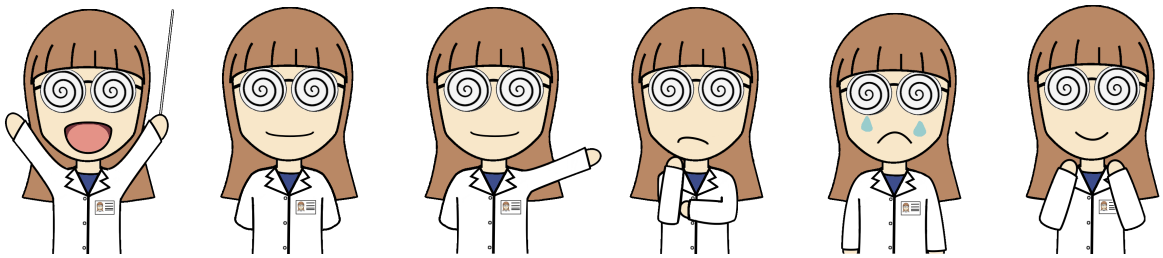


Figure 12: The six different poses of the teacher

4.1.2 Phase 2 - Core foundation

The second phase highlights the core foundation on which we built My Teaching Assistant. In order to make My Teaching Assistant not only an effective learning tool but also visually appealing to both our target audience, there are a number of design choices we've made and kept throughout the development process in order to realize everything. Most of these choices came from our own experience in gaming and the rest came from our research in serious games and serious educational game development. But it was the guides "4 ways serious games link to learning[16]" written by Sharon Boller and "4 mistakes that ruin a serious game's learning value[17]" written by Steven Boller which helped us on our way with recognizing what was really important when designing a serious educational game. From both guides it became clear that "motivation", "feedback", "relevant practice" and "the ability to retrieve what you've learned" play key roles in developing a serious game and how a game can be linked to learning. It is also

[16] Boller,S. *4 Ways Serious Games Link To Learning*. Retrieved from http://www.theknowledgeguru.com/4-ways-serious-games-link-learning-free-download/

[17] Boller,S. (2014, January 15) . *4 mistakes that ruin a serious game's learning value.* Retrieved from http://elearningindustry.com/4-mistakes-that-ruin-a-serious-game-learning-value

these 4 principles which form our core foundation on which this game is built and with this in mind we tried to carefully develop the game around these principles.

4.1.2.1 Motivation

Whether or not a player will want to keep on playing will be determined on how the game is built and more importantly how fun it is to the player. We already knew when starting development that we were going to make the design light-hearted and funny, we believed that this would make the game fun and help motivate the player. The guides helped us go even deeper and highlighted the importance of certain elements that are effective with motivating the player. These elements ranged from “various levels to mix it up”, “good level design”, “collectibles in the form of points”, “badges and leaderboards”, “a good flow” and “challenging but fun gameplay which promotes strategizing and problem solving[18]”.

4.1.2.2 Feedback

Specific and timely feedback are very important in a serious educational game. Feedback is the cornerstone when learning study material. It enables the player to evaluate his/her performance in order to make necessary adjustments and to further refine it. The guides states that with feedback and good performance should come rewards, these rewards can come in the form of escalating achievements, level progression or simply the increasing of points[19]. This however does not mean that bad performance should be punished, it also should not mean that it’s due to bad design.
Bad performance should be fair, handled correctly and it should serve as an incentive to the player to better him/herself and attempt the challenge again with the newly acquired knowledge.

Feedback in my teaching assistant plays a very large part. We also believe that education and feedback go in hand in hand as both are required for a student to make actual progress in any subject. It is because of this reason that we paid a lot of attention to how we would implement feedback in our game. The guides helped us refine our idea even further.

4.1.2.3 Relevant practice

Regardless of how serious educational games are made though, it is important that they are set in an appropriate context. The guides states that relevant practice is important and in order for the material to be relevant the context needs to be appropriate. Context is important as it

[18] Boller,S. *4 Ways Serious Games Link To Learning*. Retrieved from http://www.theknowledgeguru.com/4-ways-serious-games-link-learning-free-download/
[19] Ibid.

creates familiarity and it is this familiarity which can improve learning. However that is not the only reason why context is important, it is also essential that serious games mimic real world situations as their primary goal is to educate the player with knowledge that can be utilized in the real world.

It is therefore important that the study material is utilized correctly. We've taken very good care with the handling of the different subjects in My Teaching Assistant. We will have a range of mini-games and each of them will behave differently as they cover different subjects (we will talk more about this a bit later). The guide highlighted the importance of relevant practice and we've tried to follow it very close in this regard. The different subjects needs to help the players relate to real world situations.

4.1.2.4 Ability to retrieve what has been learned

Games are by design usually repetitive in nature[20]. This repetition allows the player to memorize and learn patterns which allows him to advance further into the game as it becomes progressively harder. The same is true for a serious educational game only here repetition is brought in accordance with the player actually learning study material and at the same time the player is also advancing through the game.

This was the last point stated in the guides and it makes a lot of sense. The whole point of a serious educational game is to learn and the player should be able to use the knowledge he/she gained from it. Thus the best way to achieve this, as the guides state, is to challenge the player by having increasing difficulty and to motivate the player by using gained knowledge in order to advance further into the game and we've also tried to implement this in accordance with our own ideas.

4.1.3 Phase 3 - The mini-games

In this phase we will discuss everything regarding the mini-games and afterwards how feedback regarding these games is implemented. My Teaching Assistant started out with having only mathematical based mini-games. When we decided on expanding it we had decided that we wanted to widen the scope of what children can learn by playing our game. We believed that by having more diversity it would make the game itself more interesting to play and usable in an educational environment such as school, but also because there are quite a lot of educational

[20] Boller,S. *4 Ways Serious Games Link To Learning*. Retrieved from http://www.theknowledgeguru.com/4-ways-serious-games-link-learning-free-download/

games which focus on one specific category (especially games focusing on mathematics). We felt it would be a “different” and strong point to offer multiple different categories of subjects the children could play and learn from. For this reason we added the categories “Math”, “Geography”, “English” and “Memory” to our main menu. Our goal was to add a few mini-games to each of these subjects, with high diversities in games using more realism or more mechanism. Our initial goal was to have two mechanism and two realism games per subject.

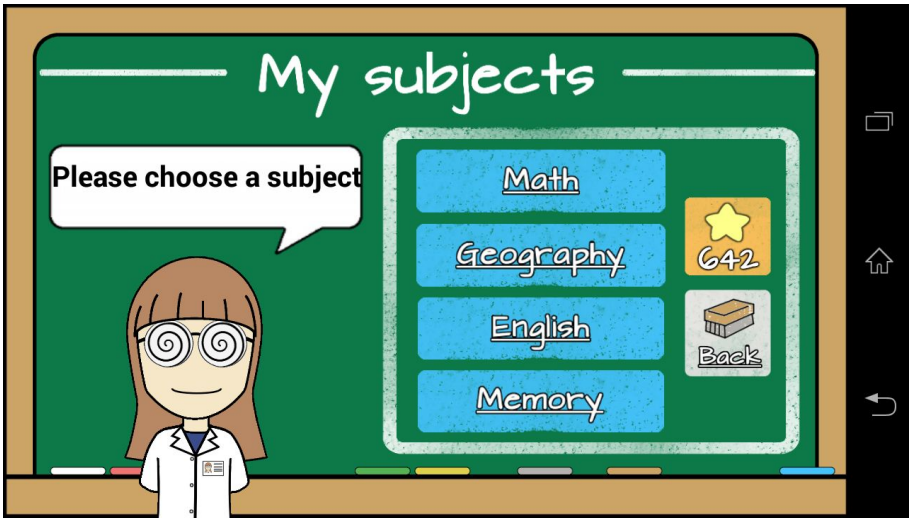


Figure 13: The different subjects

Each mini-game will be in sort of the same format. The player will get either ten or five questions, depending on what game it is and how long the questions take to answer, which need to be answered correctly. In every mini-game the question for that game will be shown in the top part of the screen. The bottom part of the screen is divided into two sections. On the left side of the screen the teacher is shown, who reacts to correct or wrongly answered questions. The right side of the screen is reserved for the input which the player uses to answer the question. How this input looks depends on the type of mini-game.

When first starting the game every subject will have one mini-game available with the easy difficulty unlocked. Players can buy new mini-games or new difficulties with stars they collect while playing the game. Each time a new mini-game is bought only easy is unlocked for this mini-game.

4.1.3.1 Mathematics

The mathematics category is the first category introduced in My Teaching Assistant. Seeing as how math was already present in the old version it only felt right to also include it in the new version. This was also relatively the easiest category to create, mainly due to it not needing any external information and very little manual input of information, with the exception of creating correct calculations and correctly balancing games among the different difficulties. The mechanism based games revolve around the equations found in math while in the realism based games we tried to make these equations blend in the background.

Problem solver (mechanism-based)

The first game of our two mechanism math games.This simple math game is nothing more than solving equations and the game focuses entirely on the mechanisms of solving mathematical equations. The player is given an equation, which can be an addition, subtraction, multiplication or a division. The player is also presented with a keypad which he/she needs to use to input the answer to the equation. In the case of a division, the resulting number is always a whole number, so no equation will be given which results in an answer with multiple decimals. The type of equation is chosen at random when creating the equation. The same is true for the numbers themselves, but depending on the chosen difficulty, the equations will get harder by having higher numbers.

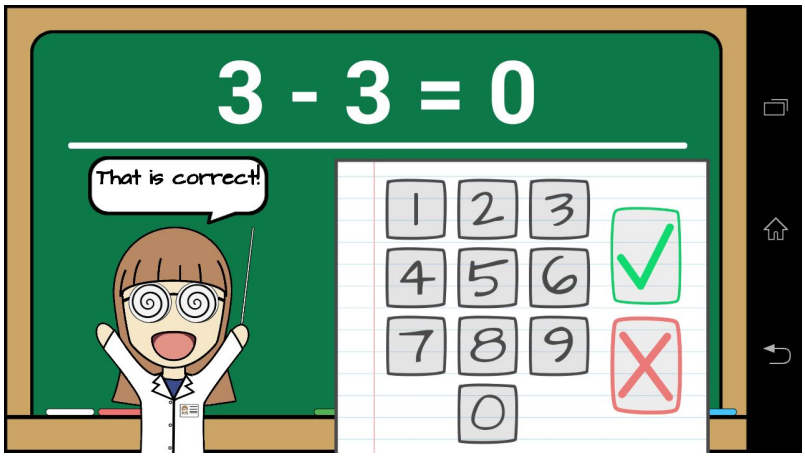


Figure 14: *Problem solver in action*

Operations (mechanism-based)

The second of our mechanism math games. This game is another simple mathematics based game which is very similar to Problem solver, but given in a different manner. This time the player will be shown the two numbers of the equation as well as the answer to the equation, but

the operator is hidden. The player is again presented a keypad but this time with the four types of operators and is tasked with choosing the operator which creates a correct equation.
There might be cases in which multiple operators would be correct like the simple equations of “2+0” and “2-0” for example. In this case both operators are correct. As with Problem solver, Operations gives harder equations in harder difficulties.

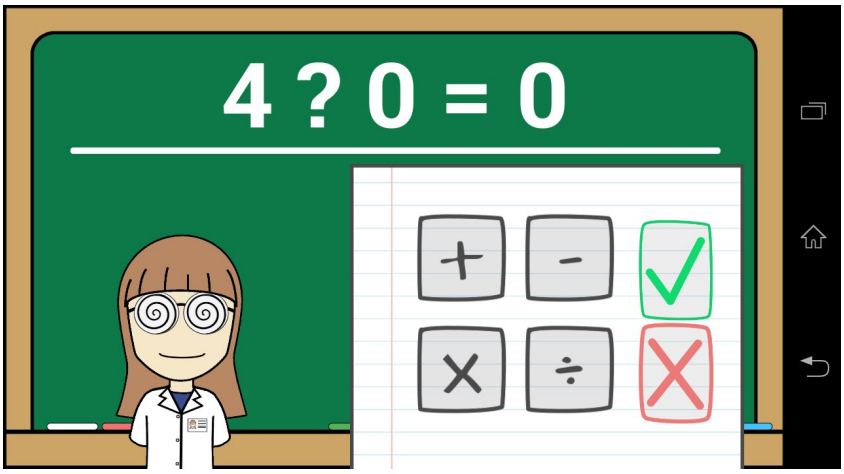


Figure 15: An exercise of Operations

Smooth parking (realism-based)

The first of our realism-based math games. Smooth parking is much more centered around a real world situation, introducing cars and a parking garage. In this game the player is tasked with counting the number of cars in the garage. In the center of the top part of the screen a parking garage is shown. After a small delay cars will start to drive from the left side of the screen into the garage. At the same time cars will also exit the garage and drive to the right side of the screen. After all cars have entered and exited the garage the player can input the number of how many cars he/she thinks is still present in the garage. On harder difficulties more cars will be driving on the screen. While this is also a simple game of counting and subtraction, it feels much less like a game teaching equations, since the equations are hidden within the counting of cars.

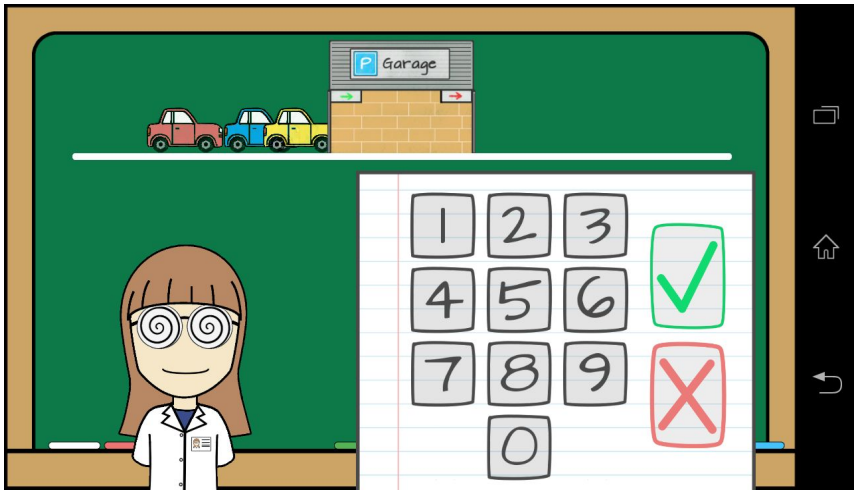


Figure 16: Cars driving into the garage in Smooth parking

Masterchef (realism-based)

The second realism math game is centered around the cooking of recipes. On the top part of the screen there are four different images of recipes shown. The same recipes are also shown on the input paper. The player needs to choose the recipe which has the shortest cooking time. Next to the recipes on the top part of the blackboard is also a small clock. The time it takes to cook the recipe is shown in red.

On easy, the player just needs to select the recipe with the smallest cooking time. On the medium difficulty another timer is shown below the cooking timer, which is the preparation timer. This time represents the preparing of the recipe, before the actual cooking. The player then needs to choose which recipe is the fastest, by combining cooking and preparation timers. On hard there will also be a number next to the recipe, which represents the total amount of this type of food that need to be created. While answering the question the player thus needs to keep the two timers in mind while multiplying them with the amount of times this recipes needs to be cooked.

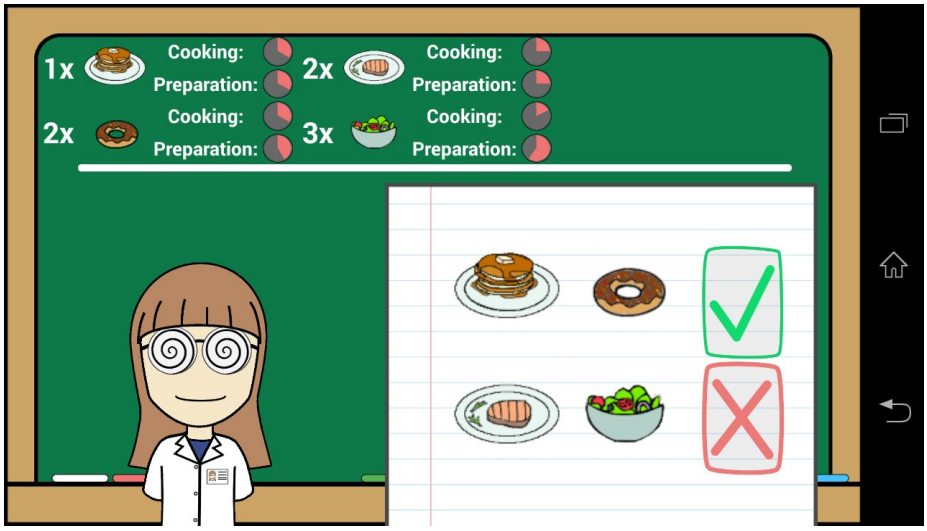


Figure 17: *Masterchef on hard*

4.1.3.2 Geography

After math we wanted to develop a completely different subject and not a subject that is usually seen in a game. This led us to geography and with that we we got the idea of country flags and capital cities. For geography we had to use multiple external resources to create the four mini-games we currently have available. First of all we had to include a list of countries. We started with the two mechanism-based geography games for which we needed the country name, country code and capital of the country. This is why we started by getting a list of all the countries with this information. For this we used an online list of the countries[21] and used some regex replacing to create a list with just the necessary info that we needed.

For the two realism-based games it was much harder. We wanted to have more in-depth information on these countries, but the only useful free-to-use file we could find was a list containing public information published by the CIA[22]. These data files contained info on all the countries in a useful ready to use JSON format. This could be loaded into the game without any problems.

Flagnation (mechanism-based)

In the first mechanism-based geography game the player is tasked to correctly identify which flag belongs to which country. On the top of the blackboard the name for a country will be

[21] Israel Science and Technology Homepage. List retrieved from http://www.science.co.il/International/Country-codes.asp

[22] CIA. *World Factbook Country Profiles in JSON*. Retrieved from https://github.com/factbook/factbook.json

shown. The player is then given four flags of which he/she needs to identify which flag belongs to the given country name. This game focusses mainly on the mechanisms of what flags belong to which countries. There are no other game elements except for choosing the correct flag and the only way to get better at the game is by learning these flags.

Figure 18: Selecting the correct flag in Flagnation

For the question the given country depends on the chosen difficulty. We manually divided all the countries we had into the three different difficulties, mainly depending on how well known or obscure a country and it's capital are. Of course this is fairly subjective depending on where the player lives and as a result has been tweaked by us quite often, to try and balance it as well as we can.

Capital city (mechanism-based)

For the next mechanism based geography game the players are tasked with something similar. This time however they need to combine the correct country with its capital city. Here instead of displaying a country as the question, the player is shown the name of a capital city. The player is then given four countries, from which he/she again needs to chose the correct country. Similar to Flagnation, this game focuses mostly on learning the correct capital and country combinations, not focussing on many more game elements. Capital city uses the same difficulty set-up as Flagnation.

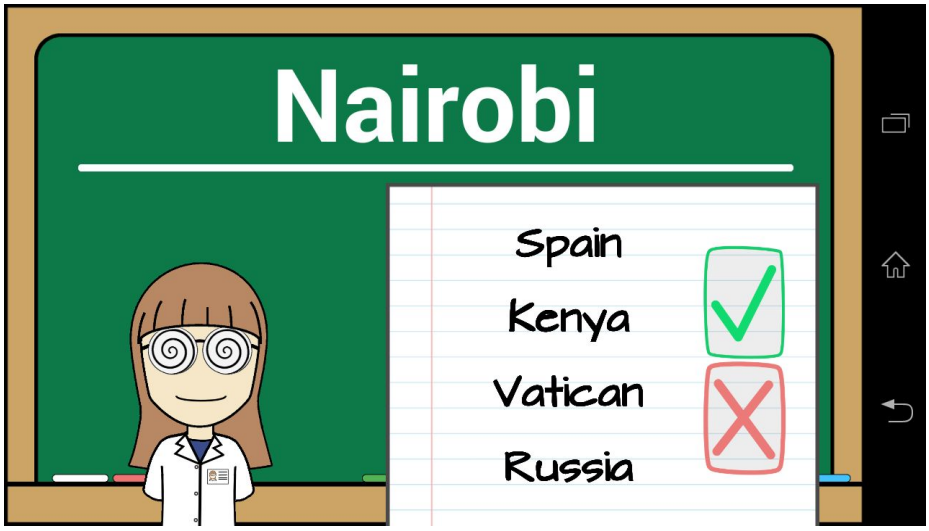


Figure 19: Finding the correct country belonging to Nairobi in Capital city

Vacation advice (realism-based)

In the first realism based game players are tasked with helping to pick a country where the anonymous question giver would like to go on vacation. The question giver presents the player with a few sentences describing a country. At the same time the player is shown a map of a certain region. The possible regions are Europe, Africa, Middle-East, Asia, South and Middle America, North America and Oceania. On the map there is a marker for the correct country, along with markers for three other countries in this region. The player then needs to chose the correct country which corresponds to the question asked by the question giver.

In each of the questions resides multiple types of information which can help the player discern the correct country. What type of information is asked for depends on the chosen difficulty. On easy a question could contain which language is spoken in the country, on medium a question can contain the climate found in this country while on hard the question could ask about the different types of elevations and mountains in the region. On easy the actual country is also given in the question, making it much easier and just a game of locating the correct country while still learning some facts about the country. This was done mainly due to the reason that the game was very difficult when we were testing it ourselves.

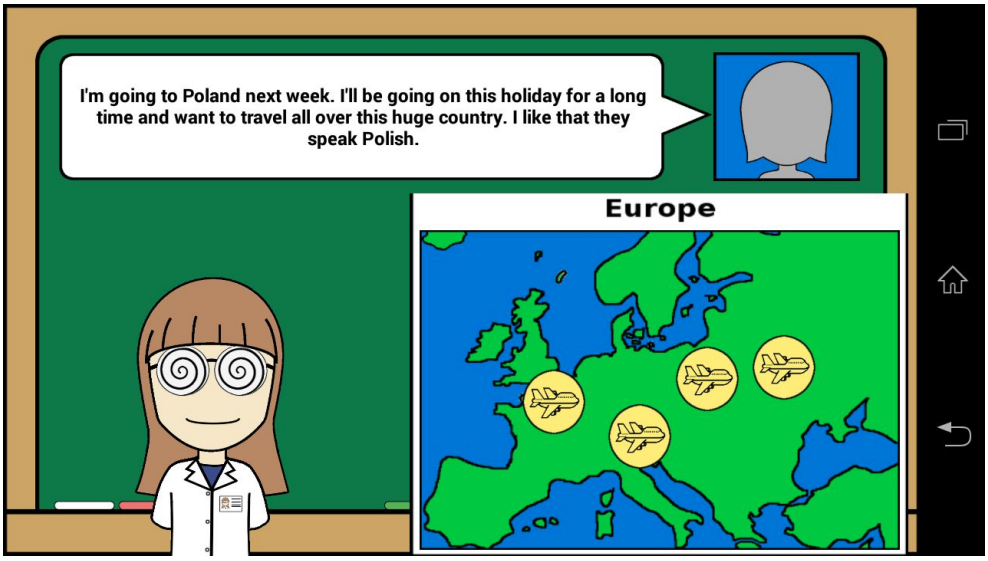


Figure 20: Vacation advice on easy

Vacation advice was probably the hardest game to implement and balance. Even after putting in a lot of hours, we feel it is still not really complete. The main problem is while there is plenty of correct information present in this data, most of it is much too specific and technical for this mini-game. Even though there was tons of information in the data, only a few objects could be used for the game and even this information was very hard to correctly use and structure in a sentence. To perfect this mini-game we would have to manually enter more information on each country which could be used to create much more interesting and easier to understand questions. It would be a much more fun game if there were question concerning geographical locations, famous landmarks or well known dishes for example.

Flight simulator **(realism-based)**

In Flight simulator players are tasked with helping to discover which airplane can reach a given city the fastest. The player will be given a sentence in which a particular city is asking for help. Below the question four airplanes will be shown which are also present on the map. The player is then tasked with choosing the airplane which can reach the given city the fastest. The displayed map is again one of the six given regions, as with the mini-game Vacation advice.

Figure 21: Hard mode of Flight simulator

When playing on medium the airplanes will also display the speed with which they travel, which the player then needs to keep in mind when selecting an airplane. Airplanes closer to the given city might not be the fastest, since they could fly slower than other planes. On hard difficulty another factor is introduced, namely the number of stops the plane needs to make for refueling or boarding of passengers, before it can reach the given city. For each stop the player has to add approximately 25 minutes of landing and liftoff time. The chosen plane needs to factor in distance, speed and stops at the same time. In the future we will add more different planes as well as colors to more easily identify them on the map.

4.1.3.3 English

In our opinion English educational games, such as the popular game Scrabble[23] or Ruzzle[24], are always very entertaining, often more so than other educational games which is why this was one of our main reasons for including an english subject in the game.
For the English subject we only have two games at the moment and both of these games are more focused on the mechanisms than on realism. The main reason for this is because of the amount of work that would need to go into the realism-based games. We did have a few ideas for games based on realism, focusing on either entire sentences or on the meaning of words,

[23] Scrabble. available at http://scrabble.hasbro.com/en-us
[24] Ruzzle. available at http://ruzzle-game.com/

however all these types of games would either need manual entering of all the meanings of the words and sentences or have a different type of UI than the other games that we already had. Regrettably the amount of time that would be needed to manually create such a game fell outside the scope of this thesis. However eventually they will certainly be added.

For our current two games we used a free dictionary we found online[25]. This dictionary consisted of the 5000 most used words in the English language. Before we could use these words we pre-processed them to reduce the list a bit. We mainly removed words we felt like would not be appropriate for children, such as curse words or words related to sex, drugs or heavy violence. We also removed all the words that did not have a minimum of three or a maximum of eight letters, since that were the only word lengths we decided to use in our two games. The result was a file containing more than 3500 words, which the application reads in via an inputreader so that the words can be used in the mini-games.

Word mystery (mechanism-based)

Word mystery is a game in which the player needs to create correct words. The player is presented a scrambled word at the top which needs to be unscrambled right below. The keypad for this game consists of the letters of the scrambled word found above. The player is tasked to enter these letters in the correct order, creating a correct word. This game thus mainly focuses on the correct spelling of words, without any further realism added to the games. Still, the game is very fun to play, even though it was quite simple.

The length of the word shown is based on the chosen difficulty of the game. When playing on easy mode, the player will see words three or four letters long. When playing on normal mode this increases to five or six letters, while hard mode has words consisting of seven or eight letters.

[25] Davies,M. *Word frequency data*. available at http://www.wordfrequency.info/free.asp

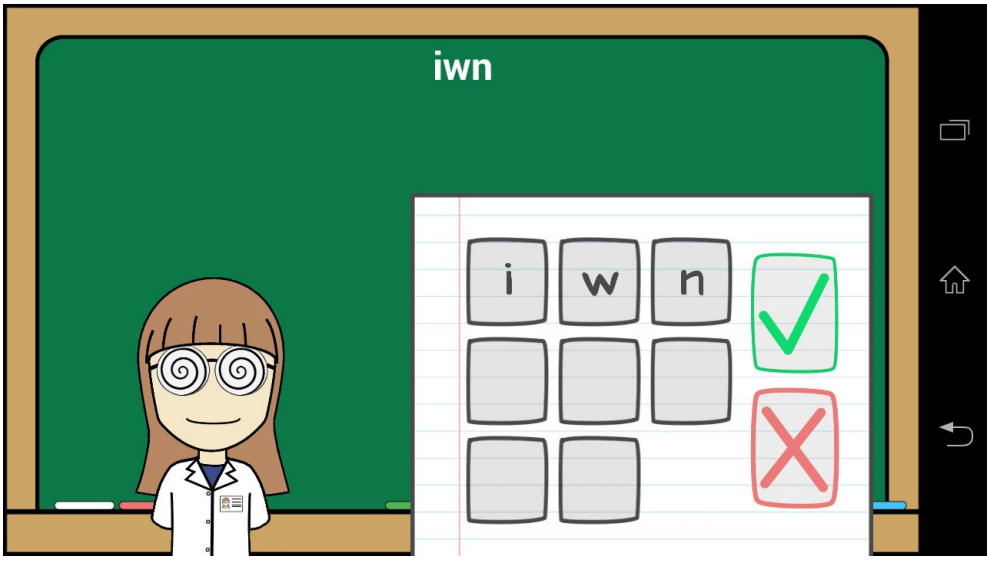


Figure 22: A scrambled word in Word mystery

Wordify (mechanism-based)

This game is very similar to Word Mystery, but in a different format. Here players are again tasked to create correct words. However this time there is no scrambled word shown at the top of the blackboard but the player is instead given a certain number of two letter combinations, for example ‘me’, ‘di’, ‘sc’ and ‘ti’, in no particular order. The player then needs to create two words with these combinations. In this particular case the answer would be ‘disc’ and ‘time’. Again, this game mainly focuses on creation of words and spelling them correctly, though since this game has two words at once, it is often a bit more puzzling to understand which letters are used together to create a word. Often the player will be able to create a word with half of the letters, only discovering the other letters do not match up to a correct word, meaning the first word was also not correct.

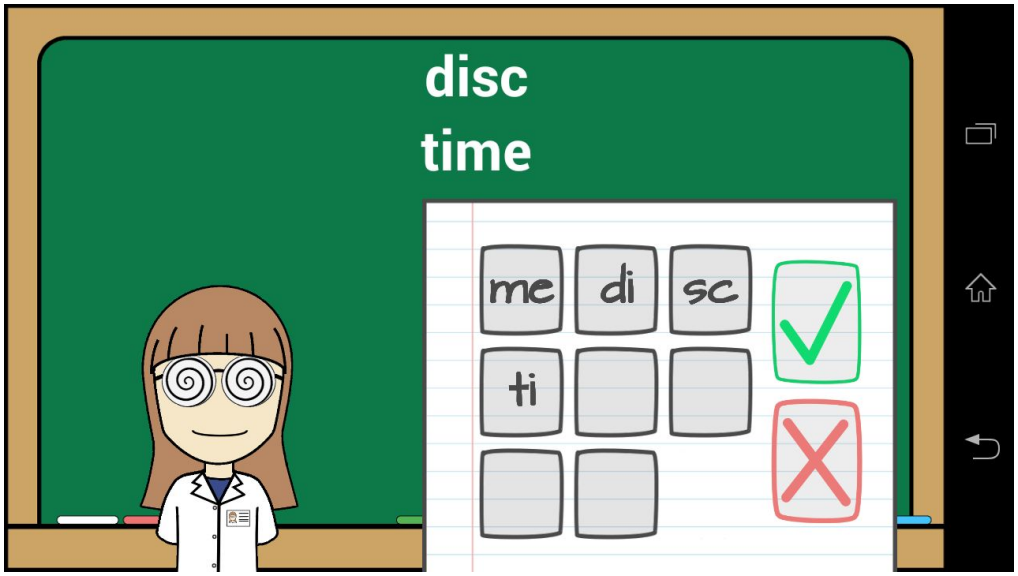


Figure 23: The two words filled in correctly in Wordify

As with Word mystery, the chosen difficulty influences the lengths of the words. Considering we are using groups of two letters, all the used words need to be even. This means on easy the player will need to create two words both consisting of four letters. On medium these words have six letters and on hard they have eight letters.

4.1.3.4 Memory

Memory is a category we wanted to introduce to more or less give the children a break from the really educational games. Memory games can be useful for children because they can help by having them remember certain sequences, objects or make logical deductions. Games like this can also be beneficial for their education and to them it would be fun having a few games which feel more like “normal” video games instead of educational games. However we invented this category before deciding on the real purpose of this thesis, which ultimately resulted in the fact that the memory category has not been implemented as of yet.

4.1.3.5 Mini-game feedback

After every completed mini-game the player is greeted with a result screen. This is one of the first forms of feedback that is received. The main idea behind this screen is to give an overview of the player’s performance during the last mini-game. It is also intended to motivate the player in order to help better him/herself. The screen itself is built on a number of stats which are

tracking various things during the mini-games. The stats which are being showed on the result screen are as followed:

1. Number of correct questions answered (completed)
2. How many questions are answered correctly continuously (streak)
3. How long was taken over all the questions (time)
4. Number of stars earned (stars)
5. Number of subject related stickers earned (stickers and more on this later).

Figure 24: The results screen

Sharing

This is not yet implemented but the idea is to make it possible to share results on social media. The game will make a picture of the middle area and this can be shared.

Answers

With the answers we wanted to make it possible for the player to view the answers that were given to the various questions. The previously mentioned points highlighted how important feedback was so the player should be able to review what went wrong and how he/she can learn from any mistake made. The answers are easily accessible on the result screen.

The answer page can be seen in figure 25. Our goal here was to make it easy to navigate and in case of a wrong answer both the correct answer and the given answer are displayed. This is done so the player can compare the answers and see what he/she did wrong.

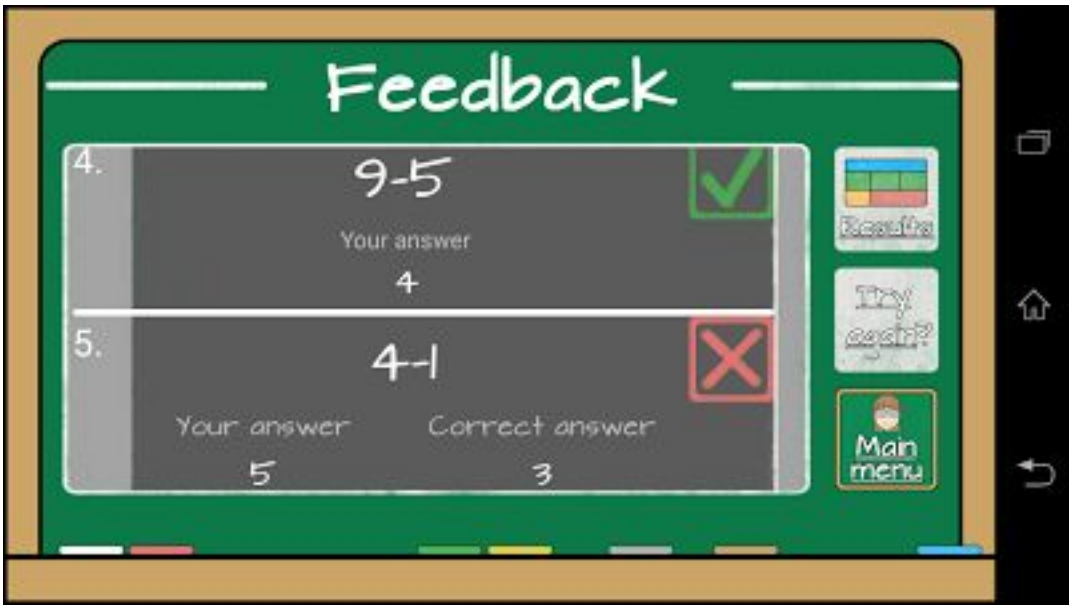


Figure 25: The feedback screen

We hope that the inclusion of both the result screen and the answers give the player enough relevant feedback from which he/she can learn. The goal here was to motivate the player in playing again and besides these forms of feedback we also implemented a robust reward system which we will talk about shortly.

4.1.3.6 My stats

This is an option in the main menu which would also feature stat tracking of some kind. Sadly we were not able to implement it in time. The idea behind this option was to provide the player with even more feedback besides what's already in place in the results screen. While the results screen only provide feedback for that individual mini game the user played, the "my stats" screen would be able to provide a summarized view across the different mini-games.

We wanted to give the player a summarized view on how well he/she performed across all the available mini games. Nothing too complex but something detailed enough to at least give you another sense of progression besides the various earnable rewards which we will talk about shortly. Stats like an overall percentage completion rate, the probability on the player answering a answer correctly given a certain difficulty and perhaps even also a bit of time tracking. We do still plan to implement this in the future.

4.1.4 Phase 4 - Reward system

In this phase we will discuss the robust reward system that we implemented. Alongside the previous phase we were constantly play-testing and balancing these two phases during development. We wanted the game to have a good sense of progression but did not want to promote blind re-playing just in order to unlock everything. We will describe in-depth how the reward system in our game is designed. We developed a fairly large reward system which hopefully gives the player extra incentive to play the game and replay certain game-modes (by e.g. unlocking harder difficulties) to not only get better but to also earn certain rewards. This ties in with the core foundation in offering ways for the player to have fun and to be able to visually see progress with performance.

4.1.4.1 Sticker book

Having collectibles helps with the performance of the player. One way to realize this was our idea to create virtual stickers. Stickers kind of fell in the context of a classroom and seemed appropriate enough so we decided to add this to the game. With the idea of having virtual stickers came the idea to have a sticker book in which these stickers could then be viewed.

These stickers are nice/funny looking images which the player can collect and view them (or possibly interact with) in their virtual sticker book. In the sticker book the players will also be able to see what stickers they're missing and how they can be collected. We hope that by having this sticker book players are encouraged to fill it out so this could act as an extra motivation to keep playing.

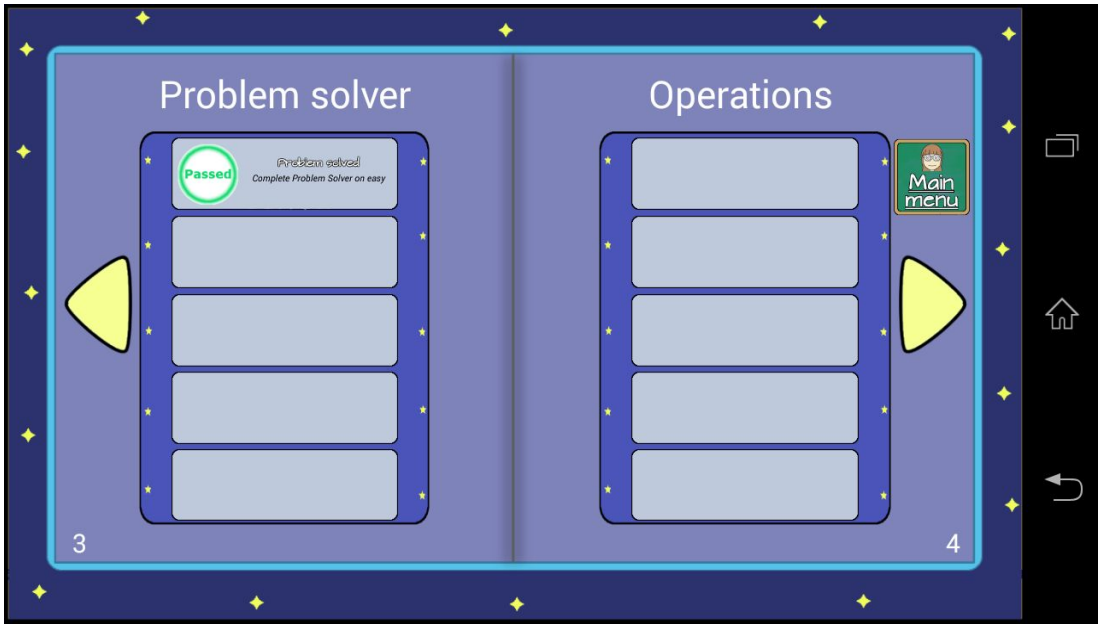


Figure 26: The sticker book

4.1.4.2 Stars

Another way that could help with the tracking of performance besides just collectible stickers was a virtual-currency. We made it in the form of stars and they can be used to unlock harder difficulties, specific stickers and even new game-modes. Stars are earned by playing the different game-modes. The maximum amount is dependant on how many questions the player answered correctly and on what difficulty they played the mini game.

Figure 27: The stars icon

4.1.4.3 Stickers

The stickers themselves are divided into three different types and each type is earned differently.

Whenever a sticker is collected a popup will show up with the collected sticker as detailed below. Every sticker will have a different visual and the visual will correspond to that particular subject. Not all sticker visuals have been implemented at the moment.

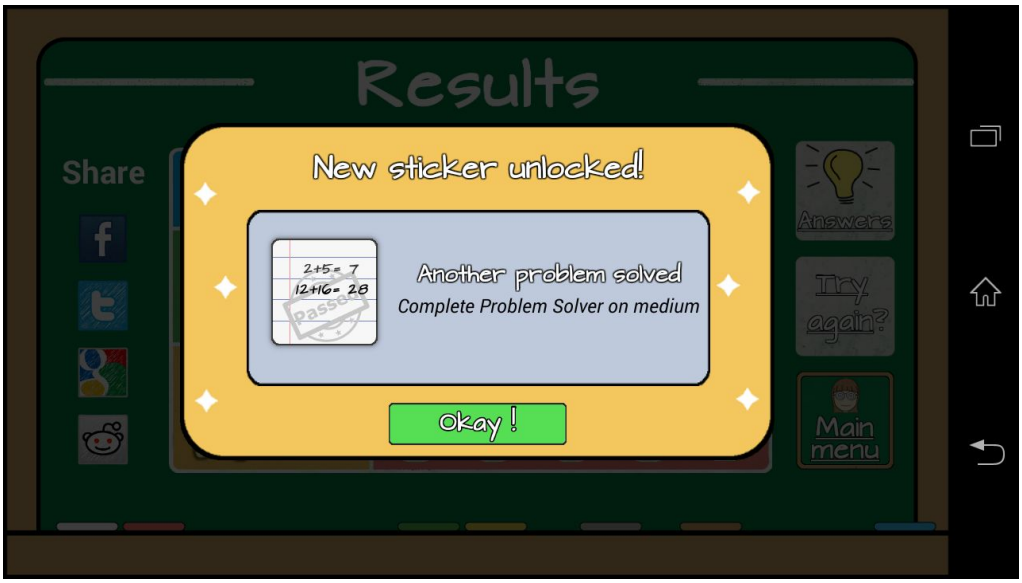


Figure 28: Earning a sticker

Each sticker comes with a small description which details it's title and unlock requirements. The three types of stickers that can be earned are:

1. Achievement based stickers
2. Completion based stickers
3. Collection based stickers

Achievement based stickers

These stickers are earned when the player achieves certain goals in the mini games. For example "Complete Problem Solver on Medium for the first time" or "Get all questions correct for Problem Solver on Medium!". These stickers all belong to one particular game mode and difficulty meaning every game and difficulty will have it's own stickers to collect.

Completion based stickers

These stickers will be handed out for completing certain milestones in the game. For example "Buy your first game mode!" or "Played Math games 10 times!". These can happen at any time

in the whole game and are not bound to a particular game mode or difficulty like the achievement based stickers.

Collection based stickers

These stickers are collected by spending earned stars on our created sticker machine. The player can choose how many stars he or she enters into the machine. The more stars are entered the higher chance there is for the player receiving a new sticker. The more stickers that are collected from this machine the lower the chances become for getting new stickers. This machine was designed as a place where leftover stars can be spent after everything else has already been unlocked in the game and to give children a reason to keep replaying games by giving them stars which they can use to collect the stickers and fill out their sticker book.

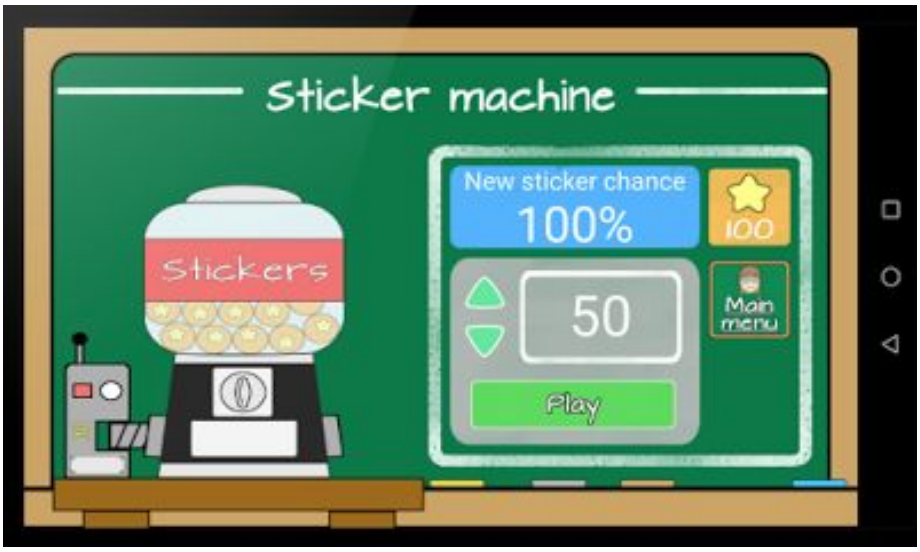


Figure 29: The sticker machine

4.1.5 Phase 5 - Analytics

The final phase of our bottom-up design and also the shortest. The shortest being that although part of the game it wasn't really the focus of thesis. To monitor how players behave in the application we created a server where we can save analytics that are sent there. While we haven't used the server explicitly during our thesis, it is still an important aspect of the game since it will ultimately help balance everything even better.

Important events are sent to the PHP server, if the device on which the game is running is connected to the internet, where they are stored in the corresponding MySQL table. Important

events can include when players start a mini-game, their results for that mini-game, if they unlock stickers and when they purchase game modes, difficulties or stickers.

With the help of these tables we could see which features and mini-games are popular and which aren't. It will also help identify which games are too hard or easy and if players get better in these mini-games.

4.1.6 Everything added up

This concludes our design methodology and how we approached all the different development phases in My Teaching Assistant. We hope that both the reward system, feedback and other elements offer enough to motivate the player to ultimately re-play the various mini-games. We really tried to differentiate both the mechanism mini-games and the realism mini-games, by placing them both in their respective context we hope to teach the player via different means and show them the workings of both realism and mechanism-based games. In the next section we will discuss important techniques we used for various aspects and options that any developer probably wants to consider when developing a serious educational game.

4.2 Detailed discussion

4.2.1 Designing the UI

As previously mentioned it was quite a problem designing the main menu, it was less of a problem in other screens when we had a clearer vision of what we wanted. Besides making the UI visually appealing and accessible enough so everyone can understand it at a glance it is very important that the UI can scale to different screen sizes. This is also one of the main problems that we previously talked about. This is not really a problem if the developer only wants to support a single screen size but that is rarely the case these days as developers want to reach as much people as possible and even on all possible platforms. Getting the UI to scale to different screen sizes can be quite a challenge depending on what kind of information the UI is conveying to the player.

4.2.1.1 Why is this such a problem ?

Getting the UI to look good on one screen size does not necessarily mean it will look good on other different screen sizes. If no care is taken depending on what is being shown the elements on the screen can get stretched out on larger screens, remain the same size thus appearing

small on a larger screen or maybe even get cut off by other elements. There are other factors to consider like working with images, text or other kinds of elements so the problem gets more complex based on what it is the developer wants to show and how.

4.2.1.2 Solutions

Because our game isn't that complex and most of our screens comprise mostly of images and a little bit of text it wasn't really that hard once we figured out what worked for us. There are a number of solutions available to deal with the scaling and support of multiple screens and a number of them are on the developer pages of Android itself[26][27], we also used the list on opensignal blog as reference[28]. A few of the points are:

Create layouts for multiple screen sizes

Everything seen on a screen is placed on a layout. It acts as a container for all elements placed upon it. The layout itself can be tweaked extensively based on the content being shown on it and it's role in the current screen. One of the ways of supporting multiple screen sizes is creating multiple layouts for different screen sizes.

Effective use of the properties wrap_content and match_parent

There are a number of properties that a developer can tweak with different elements in order to support different screen sizes. Two of the more important ones are wrap_content and match_parent. In general wrap_content is used when the width of an element is concerned, this basically tells android to place the element with the minimum size necessary in order for the element to be seen on the screen(in the case of an image it is dependant on how large the width of that image is). The property match_parent tells the element to match it's height to the height of the layout the element resides in, if the layout is equal to the whole screen the element will stretch to match the height of the screen.

Effective use of the dimens.xml file

The dimens.xml file is short for dimensions.xml. In this file the dimensions can be stored for any element relating to certain screen sizes, these dimensions will only be used in these defined

---

[26] *Supporting Multiple Screens*. Retrieved from http://developer.android.com/guide/practices/screens_support.html
[27] *Supporting Different Screen Sizes*. Retrieved from http://developer.android.com/training/multiscreen/screensizes.html
[28] James. (2013, July 30). *40 Developer Tips for Android Optimization*. Retrieved from https://opensignal.com/blog/2013/07/30/40-developer-tips-for-android-optimization/

screen sizes. The more screen sizes the developer wants to support the more dimensions that need to be defined.

Don’t scale images

The idea behind this point is to not make more images of varying sizes in order to support multiple screens. It is better to use dimens.xml to scale images in accordance to different screen sizes. Although it is by no means a bad practice to make multiple images in different sizes, depending on your programming background this could still be a good alternative.

While we followed most of the steps we did deviate a bit as in some cases it made developing easier for us based on what knowledge we had at the time. This is how we did certain things:

We scaled our images

In our case for example we created multiple different image sizes for different screen sizes. We were not adapted enough to work with precise dimensions because our layouts also were vastly different. We created the images in very large resolutions so we merely ran them through a batch processing program which resized the images to the sizes we wanted them to. The only drawback in our case to using different sizes for the images is that the total game size became a bit larger, but we deemed this acceptable.

We don’t use different layouts for different screen sizes

Because we adapted our images to the screen sizes we do not have multiple layouts for different screen sizes. Instead we basically only have a single layout which adapts itself and all the components in the layout to the screen size (more on this in a bit). Every layout and component we use also makes use of the wrap_content and match_parent properties.

We use dimens.xml

We use this for adjusting the size of certain text objects we use throughout the game. For resizing the text in a certain screen size we found this to be the easiest way.

Our usage of layouts

As previously stated we don’t have multiple layouts for different screen sizes. Instead we use a single layout which has multiples layouts in it. This sounds weird but it enables us to build a screen exactly as how we want the player to see it and the advantage is that this scales every element on the screen to the relevant screen size. So to put it short, every screen seen in our

game is comprised of multiple layouts within a single layout. The following practice is repeated for every screen the player can see in our game.

We'll start by showing what a typical screen looks like and how a layout relates to that.

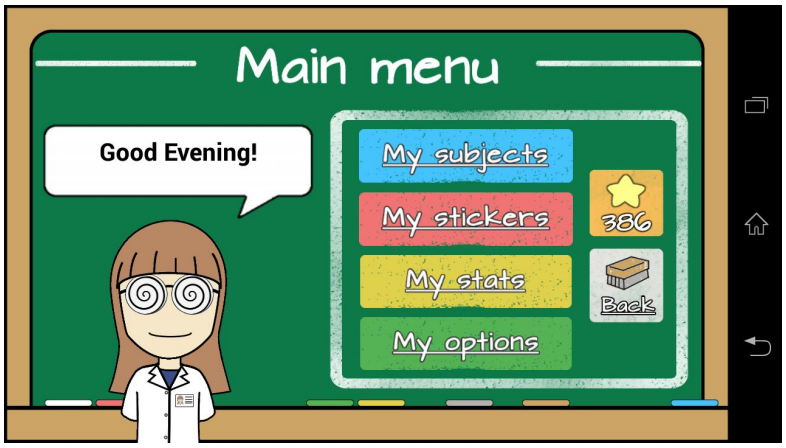


Figure 30: The finalized main menu

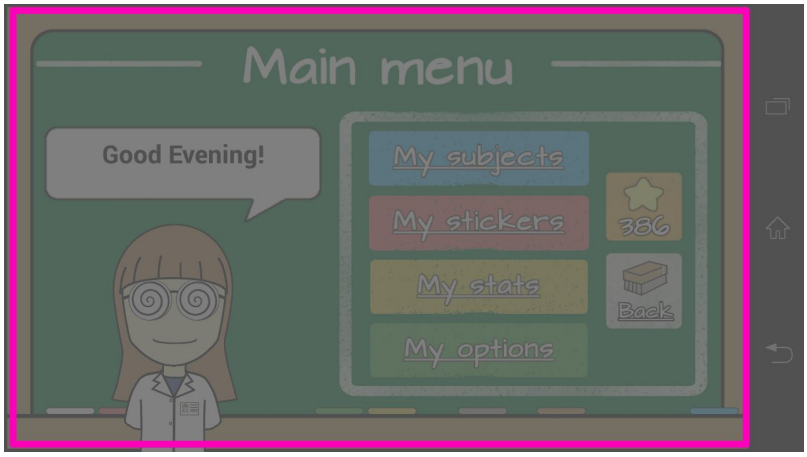


Figure 31: The main menu with the first layout highlighted

Figure 30 shows the finished version of a screen with all the elements already in place. Figure 31 displays the same screen but with the first layout shown (colored pink). The first layout encompasses the whole screen, everything added to it will be within in this layout. Before we start building the screen we literally sketch it on a piece of paper. From the first layout we slowly start rebuilding the sketched screen in android using a lot of layouts.

The layouts that are being used in our game are mainly linear layouts. There are many different layouts and although we use a few others the different screens are mainly comprised of linear layouts. Linear layouts can be placed on a screen with a weight and it is this weight that's the important factor in its placement on the screen.

Weights

According to the android developers API guide a weight assigns an "importance" value to a element on how much space it should occupy on its spot on the screen[29]. If no weight is given the element will just occupy as much space as required by its content.

Having only one layout won't change anything. Assign a weight to it is not really necessary, as it will eventually occupy the screen as it fills up with different elements. But assigning a weight to it will make it easier when creating additional layouts within it. Let's look at the next example.

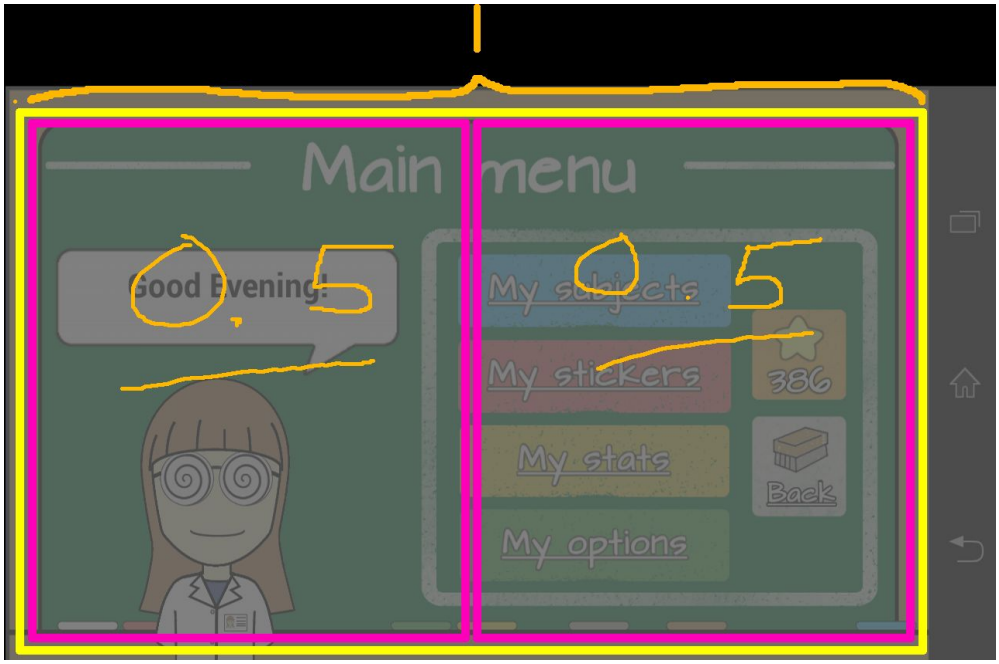


Figure 32: Dividing the first lay-out in two separate lay-outs

In figure 32 we can see the first layout colored in yellow and two additional layouts within the first one which are both colored pink. By giving the first layout a weight of e.g. 1 an evenly

[29] *Linear Layout*. Retrieved from http://developer.android.com/guide/topics/ui/layout/linear.html

distributed split of the two underlying layouts by giving both of those a weight of 0.5. Further splits starting from the 0.5 and onwards can be created.

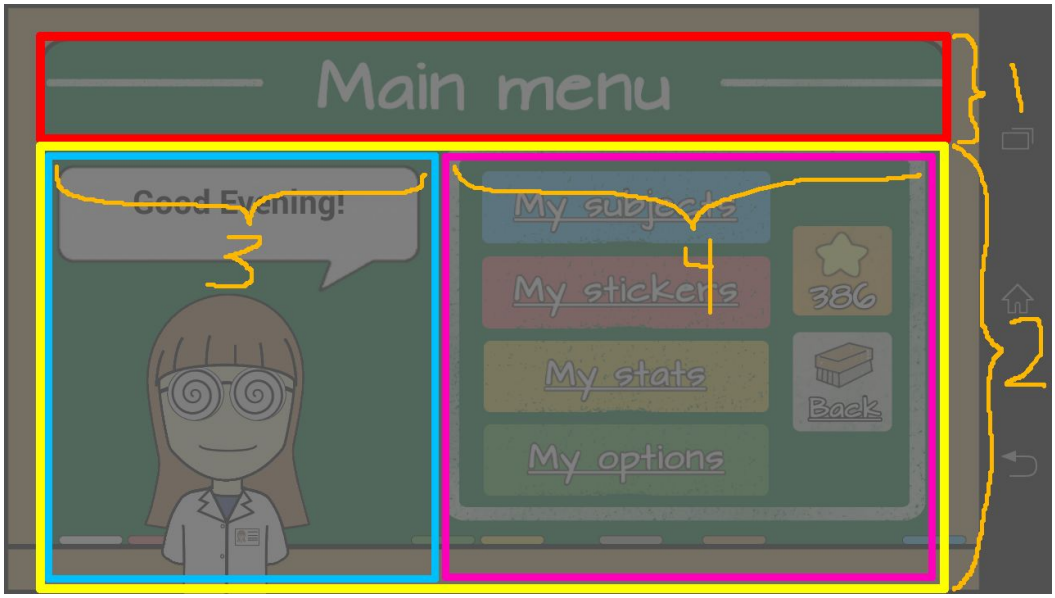


Figure 33: The main menu divided into its layouts

Figure 33 gives a better idea on how the screen is built up with layouts.This is a rough idea of how we created the whole screen and positioned each and every element that can be seen on it. Needless to say there are a lot of layouts involved. Positioning so many layouts within each other is bad practice as it can hamper performance but given that our game itself is not very complex (no advanced visuals, animations, effects etc) it does not suffer from a performance drop even on older devices. A small example of the layout can be found in the appendix. This example covers the teacher portion of the screen labeled as 3 in figure 33.

Pros versus cons

The only real pro gained by using layouts this way is that it scales everything that is put inside the layouts automatically, this is done on the entire screen and on multiple screen sizes. The only pain is building the whole screen with layouts from the ground up but once that has been done there is no need to worry about much else with regards to positioning.

The cons however are much more prevalent. The most obvious one is performance, as previously mentioned this can be a factor on more demanding apps when using so many layouts. It is also very confusing working with so many layouts, this makes it finding a certain

component in a specific layout very hard as one has to go into multiple layouts before the desired component is reached.

We ultimately chose this way of developing because at the time we did not have that much knowledge with regards to the positioning of multiple elements in a UI and when we had a better understanding we were already too far in development to make drastic changes. It became clear that in order to do it correctly one has to keep in mind multiple things (e.g. dimensions for images and layouts to support various screen sizes, correct usage of properties etc) and we now know how to position most components programmatically. The end result of developing correctly would likely benefit more complex apps much better on different devices. This is something we definitely want to look into when we are going to develop more apps in the future.

4.2.2 Programming the application

4.2.2.1 Activities

My Teaching Assistant is created as a native Android application. This means it is programmed in Java and uses many of the key features an Android application offers or needs. One of the most important concepts is the concept of an Activity. Activities are parts of the application. Each activity offers a screen on which the application can draw and the user can interact with. Activities can be compared with the many rooms in an house. Where the entire Android application is the entire house, each Activity is a separate room, offering different functions and surroundings to the user.

In a XML file called the AndroidManifest all these Activities are defined, as well as which Activity is started upon opening the application. Part of the AndroidManifest can be found in the appendix. When users move through Activities native screen transitions will be shown and pressing the native Android back button closes an Activity and re-opens the previous Activity. For our application we have defined multiple Activities for all our different screens:

- The start screen
- The main menu
- The game screen
- The result screen
- The sticker book
- The dispenser

Starting an Activity can be done by first creating an Intent and then calling the Android function startActivity:

```
Intent intent = new Intent(this, Game.class);
startActivity(intent);
```

A complete example of starting an activity can be found in the appendix.

When creating an Intent, the correct Activity that needs to be started is included. The intent is also needed to pass along data between the Activities. Where normally in Java it is very easy to just call a method in another class and pass some parameters in that method, this is not possible in Android between Activities. Activities are mostly separate from each other and can not pass data directly. This also means that Activity A can not get information from Activity B, or call any methods in it whatsoever. The best solution for this is by adding data to the Intent, which is passed between the two Activities by the native Android framework:

```
intent.putExtra("difficulty", difficulty);
```

The data passed along can than be read by the receiving Activity:

```
difficulty = intent.getStringExtra("difficulty");
```

4.2.2.2 SharedPreferences

While passing along data in an Intent is the best way to pass along data through Activities, it is not always the preferred way. Certain data in an Android application needs to be stored even when the application is closed and not running anymore. Upon restarting the application this data needs to still be available. The Intents which are mostly used for opening new Activities are not stored when the application is closed, which means this data needs to be stored in another matter.

One solution would be to store all relevant data on a server, but since this is a single player game with no multiplayer features whatsoever and no reason to have an active internet connection, this is not a good solution for My Teaching Assistant. Another solution is to use the SharedPreferences class provided by Android.

SharedPreferences are key-value pairs of primitive objects which are stored in the data storage of the application. This means that any simple object such as integers, strings or booleans are stored in a persistent storage which is saved between sessions. Saving information in the SharedPreferences can be done like:

```
SharedPreferences sharedPref =
this.getSharedPreferences("nl.craned.teachingassistant",
MODE_PRIVATE);
SharedPreferences.Editor editor = sharedPref.edit();
editor.putInt("nl.craned.teachingassistant.stars", stars);
editor.commit();
```

When creating the SharedPreferences object one of three modes can be used:

- MODE_PRIVATE
- MODE_WORLD_READABLE
- MODE_WORLD_WRITABLE

Whereas the first mode means that only the calling application can access these preferences, while the other two modes note that other applications can also read and/or write in the preferences.

Getting the stars integer is then as simple as:

```
stars = sharedPref.getInt("nl.craned.teachingassistant.stars", 0)
```

Here the 0 parameter in the getInt function represents the default value, assigned to the variable if the object is not found in the SharedPreferences.

SharedPreferences are as the name implies, shared between all Activities in an application and possibly between other applications. SharedPreferences should only be used for short primitive objects. Large files however such as entire save games, images, videos or other objects should be saved on the disk straight away. This is also supported by Android, where every application gets it's own public and private folders, but is not used in My Teaching Assistant.

4.2.2.3 Programming the games

One important design decision we have made is that we want all our mini-games to be in the same type of format. This means we want the exercise question in the top of the page, the teacher who reacts to answering questions on the left and a type of keypad on the right for actually answering the questions. For this we created a simple framework which is shared between all the different types of games.

First of we have the Game class, which is the Activity used when playing the games. This Activity contains code for displaying the reactions of the teacher, for setting up the different

types of games and to setup the click functions of the input buttons. In Android the screen is defined in XML files as we discussed above. Objects in these files such as images can be given an Android:onClick value, where the name of one of the functions in the corresponding Activity can be given. We created different XML files for all the mini-games, since each mini-game has a different layout concerning the question and the keypad, but all the input objects call a Play function in the Game Activity.

The Game Activity knows what type of Game it is and upon receiving input it will call the StandardPlay class. This class is used for the actual playing of the games and process the input. The StandardPlay class has different methods for all the mini-games. In these functions the input is processed for this specific click and mini-game.

Every mini-game contains a few questions, which are a type of Exercise. The Exercise class contains fields that are shared between all types of games, such as what type of game it is, if the question is answered correctly and how long the user needed to answer the question (which is not used at the moment, but might be used later to dispense stickers for example). Different games are types of different classes such as Arithmetics or Geography. These classes extend the default Exercise class with added fields and functions which are specific to these games, such as functions to generate an exercise for example.

The actual rendering of the question, the answers typed in so far if relevant and other objects such as confirmation pop-ups in two of the geography games is done via the Renderer class, which is called in the Game Activity after the StandardPlay class has processed the input. Once again, the Renderer class has different functions corresponding to the different mini-games, where in each function other information is placed on the correct positions on the screen.

4.2.2.4 Server

The server we have created for the purpose of storing analytics on the behaviour of players for now is hosted on a free amazon EC2 web server. This server is free for six months, after which a monthly fee is required. It has excellent support, features and bandwidth, making it a great choice for a first server to store the event data. In the future this server could be moved to another server where we would have even more control over how the server is configured.

On the server we have installed MySQL and Apache Tomcat. With Tomcat we can host a webservice, which we use by sending http requests to in the client application. The game sends

events via a http POST to a PHP file running on the server. Data regarding the event we want to log in our analytics is added to the POST in the form of JSON data. The PHP server reads the JSON data. In the JSON a field specifying the type of event is required, which is used by the PHP to forward the request to the correct method. These methods which receive the events create MySQL queries to store the data in specific tables. Every event type, such as game start, game finish or sticker unlock, has it's own MySQL table with it's own unique columns.

To identify a user each table has a userId column, which is an integer. This integer is an auto incremented integer generated on the server the first time a client connects with it. The client sends an unique string to the server, which is stored in the table userId_deviceId, with the userId being the auto incremented id and the deviceId the unique string. Every time the client connects to the server the server will look up this userID based on the deviceID and use this integer for the other tables The main reason we use this userId on top of the deviceId string is because it is easier readable en better to work with when performing analytics queries on the MySQL tables.

The first time a client sends something to the server it will generate a unique device string. this string is first off based on an unique string generated by the device itself via:

```
Settings.Secure.getString(context.getContentResolver(),
Settings.Secure.ANDROID_ID);
```

This string is further modified by getting the current date and time in milliseconds which is appended to the device id. The combination of these two will make sure the string is unique. The deviceId is then stored in the SharedPreferences, so it can be used in future server calls. This does imply that if a player removes the app or clears his/her data the application will generate a new id, since this will clear the SharedPreferences, meaning the server will see it as a new user. This however is mainly unavoidable, with the only real solution is by offering a possibility to login with accounts such as a Google or Facebook account and linking this account on the server. however that is far beyond the scope of this game and thesis.

Server communication is done via the Analytics class in the application. This class first checks if the device is currently connected to the internet. If this is true then it gets the created deviceID, or creates a new one if this is the first time the class is used. It then sends the JSON data given to it by the calling activity and sends it to the server. Since this is a static function it can be used by any class or activity by for example doing:

```
Analytics.sendAnalytics("gameStarted", json,
this.getApplicationContext());
```

The entire Analytics class as well as a snippet from the server code and database structure can be found in the Appendix.

5. Evaluation

After having discussed in great detail on how we approached the design and techniques regarding My Teaching Assistant we will now discuss the most notable problems we encountered during development. After having discussed these problems we will discuss our gathered impressions on when we play-tested My Teaching Assistant with our target audience and we will then discuss our findings regarding the answer to our research question.

5.1 Encountered problems

We've come across many problems while developing My Teaching Assistant. Sometimes the problems were small and easily dealt with, while other times they formed huge roadblocks that we really had to think about. If a problem reached a point where we had the feeling that it was going to take too much time to solve we would find ways to do things differently but still effectively. From the problems we encountered we learned a lot and the information we gained will certainly help us in the future with the development of other games. We'll talk about the most prominent problems we encountered and how we solved them. We will categorize the problems so it's a bit easier to read and understand. These categories are:

1. System problems
2. Design problems
3. Game problems

5.1.1 System problems

5.1.1.1 Screen size

Developing the game on Android has it's benefits but if the aim is to reach a broad audience it is important to think about which Android versions are supported, which introduces the problem of different screen sizes. It was important that the game looked the way we wanted it to, meaning every object on the screen had to be centered at it's intended place even if it meant a much

larger or smaller screen. It was quite challenging working across different screen sizes and we had to really delve into android to see how we could solve this. We ultimately found a solution in the usage of layers which we previously discussed in detail, it is by no means the ideal solution but for a lightweight game as this we decided it would suffice. The next problem to deal with is image size which is covered in “design problems”.

5.1.1.2 Out of memory exception

This is another problem that we encountered a lot during development. The main cause of this exception was that certain images we’re just too large in size and thus the total amount of permissible virtual memory for the game would be exceeded which resulted in the game crashing. It took us a long time to trace the cause of the exception because it would usually appear at random times during certain parts in the game. To solve it, a lot of images had to be re-drawn and edited so they would be smaller in size but visually still sharp and beautiful. To make matters worse sometimes the exception would occur on different devices (old or new) while we thought that the problem for that certain section was solved, this again lead to new re-draws and edits.

5.1.2 Game problems

5.1.2.1 Inventing mini-games

A problem that we foresaw when starting development of the game was thinking of fun mini-games to play. This was especially hard because we needed to find a good balance of having mini-games which are mainly realism-based while other mini-games are mainly mechanism-based. At the same time we also wanted to stay true to our different subjects. The realism-based geography games were quite hard because we had to figure out something interesting with real life games while still teaching information on geography, without creating a very large game around it. The developing and discussing of these games took a very long time.

5.1.2.2 Balancing mini-games

This is a common problem among video game development and it was sadly no different for us. It was important that the level of the difficulty in the mini-games was appropriate and fair. This means that all mini-games should be around the same difficulty when playing on easy and should get harder when playing on normal or hard. This proved to be quite difficult because every mini-game is completely different. For example the “Smooth Parking” mini-game was very hard to balance in such a way that it gets harder, but not too hard. Increasing the number of

cars by too high a number quickly made the game way too difficult. Another example is “Flagnation”, it was very hard to choose which countries should be shown in what difficulty, especially since this is very subjective, depending on the country of origin of the player. Furthermore there are many obscure countries that can give players of any age problems of choosing which flag belongs to that country. The main solution for balancing these problems has been by playing the games a lot and letting other people, especially children, also playtest the mini-games. Over the design process we have balanced the games a lot, but this still is an ever continuing process.

5.1.2.3 Working with data

Another problem we encountered was working with external data. For some of the mini-games we needed external data which we could use in the games. We tried to avoid using external data as much as possible, but for a lot of mini-games it reduced the workload drastically. If we e.g. had to manually create all the flags for the geography games or enter all the other relevant geography data (locations, capitals) ourselves it would take a very long time. The biggest problem with external data is that most of time data has to be filtered out that isn’t relevant to the project, this makes it quite difficult to integrate successfully as opposed to when we would create our own data. For us this was true when trying to use geographical data to create the questions concerning vacation advice. Since the external data was in a format that we could not choose ourselves it was hard to create questions which made sense. We partially solved this by creating many different checks in the code on how a sentence should be built but it took a lot of time.

5.1.3 Design problems

5.1.3.1 Images in different sizes

At first this didn’t really look like a big problem. It did however become one when we decided to support multiple screen sizes. At the time we didn’t have any choice due to the lack of our in-depth knowledge regarding layouts and dimensions. Every images from that point on had to be created with different sizes in mind, this meant it had to be sharp whether it was very small or very large but it still could not be above a certain size because otherwise the out of memory exception would be triggered. We support four different screen sizes that in general cover most sizes, android itself will know which of the four sizes is best suited for that particular system and will choose the appropriate size. This means that every image created had to be resized four times, if we decided to change even a small detail it had to be done four times (this happened a

lot across many images). So what at first seemed like a small problem as development progressed this became an increasingly big problem.

5.1.3.2 Main menu design

This took a long time to design so we definitely consider it one of the bigger problems we had to deal with. We wanted a menu that would be easy to operate, simple at first glance, colorful, clear and to get the player where they wanted to be fast. What made this so challenging was the balancing of elements like “what colors do we want to show without overusing certain colors?”, “how large should the text be in order to remain readable and not too small”, “how should certain elements be presented to the player?”. It took a lot of trial and error and feedback to get the design to where it is right now, it’s far from perfect but we feel that it captured what we wanted. We would have liked if there were less screens the player needs to traverse before actually starting a mini-game but this is something that should have been thought of at the beginning of development.

5.1.3.3 Text objects or images with text

Because the game at first did not have much changing text (e.g numbers) outside the mini-games we opted to mainly use created images with text instead of actual text objects (this makes it possible to show plain text). Created images were easier to use as automatic sizing would be handled by android itself and the positioning would be good due to the layers we were using. This is largely the same for text objects except for one extra problem namely that the text size would have to change depending on the screen size. There is no clear automatic way to do this so we avoided using text objects unless there was really no other way. As development progressed it became clear that using text objects for certain elements was a must so in those cases we had no choice. This involved manually creating a number of different text sizes to be used with certain screen sizes and when supporting a large number of screen sizes this becomes quite an ordeal. It was also of importance that the text object mirrored the created images with text so we had to be sure that there was no observable difference between how the text appeared on the images and when the text was part of a text-object.

5.2 Gathered impressions

In order to identify the strengths and weaknesses from the game we made, we showed the game to both our target audience and people in some way related to them. By gathering impressions from these two groups we can form conclusions on what kind of things work in the

game and what doesn't. We can then use these impressions and reflect back on the development process to identify important aspects serious game developers should be wary of.

As previously mentioned our target audience involves children. While they were playing My Teaching Assistant we supervised them by explaining goals and we also observed their behaviours. Whenever we saw interesting behaviour we tried to have the children explain why they did or did not do certain things. It was very important to us to try to ascertain the children's behaviour during the mini-games, rewards and game itself. The nine children we let play the game were all in the range of nine to eleven years old.

Besides the target audience we also showed My Teaching Assistant to two persons who are both active in the field of education for children. The first person is a twenty five year old male and has almost finished his study for becoming a teacher at a primary school while the other person is a thirty one year old female who is already a teacher.
Here we were mostly aiming for gathering feedback on the teachers if they perceive these type of games to be reliable teaching material for use in class or rather out of class.

5.2.1 Games

The reactions to the different games was largely consistent among the players we tested on, this fell in line with our own expectations before starting testing.

Problem solver and Operations were both games which the children did not really want to play much. Their main reason for this when we asked them was simply because they were not really exciting. Not only did they not contain any nice looking visuals like some of the other games, but they were also only about solving plain equations. This is something that the children did not really want to do while playing a game. While Operations was a bit more fun to play, since it was a little bit different than normal equations, the replayability for that game did not last much longer than for Problem solver.

Flagnation and Capital city kind of had the same problem as with the two math games, but to a lesser extent. Flagnation was played a bit more by some of the children who were trying to get better scores in the game. Capital city was played less which was probably due to capital city having only text. Even though Flagnation only contained flags, the children liked that game more than Capital city. The main reason being that in Capital city there was only text while Flagnation had some easy to identify flags with nice visuals.

The last two games lacking much realism were Word mystery and Wordify. Unlike the previous four games which were also mechanism-based, these were a bit more popular with some of the children. It is important to note however that this was limited to the easy difficulties, since the other two difficulties were above the children their grasp of the English language (since it is not their native language). However the children that had a basic understanding of English liked the puzzling and creating small words of the scrambled letters. Wordify was the less popular one of these two, mainly because it was harder to understand, it was confusing in the beginning and did not offer anything beyond what Word mystery offered.

Vacation advice was as we expected too difficult without including the name of the country in the question. This had the effect that the players only wanted to play on easy, since medium and hard were simply too hard; reading the entire question and forming a conclusion on which country it could be was much too difficult for the children. When asked “if they would understand more if the game included questions about landmarks such as the Eiffel Tower” many of them answered that this would at least be an improvement. On easy however the children played the game for a while, it simply being a case of finding the country on the given map, which was doable for some of the regions like Europe, and much more difficult for other regions.

Masterchef and Flight simulator were among the most played games, but both suffered from the problem that adding extra rules in higher difficulties made it harder for the children to understand. Adding more conditions on what they needed to calculate usually took some time to understand. Some of the children were able to figure out how the games really worked on the higher difficulties and they were then able to enjoy it, but most of them just stuck to playing on easy. Nevertheless, Masterchef was one of the games the children played to earn more stars. When asked what they liked about these two games, reactions included they liked the visuals of the recipes and how they could quickly finish the games by just quickly identifying the length of the recipes or the position of the planes.

The most popular game was without a doubt Smooth parking. While it was not the best way to get stars, since the animations took some time, the children had the most fun with looking at the driving cars and counting how many cars were left in the garage. While hard was still a bit on the difficult side, most of them could finish medium with some practice.

5.2.2 Stickers

The reaction among the children regarding the collectible stickers and the sticker book was very positive. Collecting all the stickers in a mini-game was usually part of the reason why some of the mini-games were played multiple times. It is thus important that the stickers are visually attractive for the children. The reaction to receiving a sticker (which resembled a car) was much more positive than the reaction to collecting a sticker which just said “passed” on it. Having visually attractive stickers made the kids curious as to what the other stickers would look like.

However there are some improvements that can be made to the current state of the stickers:

- More collectible stickers from the mini-games or by performing other actions in the game, giving more reasons to keep playing mini-games and get better in them.
- The dispenser functionality was a bit confusing at the start, although most children liked the animation. However the main problem was that the children did not really want to spend stars since they also needed those for buying new mini-games or difficulties.
- While the reactions to the idea of having a sticker book with all the stickers in it were pretty positive, some of the children tried to rearrange the stickers, since the name implies that they can be sticked anywhere in the book. This and giving the sticker book some more attractive backgrounds would greatly improve the reasons to collect all the stickers.
- Even further improve the design of the stickers. While there were some stickers which were reacted to positively upon receiving them, many others were not so exiting.

5.2.3 Game results and feedback

An important aspect of the game is the available feedback and answers whenever a player completes a mini-game allowing him/her to improve for the next time. However the main problem with how this is implemented is that the results are only shown after completing all the questions and then the player still has to press the answer button to finally see the correct answers. The children usually did not bother with checking the answers, since it would mean they were more focussed on studying instead of on playing a game. It would be better if the correct answers would be presented during the games itself, making sure children at least have to look at them before continuing to the next question.

5.2.4 Art style

The current style we chose for the visuals in-game seemed to be very good. Children seemed to respond well to the bright colors and some of the goofier looking elements such as the teacher and the cars. Some of the children reacted very positively to the reactions of the teacher upon

correctly or wrongly answering questions to the point where these kids got happier if the teacher kept being happy. More interactivity with the teacher with more texts and poses would certainly be a good thing.

While there is definitely room for improvements, such as better mini-game feedback and in some places even brighter and more funny objects, the art style was definitely one of the biggest positive reactions of the game. While not part of the art style per se, sounds and music would also be a very good addition. Two elements which were missed by some of the children.

5.2.5 Teachers

As previously mentioned we had contacted two different people from which one was training to be a teacher while the other is already active in the primary school sector. The initial reaction of these two persons was very positive. The whole game with it's vibrant colors, light-hearted feel and goofy teacher were a big selling point for them. They liked the idea of there being multiple mini-games of different types of categories, though they would have preferred more games per subject and even more subjects. Furthermore the teacher would have liked a larger range of difficulties per mini-game, this opens the game up for more age groups in school.

They were both enthusiastic about the idea of using games in a classroom environment. However they both think it's more of an addition to the normal way of studying rather than a replacement or extension. They see it mainly as an activity children can do after finishing their normal program. By doing it like this they can practice the things they learn in their normal program in a fun way. Of course this means that the content of the game should match the content they are teaching, which is another reason to have more mini-games and difficulties.

5.3 Discussion of findings

As stated at the beginning of this paper we started this project with the question "*How can an educational game bridge the gap between realism and mechanism?"* and in order to help us answer it, as an additional aid, we researched how to develop an educational game which is fun to play for children and at the same time can also teach them about relevant school subjects. Reading about existing serious games, guides on how to create a serious games, the gathered impressions of our own developed game and all the existing articles about various experiments involving serious games all helped shape the answer that we were looking for. Every different

aspect that we studied gave a different but valid answer as to what is important in such a game and how that can lead to developing an effective and fun educational game.

In order to present our answer we will first evaluate observations from our gathered impressions and afterwards we will evaluate our readings which cover related work. We will then present our findings on how to develop a good serious educational game and how we answered our research question.

5.3.1 Evaluation of our gathered impressions

The main thing we observed from our gathered impressions is that there certainly is potential in a educational game such as My Teaching Assistant. Both children and teachers responded positively to the game, either by having fun playing it or seeing the value of it in the context of learning material.

It became clear that it is very important that the game needs to be well-polished. It needs to have a lot of different mini-games with many varying difficulties that are all well balanced. At the moment this is not entirely the case in My Teaching Assistant, but it is something we had foreseen before showing the game to the target audience. Having many different mini-games to choose from ensures that there is much to do for the players (without them getting bored fast) and at the same time ensures that the learning material is diverse.

Aspects such as the artstyle and what rewards are given are also very important for the children. These elements make sure they will like the game and keep playing the game. By having a good artstyle children will be more involved in the game while having a good reward system means that they will want to keep on clearing content.

5.3.2 Evaluation of our readings

The process of researching how a fun serious educational game can be developed brought us through numerous serious game articles. Each of them shed light on different aspects that were equally important. We will highlight a few of the articles we came across.

In *“A case study of computer gaming for math: Engaged learning from gameplay?”* a mix of 4th and 5th graders were examined while playing educational math games in a summer math program. The results showed the importance of making games challenging, having learning

activities correctly integrated within gameplay and scaffolding reflections[30]. This article also highlighted the importance of concealing learning within games in order to be effective and making learning as the goal itself not obvious as the participants were less engaged with the games when this was the case.

Similar sentiments were shared in parts of Van Eck's article *"Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless"* in which he talks about how the public has finally shown interest in games as learning tools and also mentions than when designing a game it is important to design activities that keeps the player within the game world as this constant engagement is what contributes to the student learning[31]. Reading these two articles it began to become clear that proper design plays an integral role in serious game development and for the players to be engaged enough. Design which ties directly in how challenging the game is, how well the study material is integrated with gameplay, how compelling the game is and most importantly how fun it is.

In "*Math is not only for Science Geeks: Design and Assessment of a Storytelling Serious Video Game"*[32] the goal was to examine the effect of a designed storytelling math game on a small group of students from which some had prior poor performance in mathematics. The results were similar with what we have seen so far in the previous articles. The game was designed well enough for the students to be captivated by it and this in turn was beneficial to their improvement.

In the article *"Serious Game Design: Motivating Students through a Balance of Fun and Learning"* numerous methods are presented when developing a serious game. The article follows three games in development and highlights important elements which need to be present. The article highlights the importance of borrowing elements from mainstream games and to integrate these with educational features[33]. This to help motivate students via familiar features with the hope of motivating them and to keep them engaged. It also highlights the

[30] Ke,F.(2008). A case study of computer gaming for math: Engaged learning from gameplay?. In C-C. Tsai & R.S. Heller & M. Nussbaum & P. Twining (Eds.), *Computers & Education 51* (pp. 1609–1620).
[31] Van Eck, R. (2006). Digital game-based learning: It's not just the digital natives who are restless. In *EDUCASE* Review, 41(2) (pp. 16–30).
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[33] Franzwa,C.Tang,Y.Johnson,A.(2013). Serious Game Design: Motivating Students through a Balance of Fun and Learning. In *Games and Virtual Worlds for Serious Applications (VS-GAMES), 2013 5th International Conference* (pp. 1-7). Poole: IEEE

importance of balancing fun and learning. Feedback received about the games from the students were very positive and they applauded the games for presenting the problems within relatable and realistic contexts as they found that aspect to be very important. What made this article interesting is that it was very relatable to the development of our game as most methods and elements that were discussed that were important to educational game development was mostly employed in our game.

5.3.3 What makes a good serious educational game?

From both the gathered impressions and every article/guide that we read we can conclude that there is no definitive one sentence answer on how to make a good serious educational game which balances fun and learning, but based on both evaluations and everything we've come across during our research there are however a number of features we think any serious educational game should have in order for it to be meaningful and by extension for it to perhaps be considered good. At this point it comes as no surprise that good design is very important as this is surely the one thing all good serious games had in common, but good design by itself is not a sufficient answer to the question as good design, we believe, should be the basis of every game. With all this in mind we've compiled a list of features based on our gathered impressions and on what we learned by reading the various articles and guides on serious games, we've also combined all this with our own knowledge regarding games.

We strongly feel that every serious educational game needs to at least have most of the following features:

1. **The study material must be integrated seamlessly with the gameplay.**
   In every good serious game the study material was tightly woven in the gameplay. The player would be playing the game and at the same the player would be learning about the subject he was playing, without it being obvious he was doing these two different things at the same time.
2. **The player cannot be aware of teaching as the game's primary goal.**
   The key here is that the game comes first and the teaching part should be cleverly hidden within the gameplay. It should not be obvious to the player that the game itself is about teaching.
3. **The game must challenge the player.**
   If the player does not feel challenged the game itself can get boring. There needs to be sufficient challenges in order for the player to keep being engaged within the game.

4. **Combine studying and fun.**
   Rewards, high scores, collectibles and multiple game modes can all help with making the game fun. Most of it however must come from good gameplay. These factors combined with the previous points will make for an effective combination.
5. **The player must feel involved when playing.**
   Control must be in the hands of the player at all times. The player must be responsible for every action he/she makes within the game.
6. **The player cannot be asked to step outside the game world as this breaks immersion.**
   The gameplay cannot not be interrupted by game elements which are outside the current game context. If e.g the player is supposed to solve math equations they cannot be interrupted by suddenly having the player complete another game element which is not relevant at that very moment or required to advance.
7. **Give the player reasons to solve problems within the game.**
   This ties with having rewards, collectibles, high scores and various forms of feedback. All of this motivates the player into playing the game and consequently solve the problems.
8. **Fun and learning must be balanced accordingly.**
   Combining fun and learning is the first step but it is very important that neither one overshadows the other. A game at its core needs to be fun while a game in this context also needs to provide sufficient learning possibilities. Having too much learning in it will run the risk of going against the second point.
9. **Study material must be presented in a relevant context.**
   The study material within the game must be applicable in the real world and it must mirror real world situations. The player must feel familiar with the material in the game.
10. **Give the player adequate means to reflect.**
    As the player it is important to be able to reflect on the actions made during gameplay. Good feedback within the game allows the player to learn from mistakes and to be motivated to possibly play again.

5.3.4 How My Teaching Assistant compares to our findings.

	My Teaching Assistant
1	**The study material must be integrated seamlessly with the gameplay.** The different teaching subjects in the game are given in the form of relevant mini-games and the mini-games form the core of the whole game so we believe it is integrated sufficiently.
2	**The player cannot be aware of teaching as the game's primary goal.** Although the title of the game can make one think otherwise there is nothing else in the game that suggests that teaching is the primary goal. Everything is built around gameplay first. From the feedback we received however the games which had less visual elements might have given off a more "teaching" feeling so maybe this one of the reasons why these games were played less.
3	**The game must challenge the player.** There are three different difficulty modes and each of them provides a fair amount of challenge for the player to overcome. Even more so when the player chooses to go for a perfect score within a certain time or tries to unlock everything. Most games were still too hard on the higher difficulties and having more difficulties in order to offer a better gradual difficulty curve would have been better.
4	**Combine studying and fun.** The game itself has the necessary elements that can make a game fun. We believe the gameplay itself to be also fun and teaching at the same time. This was largely the case as most elements besides the mini-games were praised, the design of some of the mini-games ultimately detracted a bit from the overall feel. There also needed to be more mini-games and subjects.
5	**The player must feel involved when playing.** It is entirely up to the player to solve the questions within the gamemode, unlock difficulties and earn rewards. At no point in the game will the player have no control or will the game play itself. This was also the case with our target audience.

6	**The player cannot be asked to step outside the game world as this breaks immersion.** There is no interruption at any point during the minigames. Possible rewards earned during the minigames are given at the end and nothing in the game is required to solve something outside the gameplay. The player will remain within the gameworld until he/she chooses otherwise. This was also the case with our target audience.
7	**Give the player reasons to solve problems within the game.** There are a lot of different rewards and other aspects within the game which we feel will give the player incentive enough to play through the mini-games multiple times. The incentive was definitely there because these elements were praised however as previously stated the design of some of the games lowered the incentive to replay those particular games.
8	**Fun and learning must be balanced accordingly.** This is a very tricky feature. The game itself has the basics of the subjects and we hoped that this would be sufficient for a beginning serious educational game. We don't believe that the fun overshadows the material. We saw this in effect during our play-testing, the children did not really play the games without much realism since they thought they were not fun enough and reminded them of school work.
9	**Study material must be presented in a relevant context.** The material in the game is reminiscent of the material one would find in real classes. The realism games even more so as we tried to mimic certain real world situations when creating them. Children responded well to recognising elements from their usual surroundings, such as the cars or some of the recipes. Since they reacted positively to seeing elements they knew they were more involved in these mini-games.
10	**Give the player adequate means to reflect.** Because the game is designed to be played over and over the player will be able to reflect every time a mini-game is finished. The ability to see what the player answered vs the real answer as feedback will hopefully also motivate to reflect and better him/herself. In theory this is possible in the game but in reality the target audience was less eager to do this willingly so in the long run this needs to be implemented seamlessly in the gameplay.

Table 2: How My Teaching Assistant compares to our findings

5.3.5 Answering our research question

This brings us finally to the question with which this thesis started with. How can an educational game bridge the gap between realism and mechanism?

From the onset of this research we wrestled with the idea of either having both realism and mechanism separate, still retaining their characteristics, or try to create a hybrid aspect with the defining characteristics of both. But seeing as how we decided to really discuss these two aspects in-depth and research how to develop a serious game we felt it appropriate to include both of the different aspects in our developed game untouched. By keeping the two aspects separate this the player can experience first hand how mechanism and realism differ yet try to convey the same message.

This brings us to the second problem that we dealt with after we decided to include both aspects. It was already made clear that it is not wise to overuse mechanism as this can make the game boring but at the same time overusing realism might have the effect that the educational value is not as high as how one would want it to be. Striking a balance in a game featuring both was crucial especially if one of the goals is to highlight the strength of both aspects. We can't really say that we succeeded with this, the mechanism-based games tended to bore the target audience faster than the realism-based games but that was largely because of their nature. The mechanism-based games had to be designed better especially because their study material was more basic and raw. But none the less it is by designing the game this way that we stumbled on our answer to what we believe bridges the gap between mechanism and realism. Our answer to the question is two-fold.

Apply a correct balance in study material and education value
By having both realism and mechanism separately in a serious educational game it is important that neither of them overshadow each other. The study material and educational value need to be relevant, sufficient and equal in both *aspects*. But in order to ensure that both of these aspects actually teach the target audience as they are supposed to it is important to increase the playability and immersion of the game as much as possible. The target audience should be able to become immersed and playing the whole game should be a joy. Key elements like the gameplay, theme, art style and most importantly the reward system contribute to this. In our case this would lead to the target audience having fun in both the realism-based and

mechanism-based games thus experiencing the difference between them and still learn. In this way the gap between the two aspects can be bridged.

6. Future extensions

6.1 Project reflection

When looking back at this project we can honestly say that we had a lot of fun. It was fun researching about serious games, fun creating the game and fun garnering the impressions of the children. We learned a lot during the course of this project, it was very interesting researching existing serious games, the various projects regarding serious games and most importantly mechanism and realism. It really gave us the insight that we needed in what makes a good serious game and also how our own developed game matches up to the many already available serious games.

Because of our love for games we had a general idea on what features a game should at least include. This helped us a lot when developing My Teaching Assistant but admittedly we learned a lot of the more finer points, we did not know about, when researching how to specifically create a serious educational game. Features geared at the study material, keeping the player's interest in order for him/her to take in the material and of course having material that is relevant to real world situations all play significant roles in such games geared at education.

We honestly did not expect that the creation of the realism games would be as difficult as they were. It showed us that in order to make a good realism based game it requires a lot of creativity and correct use of the material as it needs to correctly employ the study material in a relatable contextual medium. We saw this problem in the vacation advice realism game as it was hard in the first place to think of a suitable geography game given the material we had in the mechanism geography games, the end result was playable but we strongly felt that the study aspect in it was mostly lost.

Seeing children actually play the game we have been developing over the course of a few months was extremely fun. While there were many aspects of My Teaching Assistant which were not perfect as we could see from the reactions of the players, it was still very encouraging to see the positive reactions on certain elements such as the visuals, some of the games or the

sticker collecting mechanism. Furthermore the feedback we gathered from these playtests with the children as well as with the two teachers will be very valuable for improving on the game in the future. Testing the application on the target audience is something very valuable which we will be doing more often in the future, to keep on improving the game.

Regardless we were able to come to a much better understanding on what could have been done better based on what we learned from all our research. We believe that our game, while not perfect by any means, is a good stepping stone and indicator on what to expect on the way to the world of serious games

6.2 The future of serious games

In our own opinion, which is reflected in the impressions of the teachers as well as some of the literature we have read about serious games there is still much untapped potential in this type of learning. We think that serious games in the educational field, as well as in many other fields can certainly be used as a supplement to the normal way of teaching and perhaps even replace some parts of it entirely.

While we do feel that serious games usually are better used for mastering techniques instead of learning them all together, we believe they can certainly be used to practice the material instead of practising the material by the normal ways of making homework on paper. Serious games should mainly be about creating meaningful experiences and activities for the playing where they can hone their knowledge, instead of being a means of directly trying to learn new knowledge to the player[34].

An important limitation for the success of serious games is the fact that there are many negative biases about video games[35]. Many people will not see the potential of serious games since video games have the reputation of being just hobbies which waste time instead of studying the actual material. This is true in all the fields, not only for education. Once this hurdle can be solved we feel like there can be many different types of serious games which can be used in all kinds of environments and subjects

[34] Stapleton, A. (2004) Serious Games: Serious Opportunities. Paper presented at the Australian Game Developers' Conference, Academic Summit, Melbourne, VIC.
[35] Miller, Sheena M.(2015). *The Potential of Serious Games as Mental Health Treatment*. Thesis.Paper 148.University Honors.

For My Teaching Assitant itself we also see that it has some potential for usage in an educational environment. While there is much to improve such as improving the sticker collection system, give better feedback on answered question, adding more games, balancing some of them or even removing the games which were not fun for the children, it can certainly be a helpful addition to the school education. As we see it My Teaching Assistant can be a fun tool to practise material taught by the teachers.

7. Conclusion

We can honestly say that we not only learned a lot regarding realism and mechanism but also how to develop a good serious educational game. Both realism and mechanism are essential in serious games but we believe that they need to be integrated seamlessly into the gameplay in such a way that they are not directly noticeable. The feedback that we gained for My Teaching Assistant was valuable although there were noticeable elements that needed to be made more engaging. It is very important that a serious educational game is fun to play and immersive enough to keep the player playing without making the teaching aspect obvious.

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Appendix

Code

Teacher lay-out

```
<LinearLayout
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  android:layout_weight="0.05"
  android:orientation="vertical" >
  <LinearLayout
     android:layout_width="fill_parent"
     android:layout_height="fill_parent"
     android:layout_weight="1.25"
     android:orientation="vertical" >
  </LinearLayout>
  <LinearLayout
     android:id="@+id/textballoon"
     android:layout_width="fill_parent"
     android:layout_height="fill_parent"
     android:layout_weight="0.98"
     android:orientation="horizontal"
     android:visibility="visible" >
     <LinearLayout
        android:layout_width="fill_parent"
        android:layout_height="fill_parent"
        android:layout_weight="0.05" >
     </LinearLayout>
     <LinearLayout
        android:layout_width="fill_parent"
        android:layout_height="fill_parent"
        android:layout_weight="0.025"
        android:orientation="vertical" >
```

```
        <FrameLayout
            android:layout_width="fill_parent"
            android:layout_height="fill_parent"
            android:layout_weight="0.0001" >
            <ImageView
                android:id="@+id/smallBalloon"
                android:layout_width="fill_parent"
                android:layout_height="fill_parent"
                android:src="@drawable/smallballoon"
                android:visibility="invisible" />
            <nl.craned.teachingassistant.helpers.OutlineTextView
                android:id="@+id/editText1"
                android:layout_width="fill_parent"
                android:layout_height="wrap_content"
                android:layout_gravity="center_vertical"
                android:layout_marginBottom="10dp"
                android:clickable="false"
                android:ems="10"
                android:gravity="center_horizontal"
                android:textColor="@color/black"
                android:visibility="visible" />
        </FrameLayout>
    </LinearLayout>
    <LinearLayout
        android:layout_width="fill_parent"
        android:layout_height="fill_parent"
        android:layout_weight="0.048" >
    </LinearLayout>
</LinearLayout>
<LinearLayout
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:layout_weight="0.32"
    android:orientation="horizontal"
    android:visibility="visible" >
    <RelativeLayout
```

```
android:id="@+id/teacher"
android:layout_width="fill_parent"
android:layout_height="fill_parent"
android:visibility="visible" >
<ImageView
    android:id="@+id/hopems"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:layout_alignParentBottom="true"
    android:layout_alignParentTop="true"
    android:layout_centerInParent="true"
    android:src="@drawable/hope"
    android:visibility="invisible" />
<ImageView
    android:id="@+id/pointms"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:layout_alignParentBottom="true"
    android:layout_alignParentTop="true"
    android:layout_centerInParent="true"
    android:src="@drawable/pointms"
    android:visibility="invisible" />

<ImageView
    android:id="@+id/thinkms"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:layout_alignParentBottom="true"
    android:layout_alignParentTop="true"
    android:layout_centerInParent="true"
    android:src="@drawable/thinkms"
    android:visibility="invisible" />
<ImageView
    android:id="@+id/neutralms"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
```

```
            android:layout_alignParentBottom="true"
            android:layout_alignParentTop="true"
            android:layout_centerInParent="true"
            android:src="@drawable/neutralms"
            android:visibility="visible" />

        <ImageView
            android:id="@+id/happyms"
            android:layout_width="fill_parent"
            android:layout_height="fill_parent"
            android:layout_alignParentBottom="true"
            android:layout_alignParentTop="true"
            android:layout_centerInParent="true"
            android:src="@drawable/cheerms"
            android:visibility="invisible" />

        <ImageView
            android:id="@+id/sadms"
            android:layout_width="fill_parent"
            android:layout_height="fill_parent"
            android:layout_alignParentBottom="true"
            android:layout_alignParentTop="true"
            android:layout_centerInParent="true"
            android:src="@drawable/sadms"
            android:visibility="invisible" />
    </RelativeLayout>
  </LinearLayout>
</LinearLayout>
```

AndroidManifest

```
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    package="nl.craned.teachingassistant"
    android:versionCode="1"
    android:versionName="1.0" >
```

```
    <uses-sdk
        android:minSdkVersion="8"
        android:targetSdkVersion="17" />

    <application
        android:allowBackup="true"
        android:icon="@drawable/ic_launcher"
        android:label="@string/app_name"
        android:theme="@android:style/Theme.NoTitleBar.Fullscreen" >
        <activity android:name=".MainActivity"
         android:configChanges="orientation|keyboardHidden|screenSize"
            android:label="@string/app_name"
            android:screenOrientation="landscape"
           android:theme="@android:style/Theme.NoTitleBar.Fullscreen">
        </activity>
         <activity android:name=".Game"
          android:configChanges="orientation|keyboardHidden|screenSize"
            android:label="@string/title_activity_game"
            android:screenOrientation="landscape"
           android:theme="@android:style/Theme.NoTitleBar.Fullscreen">
            <meta-data
                android:name="android.support.PARENT_ACTIVITY"
            android:value="nl.craned.teachingassistant.MainActivity"/>
        </activity>
    </application>
</manifest>
```

Starting an activity

```
public void playGame(View view){
 String tag = view.getTag().toString();
 if(tag.contains("locked;")){
    teacherTalks(tag.split(";")[1], findViewById(R.id.thinkms));
 } else {
    Intent intent = new Intent(this, Game.class);
         Random random = new Random();
```

```
          Date now = new Date();
          long randomint = random.nextInt(999999) + now.getTime();
            intent.putExtra("type", gameType);
            intent.putExtra("difficulty", tag);
          intent.putExtra("identifier", randomint);
          JSONObject json = new JSONObject();
          try {
              json.put("type",gameType);
              json.put("difficulty",tag);
              json.put("identifier", randomint);
              Analytics.sendAnalytics("gameStarted", json,
this.getApplicationContext());
          } catch (JSONException e) {
              e.printStackTrace();
          }
     startActivity(intent);
 }
}
```

Analytics

```
public class Analytics {
  private static boolean checkInternet(Context context){
 ConnectivityManager connectivityManager  = (ConnectivityManager)
context.getSystemService(Context.CONNECTIVITY_SERVICE);
      NetworkInfo activeNetworkInfo =
connectivityManager.getActiveNetworkInfo();
      return activeNetworkInfo != null &&
activeNetworkInfo.isConnected();
  }

  public static void sendAnalytics(final String method, final
JSONObject json, final Context context){
      new Thread(new Runnable() {
          @Override
          public void run() {
```

```
if(checkInternet(context)){
    HttpClient httpclient = new DefaultHttpClient();
  HttpPost httppost = new
  HttpPost("http://52.28.105.54/mta/analytics.php");
    try {
        SharedPreferences sharedPref =
        context.getSharedPreferences("nl.craned.teachin
        gassistant", context.MODE_PRIVATE);
         String deviceId =
        sharedPref.getString("nl.craned.teachingassista
        nt.uniqueMagicId", "");
         if(deviceId==null || deviceId.equals("")) {
              deviceId =
              Settings.Secure.getString(context.getConte
              ntResolver(), Settings.Secure.ANDROID_ID);
             Date now = new Date();
             deviceId+= now.getTime();
              SharedPreferences.Editor editor =
              sharedPref.edit();
              editor.putString("nl.craned.teachingassist
              ant.uniqueMagicId", deviceId);
             editor.commit();
         }
         json.put("deviceID", deviceId);
        List<NameValuePair> nameValuePairs = new
        ArrayList<NameValuePair>(4);
        nameValuePairs.add(new
        BasicNameValuePair("method", method));
        nameValuePairs.add(new
        BasicNameValuePair("json", json.toString()));
        httppost.setEntity(new
        UrlEncodedFormEntity(nameValuePairs,
        HTTP.UTF_16));
        UrlEncodedFormEntity formEntity = new
        UrlEncodedFormEntity(
         nameValuePairs);
```

```
                    httppost.setEntity(formEntity);
                    httpclient.execute(httppost);
                } catch (ClientProtocolException e) {
                    e.printStackTrace();
                } catch (IOException e) {
                    e.printStackTrace();
                } catch (JSONException e){
                    e.printStackTrace();
                }
            }
        }
    }).start();
  }
}
```

Server

```
<?php
  $method = $_POST["method"];
  $jsonString = $_POST["json"];
  error_log("Method:" . $method);
  error_log("Json:" . $jsonString);

  $json = json_decode($jsonString);
  //save+get the id of the device based on the passed deviceId. we
then identify the user based on this id
  if($method!=null && $method!=""){
      $servername = "localhost";
      $username = "root";
      $password = "mtamysqlr00t";
      // Create connection
      $mysqli = new mysqli($servername, $username, $password);
      // Check connection
      if ($mysqli->connect_error) {
          die("Connection failed: " . $mysqli->connect_error);
      }
```

```
    $mysqli->select_db("mta");
    $userId = getUserId($json->deviceID, $mysqli);
    saveAnalytics($method, $json, $userId, $mysqli);
    $mysqli->close();
}

function getUserId($deviceId, $mysqli){
   $sql = "SELECT userId FROM userId_deviceId where
   deviceId='$deviceId'";
    $result = $mysqli->query($sql);
    if ($result->num_rows > 0) {
        while($row = $result->fetch_assoc()) {
            return $row["userId"];
        }
    } else {
          $sql2 = "INSERT INTO userId_deviceId (deviceId) VALUES
         ('$deviceId')";
        if ($mysqli->query($sql2) === TRUE) {
             $result = $mysqli->query($sql);
            if ($result->num_rows > 0) {
                while($row = $result->fetch_assoc()) {
                    return $row["userId"];
                }
            } else {
                return null;
            }
        } else {
            return null;
        }
    }
}

function saveAnalytics($method, $json, $userId, $mysqli){
    switch($method){
        case "gameStarted":
            saveGameStarted($json, $userId, $mysqli);
```

```
            break;
        case "gameResult":
            saveGameResult($json, $userId, $mysqli);
            break;
        case "stickerUnlocked":
            stickerUnlocked($json, $userId, $mysqli);
            break;
    }
}

function saveGameStarted($json, $userId, $mysqli){
   $sql = "INSERT INTO game_started (userId, game, difficulty,
   identifier) VALUES ('$userId', '$json->type',
   '$json->difficulty', '$json->identifier')";
    error_log($sql);
    $mysqli->query($sql);
}

function saveGameResult($json, $userId, $mysqli){
   $sql = "INSERT INTO game_results (userId, game, difficulty,
   starsCollected, secondsPlayed, correct, exercises,identifier)
   VALUES ('$userId', '$json->type', '$json->difficulty',
   '$json->stars', '$json->time', '$json->correct', '" .
   json_encode($json->exercises) . "', '$json->identifier')";
    error_log($sql);
    $mysqli->query($sql);
}

function stickerUnlocked($json, $userId, $mysqli){
   $sql = "INSERT INTO unlocked_sticker (userId, sticker,
   stickerType, dropWeight) VALUES ('$userId',
   '$json->stickerTag', '$json->stickerType',
   '$json->dropWeight')";
    error_log($sql);
    $mysqli->query($sql);
 }
```

```
?>
```

Server database

```
CREATE TABLE IF NOT EXISTS userId_deviceId(
  userId INT NOT NULL AUTO_INCREMENT,
  deviceId VARCHAR(100) NOT NULL,
  creationDate TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
  PRIMARY KEY ( userId ),
  UNIQUE KEY (deviceId)
);

CREATE TABLE IF NOT EXISTS game_started(
  id INT NOT NULL AUTO_INCREMENT,
  userId INT NOT NULL,
  game varchar(255) NOT NULL,
  difficulty varchar(255) NOT NULL,
  startTime TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
  identifier BIGINT NOT NULL,
  PRIMARY KEY ( id )
);

CREATE TABLE IF NOT EXISTS game_results(
  id INT NOT NULL AUTO_INCREMENT,
  userId INT NOT NULL,
  game varchar(255) NOT NULL,
  difficulty varchar(255) NOT NULL,
  starsCollected INT NOT NULL,
  secondsPlayed DOUBLE NOT NULL,
  endTime TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
  correct INT NOT NULL DEFAULT 0,
  exercises varchar(4096) NOT NULL,
  identifier BIGINT NOT NULL,
  PRIMARY KEY ( id )
);
```

```
CREATE TABLE IF NOT EXISTS unlocked_sticker(
  id INT NOT NULL AUTO_INCREMENT,
  userId INT NOT NULL,
  sticker varchar(255) NOT NULL,
  stickerType varchar(255) NOT NULL,
  dropWeight INT NOT NULL,
  unlockTime TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
  PRIMARY KEY ( id )
);
```

Personal reflections

Reflection Christian

Project contribution

Thesis

In order to write the thesis we both collaborated and discussed about every single chapter found in it. Depending on what we worked on during development would usually decide which person took the lead in writing a corresponding chapter in the thesis. It is important to note that every chapter and piece written has both of our thoughts behind it. Below I will highlight my written contribution:

- Introduction
- Abstract
- Preface
- Background
    - Origins of serious games
    - Our game philosophy
    - The gap between realism and mechanism
- Serious games
    - DimensionM
    - DimensionU Meltdown
    - Math workout
    - Game overview

- Design decisions
    - Design methodology with the exception of the mini-games
    - Detailed discussion concerning designing the UI
- Evaluation
    - Encountered problems
        - System problems
        - Design problems
    - Gathered impressions
        - Gathering the impressions
    - Discussion of findings
        - Evaluation of our gathered impressions
        - Evaluation of our readings
        - What makes a good serious educational game
        - How My Teaching Assistant compares to our findings
        - Answering our research question
- Future Extensions
    - Project reflection
- Conclusion
- Endnotes

My Teaching Assistant

My Teaching Assistant was developed by both of us. It is the result of a tight collaboration and long standing friendship. Everything is the result of many discussions, testing and feedback. Below are the parts I worked on:

- Creating all the graphics
- Creating all the lay-outs
- Coding of the results and feedback activity
- Coding of the sticker machine
- Coding of the teacher poses and texts

Project reflection

The gap

Reading all the different articles and researching the various serious games available was really fascinating. Giving our own answer to the research question did not come easily. It was a

question that could be answered in different ways and we answered it based on our experiences and the knowledge we gained via the articles,guides and My Teaching Assistant. Having both realism and mechanism in serious games is in my opinion the way to go forward when developing serious educational games. They both have strengths that can benefit the game and the player playing it, it is however important that they are integrated seamlessly into the game without making them apparent.

Beginning of My Teaching Assistant

Looking back at the whole project I can honestly say that I had a very fun time developing My Teaching Assistant with Erik. Seeing how smartphones opened up the world to mobile gaming and making it easier than ever to reach people motivated us to also start developing mobile games one day. In the class Serious Games we started on My Teaching Assistant and at that time we had no idea how far we we're going to go with that small idea.

Design

Developing My Teaching Assistant required lots and lots of hours both coding and designing new content. The main menu was the hardest element to design and develop. We went through numerous iterations, constantly asking for feedback from friends and family before we ultimately decided on the current design. Not to mention that every iteration took hours in order to be able to preview it in the first place. This largely repeated itself for the result screen, feedback screen and certain mini-game screens. It is very hard to create something that can appeal to multiple people.
It was during development that we slowly began to realize that much of the problems we struggled with could have been avoided with better planning in the beginning, a lesson learned for the future.

Teacher

The teacher is an original design which I created. Both Erik and I love animated features and we found her to be fitting in the overall design of the game which would already be cartoony. As mentioned in the teacher section we at first wanted to give her an AI. The teacher would then comment on the player's performance, if he/she achieved a high score (different scoring system back then) or give random advice. I saw it as a challenge to make something like that and her opening sentences are leftovers of it. But as we began navigating through the menu we both saw that it would be much better if she acted as a guide and offered help to the player. This gave her role much more meaning and more in line to how a teacher would be. Having an AI

would be something nice to see for the first three times but the novelty would wear off fast and at that point on she would be annoying.

Mini-games

Each and every mini-game took a lot of time to develop. We would first start by brainstorming about the subject and discussing what kind of mini-games would fit into that specific subject. We would then move on to coding the game and creating all the necessary art (if any) for it. After the game was roughly completed we would then begin play-testing it over and over in order to adjust the balance each time. This was roughly the schedule that we maintained for each mini-game but even so, thinking of something that other people could enjoy is a whole different matter. It gave us a very good feeling when the children enjoyed a mini-game and I would be lying if I said that we didn't feel a bit disappointed when they did not.

Feedback

The idea and design for the feedback with all the answers was inspired by how exam papers are graded in the real world. The teacher will grade the paper and will sometimes even add the correct answer besides the wrong ones. On paper it seemed like a good idea but after seeing that most children did not bother reviewing what went wrong we realized that it would have been better if it was cleverly implemented as part of the whole gameplay instead of giving the children the option to review or not.

Realism and mechanism

These two aspects were part of the problem why it was so hard to develop certain mini-games. We wanted to have both of these aspects in the game to highlight their strengths but by doing this it limited us in the types of mini-games that we could make. In each mini-game it was of the utmost importance that the game adhered to the aspect it was representing. In the case of the mechanism-based games it was hard to make them enjoyable for everyone and in the case of the realism-based games it was hard to make them relate to the real world without having to enter massive amounts of data manually. The available data online that we worked with was not enough to create very interesting or complete realism-based games.

Rewards

The reward system was inspired by how modern reward systems work. The player gains stickers when certain requirements are met and these requirements range from "the completion of a mini-game", "perform a certain requirement in a mini-game" to "answer all questions correctly in a mini-game".

The only form of reward the old version of the game had was a simple stamp indicating a “grade”. We wanted the game to have some form of rewards in it because we felt that it would be a very good way of motivating children to keep playing. This idea got reinforced when we read various articles and the guide on how to create a good serious game. The feedback we received from the children was positive and it made us want to include even more unlockables in the game but not to the point that it becomes intrusive.

The future of My Teaching Assistant

By reading the articles we already had an idea that serious educational games really do work. With My Teaching Assistant however we were fortunate enough to experience first-hand that serious educational games really do have a place in the future. Maybe not specifically with this game (especially as it is right now) but definitely serious educational games in general.

The power of games to immerse the player can really benefit studying but developing a game with all the right key elements is a different story. My Teaching Assistant as it is right now has faults that need to be fixed. The game’s strengths were in the art style, visuals and rewards. The mini-games as we mentioned were mostly a hit or miss with the children, the mechanism-based games especially can use a design overhaul and extra focus on making them more enjoyable.

For our game to have a future the feedback we received first needs to be addressed. After this has been done we can begin working on the features that we were unable to implement in the game during development.

Extra stat-tracking is one of the main features that we would like to implement. We’ve already briefly explained it earlier but we believe that a feature like this is essential in helping to improve the player. If we can somehow adapt the reward system in order to accommodate the stats it could make it even more accessible to the players thus making them want to play the game more. Daily and/or weekly challenges is something that could be interesting in this regard.

We still want to enable the share-option in the result screen. We’ve seen the success of serious games that promoted head to head competition between students and we believe that we can do something similar with the share functionality. Perhaps have a dedicated website where these shares can be uploaded to are all possible ideas that could be implemented.

There is no shortage to ideas on how My Teaching Assistant can be expanded. It was at the very least reassuring that certain elements were favorable and that was enough motivation that we needed in order to continue development on it. We will strive to at least make it a very good serious educational game.

Reflection Erik

Project contribution

Thesis

Below are all the points which I mainly worked on. Some of these we wrote together completely and will also be included in Christian's list. Important to note however is that we always heavily discussed on the contents of all the sections and the thesis as a whole. Furthermore we both read all relevant research and we both continuously improved all the parts of the thesis. As a result we both have worked at least for bits and pieces in every section.

- Introduction
- Abstract
- Preface
- Background
    - Our game philosophy
    - Realism and mechanism
    - The gap between realism and mechanism
- Serious games
    - Where in the world is Carmen Sandiego
    - Lumosity
- Design decisions
    - Design methodology concerning the mini-games
    - Detailed discussion with the exception of designing the UI
- Evaluation
    - Encountered problems
        - Game problems
    - Gathered impressions
        - Gathering the impressions
        - Process the results
    - Discussion of findings

        - Evaluation of our gathered impressions
        - Evaluation of our readings
        - How My Teaching Assistant compares to our findings
        - Answering our research question
- Future Extensions
    - Project reflection
    - The future of serious games
- Conclusion
- Endnotes

My Teaching Assistant

For My Teaching Assistant all the designing of the functionalities of the game as well as the mini-games was done by us both during the course of many discussion. This is also true for any testing of functionalities or mini-games. All other elements I have worked on are as follows:

- Coding of all the mini-games
- Coding of the main menu flow
- Coding of the stickers and sticker book
- Coding of the stars functionalities
- Coding of the server

Project reflection

Over the course of this thesis I not only have learned a lot about serious games as well as the realism and mechanism concepts, but also had a lot of fun in researching these terms as well as implementing them in our own game.

Research

Not only during this thesis but also during the Serious games class as well as the Seminar class I had to do a lot of research in the subject of Serious games. During this research I learned quite a lot about Serious games, making me more and more interested in the subject as well as more knowledgeable. I would very much like to further use this found knowledge in helping me implement more Serious games and also improve upon My Teaching Assistant. Even though we have researched Serious games for three different courses I feel like there is so much to learn about them as well as diversity in opinions that I still stumble upon new information every time.

Realism and mechanism

Before starting this thesis I never really thought about these two concepts. While they certainly make sense upon hearing them and researching more about them, they were not topics I took the time for when first working on My Teaching Assistant. This meant that the mini-games we had developed prior to this thesis were devoid of any real thought about if these mini-games contained enough realism or mechanism. I feel like that this new knowledge about these two aspects will certainly help me and hopefully also other developers implement better and more entertaining serious games while still having a high educational value.

Working on Android

Before the Serious games class I was very interested in developing applications for Android. Developing the game for that class gave me an even bigger interest into creating applications for smart phones, not limited to Android, even leading up to the point where I recently took a job in this field. I feel like that this is something I would like to keep doing, since I feel like this a market with amazing potential, for both normal games as well as Serious games. During the thesis I also learnt a lot about Android development which will certainly help me in the future.

Designing the UI

While developing My Teaching Assistant Christian and I spent many hours discussing the state of the user interface and how everything should look like. We both agreed on the fact that the style should have vibrant colors and fun graphics. Placing all the elements in correct places in the interface took a lot of thinking and testing on what works the best. While most of the interface was created by Christian we always discussed how it would look like and how the results were.

Creating the mini-games

This was without a doubt the hardest part of creating My Teaching Assistant. Together we had many ideas about what mini-games would be included in the game but taking the time to really envision what would work and what wouldn’t, considering we wanted to try to keep the same type of input during all the mini-games while also incorporating the realism and mechanism concepts in a good manner took us a lot of hours of meeting and discussing.

After deciding upon a mini-game, implementing them was quite hard for some of the mini-games. A prime example of this was the Vacation advice mini-game. Not only was it quite

some work to create good looking map with correctly placed markers on it, creating the questions proved way beyond the scope of this thesis. This was mainly due to the fact that the external data we had proved to be quite hard to create understandable and solvable questions from. Of course I felt like that the game should still be incorporated since we both thought the idea behind the mini-game was very solid. This meant that I there was a lot of testing and improving on the way the question was formulated by doing a lot of different string formatting. While this was probably the hardest mini-game to implement, other mini-games also often took quite some work. Nevertheless, it was very fun to create these mini-games and add them to My Teaching Assistant and I'm really looking forward to adding more and better games in the future.

Working with Christian

I have worked with Christian on multiple occasions during my years in the University. Time and time again this co-operation between us proved to be quite effective. We really like working together and feel like we complement each other's strengths and weaknesses a lot during different projects. This thesis as well as My Teaching Assistant was no different. We both had our expertise and together I feel like we created a well-standing product. We have often discussed creating more games or applications in the future, as well as improving My Teaching Assistant, which might even expand into creating our own company.

The future of My Teaching Assistant

As I see it the future of My Teaching Assistant can be quite positive. We have learned a lot during the course of this thesis (and even before the thesis during the "Serious Games" course) which we can certainly use to improve our game. While it may not be the most advanced serious game on the market, I feel like it can still perform very well as a fun tool to help train certain subjects.In my opinion it could very well be used during short breaks in which children have finished their usual homework. In these moments they can than still study the material but in a more fun and interactive manner; by playing a serious game such as My Teaching Assistant. There are of course many different options for serious games but My Teaching Assistant could certainly be one of these options.

Of course much needs to be improved in the game before it can reach this target. While many of the key features are already in place I think there is still quite some work to do.

The most important aspect which still needs improving are the mini-games. First of all more mini-games need to be added, in all of our subjects as well as any new subjects such as the previous talked about “memory”. As we have learned during this thesis these mini-games should be balanced with a healthy amount of realism while still keeping enough mechanism. One important aspect for me is the fact that the mini-games should be fun to play, which according to our gathered impressions was not the case for some of the games which were lacking much realism.

That also means that the current mini-games we have should either be improved or perhaps even removed. For example Problem solver and Operations should probably be altered in some ways to make them more entertaining. A simple example for Problem solver would be to use different visuals instead of just numbers where the children have to count the objects on the screen. Some other games such as Vacation advice need improving on the mechanism factors. The content of Vacation advice as of now is largely not at the level of our target audience and needs a lot of improving, though how the mini-game itself works is fine.

Another improvement I would still like to see is an even more immersive and thought out rewards system. While the current system is a great start I feel like we should expand this with even more stickers which can be earned during the mini-games or in other manners. Having dozens or even hundreds of stickers which can than be “glued” in a fun and gorgeous book by the children themselves will be an amazing mechanic to keep the players interested in the game.

Other improvements the game should probably have include a little more feedback on what the correct answers are and a tracking system of the players current stats. While the brain statistics we spoke about in the game Lumosity are a little beyond what children might be interested in, it is a good idea to keep stats on how well a player performs in the mini-games and in the different subjects.

Endnotes

We want to explicitly thank Prof.dr.Anton Eliens for having always helped and guide us. We’ve learned a lot these last few years and we really tried to reflect that in both this thesis and our game My Teaching Assistant. Also a thanks to Dr.Victor de Boer for being our second reader.

We will continue development on our game because it is only fitting to finish what we started and especially after all the feedback we received. We’re still very much motivated to see how far we can go with this game.