Tiivistelmä

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Designing and prototyping a learning game

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The topic of this thesis is learning games; how games can be used to learn in a fun and motivating way and how to design a good learning game. The focus is on mobile platforms and on its perks and limitations. This thesis discusses briefly the history and the mechanics behind a learning game.

I made a prototype of a user interface of a learning game in collaboration with Grenoble Alpes University's chemistry department. The customer's wish was to create a mobile game that allows you to learn a variety of amino acid structures. The project was made in a small team of other students and my responsibility was to design the application's user interface and overall look.

Unfortunately, the project was never completed. Despite that I learned a lot of mobile game design as well of learning games. The prototype is a good start for further development of the game. As a result of the project I prepared a flow chart of the different actions that will take place in the game and a plan of the different screen layouts and connections between them. I also designed icons for the interface of the game.

Keywords	Game design, learning games, mobile application, UI/UX

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Insinöörityön tarkoituksena oli selvittää, mitä ovat oppimispelit, miten sellainen suunnitellaan ja kuinka pelien avulla voi oppia hauskalla ja motivoivalla tavalla. Insinöörityön tavoitteena oli erityisesti kartoittaa mobiilipelisuunnittelun rajoitteita ja mahdollisuuksia. Selvityksen lisäksi insinöörityön tavoitteena oli saada aikaan prototyyppi kemian oppimispelistä.

Oppimispelit ovat olleet keskustelun aiheena vuosikymmeniä, mutta vasta viimeisen vuosikymmenen aikana asenteiden muuttumisen ja teknologioiden kehittymisen vuoksi niistä on tullut valtavirtaa. Mobiililaitteiden yleistymisen myötä pelaaminen on yleistynyt. Mobiililaitteiden etuja ovat muun muassa helppo saavutettavuus, laaja käyttäjäkunta ja lähestyttävyys. Projektin kohderyhmänä olivat yliopisto-opiskelijat, joille mobiili on tuttu alusta, joka on lähes aina mukana. Mobiilisuunnittelua rajoittaa laitteiden näyttöjen pieni koko, rajoitettu tallennustila ja mobiilisovellusten lyhyet käyttöajat.

Insinöörityö tehtiin opiskelijavaihdon yhteydessä yhteistyössä Grenoble Alpes -yliopiston kemian laitoksen kanssa. Asiakkaan toiveena oli saada mobiilipeli, jolla voi oppia erilaisia aminohappokoostumuksia. Insinöörityön osuutena projektissa oli suunnitella sovelluksen käyttöliittymä ja design.

Projekti ei valmistunut, mutta aiheen tutkiminen ja prototyypin asteelle pääsy opettivat paljon mobiilipelisuunnittelusta ja oppimispeleistä. Selvityksen ansiosta tiedetään, kuinka mobiili oppimispeli kannattaa rakentaa ja kuinka prototyyppiä voidaan kehittää ja parantaa.

Prototyyppi on alku myöhemmälle pelin kehittämiselle. Pelistä tehtiin selainpohjainen versio, joka voidaan myöhemmin kehittää myös alkuperäissovelluksiksi eri mobiilialustoille. Projektin tuloksena tehtiin suunnitelma pelin näytöistä ja käyttöliittymään kuuluvista kuvakkeista.

Avainsanat	Pelisuunnittelu, oppimispelit, mobiilisovellus, käyttöliittymäsuunnittelu

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List of Abbreviations

HTML	Hypertext Markup Language
CSS	Cascading style sheets
SVG	Scalable Vector Graphics
PDF	Portable Document Format

1 Introduction

The purpose of this thesis is to present some theory of learning games, especially on mobile platforms. Another purpose of this thesis is to describe a project for making a learning game. I will explain what a learning game is and what is generally wished to accomplish with such games. I chose this subject because I am interested in bringing more joy to learning, finding tools that make learning easier and more natural. For example, children learn from play, from trying things out and wondering. This same kind of learning is visible in games, they intrigue the imagination and they give a possibility of unlimited choice, to test things out without fear. (1: p. 4)

I was part of a group that made a prototype of a learning game. The objective of the project was to help chemistry students to solidify their learning base on amino acids and test the skills they already have. This will be useful for them before exams and when doing more complicated work, where a good knowledge of the amino acid structures is essential. Making the application into a game form makes learning more intuitive and fun.

The customer of this project is chemistry department of French university Grenoble Alpes (UGA). The customer set the targets and the requirements of the project. The teachers who were kicking off this project were excited about having new ways of teaching and wished to improve education for the new generation, to the young people who are used to the interactivity of mobile and web platforms. The chosen platform for the game is thus mobile, since most students have mobile devices with them almost all the time.

My team's job was to make a browser based prototype of the game so it can be tested and developed further and later to be implemented into native applications for iOS and Android. The customer had no knowledge of game design, interface planning or user experience designing, so we were there to assist them in these subjects and they gave us the knowledge for the chemistry parts of the game. The team had fairly free hands. My role in the team was to do the graphical guidelines and user interface design of the application. This proved to be not a simple task because of the limitations of mobile devices and the requirements of the game. Unfortunately, the time was quite short and we had our hands full of other assignments so the project never went further than the prototyping phase. The project is an excellent start for building something that will enhance

the learning of the chemistry students, and it was a great opportunity for me to learn about game design and mobile game publishing.

2 Learning games

Learning games have been a well discussed topic over a decade (1: p. 3) but there have not been significant results until recent years. The idea is hardly new but with the presence of the new technologies and researches the field has finally started progressing towards more promising results. Many researchers, game designers, educators and other academics have been intrigued by the idea of using games to educate and motivate people (1: p.3). But historically games have been seen only as distractions from the serious world and from learning. The common opinion seemed to be, only like bit more than ten years ago, like James Newman pointed out in his study Videogames: “Games are [--] just for fun. They are just entertainment.” (2: p. 6) The tide of opinions changed slowly but surely and these days game makers are celebrated rock stars that bring generous amounts of new tax income and work positions to the market.

2.1 Games teach

Games are itself considered as fun, as free time, not as anything serious. But as proved, video games can teach many valuable skills. It might take up to 50 concentrated hours to finish playing a traditional video game. That requires consistency, patience, continuous development as the levels get harder and harder. Video games teach patience, goal orientation, and determination to finish all needed tasks to improve continuously. One great advantage that games have given is the improved English skills. In the case study of learning English language through video games by Satu Eskelinen the connection between better English skills and playing games on free time has been proved. She did a questionnaire in Finnish schools and the results was that those that spend time outside the classroom engaging in English spoken activities tend to get better scores in tests in school. (3: p. 26) Many massive multiplayer games are played with international people and require some communication skills in English. Also, most of the games are in English, the user interfaces, the stories, the tips and so on. Other skills to mention are cooperation and tactical skills. All these taught by games that were considered only a pass time and even a danger for normal development of children. No one could have predicted how video games could fundamentally change learning!

The smart phone era accelerated the positive attitudes towards gaming even more. Now that everyone had a gaming device in their pocket the habit of playing games started to increase in every age group in both genders. (4) Gaming became popular. They were not anymore just for marginal group of sweaty nerd boys; they were for everyone. After the smartphones became more and more common the mobile games started to take a bigger part of the market.

Since gaming has become more popular it can be seen in the number of teachers that play too. A study by The Joan Ganz Cooney Center "found that 78 % of teachers who play digital games also use them in instruction, whereas only 55 % of teachers who do not play games use them with their students." (5) The study was made for 694 teachers across the United States. Below in figure 1 the percentages are illustrated clearly.

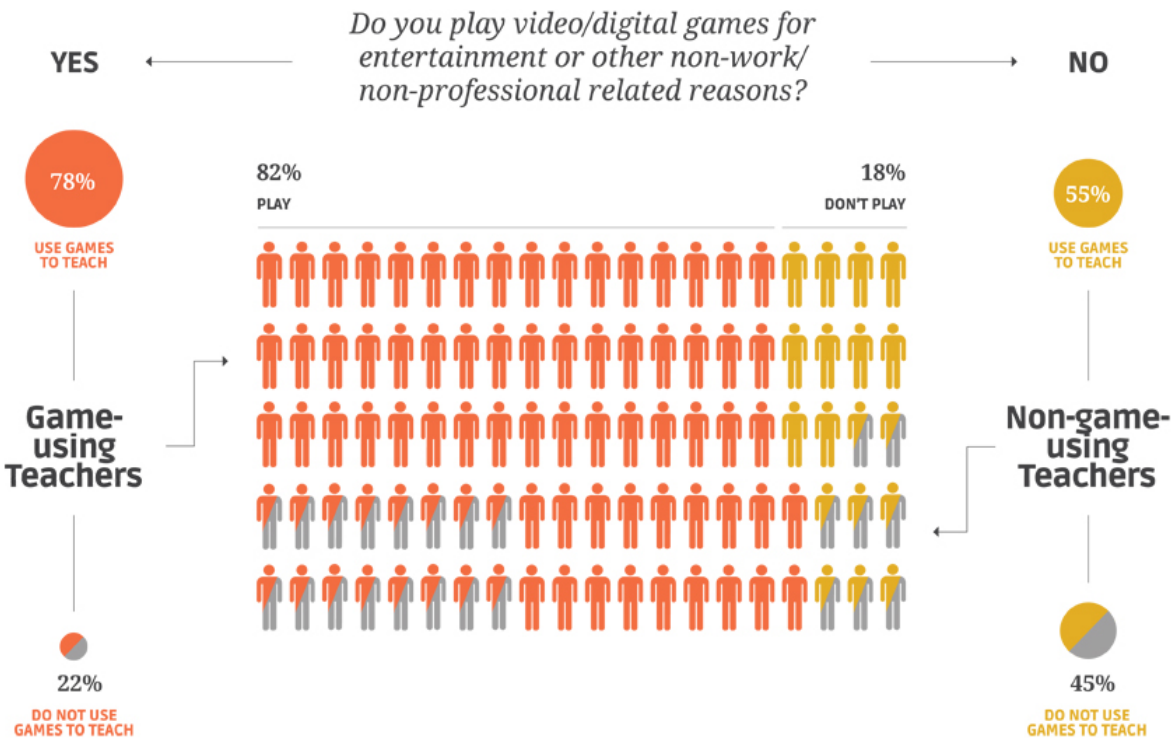

Figure 1. Graph of the percentages of teachers who play games and teachers that do not, and percentages of both groups that use games as a teaching method. (5)

The study shows that teachers who do not play videogames in their past time do not use games in their teaching compared with teachers who play videogames. I believe that the need of quality teaching games will rise when the percentages of playing teachers rise.

2.2 Definition of a game

But what is a game, how to define it? In the book The Art of Game Design a game is defined as a problem-solving activity approached with a playful attitude. (9: p.503). By this definition every game is a way of learning. Games intrigue the imagination of the user; you either must imagine the possible outcomes of each choice or be willing to take risks and go back. Playing is manipulation that indulges curiosity. The possibility having an unlimited choice makes it possible to pay without fear. It's always possible to undo, to play the level again, try again. Testing boundaries inside games gives the possibility to see from different point of views and testing multiple outcomes. Schell put it well: "Games create whole new realities, with new sets of rules". Showing what more is possible – games can help imagine the success and make it seem more achievable. (9: p. 506) All these aspects make games perfect environments for learning big complex structures.

As mentioned before, learning through games and playing is the natural way of learning for kids and animals. The goal would be combining the fun with good learning results. Making the game fun makes the game more attractive for users because having fun is intrinsically motivating. Who would not want to have fun?

2.3 How to make a learning game

But how to make a good learning game? And especially, how to make a good learning game mobile application? In the book called Serious games - mechanisms and effects (1: p. 4-6), the main goals of a learning game are following:

1. Get the attention of the players
2. Discuss the wanted change, or visually show it
3. Show that there is rewards or advantages in adopting the changes
4. Keep users emotionally involved and affected
5. Have something to identify with
6. Keep users motivated to seek more information
7. Evoke discussion

The first part, getting the attention, means getting someone to start using your game and getting interested in it. In the case of mobile games this usually means finding and downloading the application from the mobile marketplace, such as AppStore or Google Play. To get to that point users must know the application name from somewhere, so, it needs to be advertised. The advertisement can be made in other app, in social media, and even in traditional medias like newspapers & TV. Many apps release a press release and contact technical blogs to talk about your application. There are millions of different kinds of applications on the market so it's an achievement to get to this point. In addition, the description of the application needs to have enough information and there should be at least few screenshots showing what is the game like. The name of the app should be very descriptive as well so users that are looking for apps from the same subject that your application will see it as high in the search results as possible. It is also important to have tempting screenshots of the application. There should be at least 3 of them but preferably 6, and they all should show different instance of the application. (18) After downloading and opening the application user also needs to be interested enough to start the game play itself.

The second point, discussing the change, means that the game should point out obviously, what is it and what are the goals it wants to fulfill. It should tell what can be learnt from playing the app. In the example of the amino acids learning game the goal is to teach the players the amino acid structures. The change that will happen in users this case is that after playing, the users will remember the amino acid structures better.

Showing rewards to the user means discussing them what is the point to play the game and how the user can get advantage from it. Traditionally the reward is pure entertainment, interesting story or challenging yourself. In learning games the reward is in a way even easier to discuss, because the goal is usually to teach something specific. In the case of the example project, the knowledge of amino acids and better results in exams is the reward of playing the game. The reward can be told in the app description, or it can be discussed by other means such as gaining points in the game.

The following point, keeping users involved and affected, means keeping the interest of the players. The players should feel involved, that their actions make difference and there is real value for them playing your game. This value can be increased skills or entertainment, or possibly better social connections.

The fourth point is about having something to identify with. The players need to find a common point from the game with their lives, and in the case of our example project this means the amino acids are a real help for studying for the exams and the career the students have chosen. Having something to identify with encourages the users make the application their own and they are more likely to return to the application and continue using it long term.

The last point from the list is to evoke discussion. This means to make a successful game it should have something that people want to talk about. Be it something scandalous, something new and very different from anything that have seen before, or maybe just pure excellence of great game play and beautiful presentation – it should be something that evokes feelings and that way also the need to share. Game that is discussed will be better known and thus more popular.

One important aspect of reaching these targets is the design and looks of the game. A user interface that is pleasing to eye is nicer to use. Strikingly good looking app can evoke discussion, can help discussing the awards and get the attention of the users. But the application should not only look good, but the used solution also should be considered from the point of view of functionality and accessibility. Good design facilitates the learning. Learning things by visual feedback is efficient too – immediate visual feedback is a huge human motivator. (10)

Games can provide an optimal way to learn complex concepts and especially help users to understand the big picture and the connections between things This is because in games and simulations users have a permission to fail safely: it is possible to test and try the boundaries and see the effect of different kind of actions. (6) The permission to fail is important because it allows people to try things out and this way learn how different things are connected to each other.

However, making people learn the right things is not an easy task. How to keep people interested, motivated and engaged? And at the same time, how to make users understand and learn? It is a challenge to design learning games that are both entertaining and educating. (7) The challenge comes from not making it to seem too forced and repetitive. The games that have been done only from the educational point of view supposing, that the game format itself would bring the user satisfaction, have not succeeded. If the user experience is dull or the game is repetitive or boring, it won't be fun. Having

a good user experience in games consists of enjoyable graphics and good gameplay. Having diverse enjoyable game with clear goals and fun rewards are more likely to become a success. (1: p. 26) The problem is also to make games that people want to engage how to predict the things the users will learn from the games and how to make them enjoy it. Many video games that's original purpose was to just entertain has proved to increase many skills of the players, including logical skills and language skills. (3: p. 6) The big question in making a learning game is to gain that affect and control the topic that the users should learn from the application.

Different individuals find different elements engaging and fun to play with, for example, some people like challenges and some like simpler games without struggle. This again shows how important is to be aware of the target group and the average preferences within it. This can be researched by for example making a questionnaire asking the user group what kind of games they find entertaining and what they would like to learn. One approach to please many types of learners could be to have different kind of ap-proaches of teaching the subject, within the application. In the case of the amino acids learning game we planned the application to have two different kinds of games; one for naming the amino acids and another one for assembling the amino acid structure. This way there are more ways of learning which also eases memorizing but provides also options for different types of learners.

One aspect that has an effect to the popularity of a game is the attitude of the users. Are they willing to learn? Do they find the application like it is made for them, not just as some dull tasks in a different form? User testing and questionnaires help with this. It is proved that users with a positive attitude, will be more willing to learn. In a study made for learning mathematics through computers showed clear correlation between the positive attitude and good performance in mathematics. (19) Those students, that had a positive image of mathematics and of them as learners were more open for using a learning game that taught mathematics. Also, the students that were more familiar with digital games and playing were more likely to have positive attitudes.

Nonetheless, a game is not always the best solution for learning. They are excellent tools for learning, but they do not perform well as a complete education system for those subjects that need a large knowledge base. (10) In the case of the amino acids project a learning game is an excellent choice because it will be used as a tool to enhance and strengthen the existing skills of students, and not to teach them completely new topics.

The game also will provide learning by visual feedback, since the students must assembly and recognize the amino acid structures.

3 Gaming platforms

Digital games can be played in various platforms; on personal computers, on consoles, on smart TV applications, and on mobile devices. In this thesis, I am focusing on mobile platforms because it seems to have the most potential and because the amino acid example project was made for mobile. Nevertheless, the other platforms should not be forgotten.

3.1 Mobile is essential

The game platform for the example project is chosen to be mobile, because it is easily reachable. Every student has their mobile appliances in their pockets, and they use them in public transport, in cafés, in hallways, everywhere. The goal is to make the students use their mobile time pro-actively. To achieve this, we wanted to make an application which is both fun and educating. If the application is easy to use and rewarding the users will return again and again. (6) The main advantages using mobile devices for learning are that they motivate students, enhance their learning and help track their progress. (7) Mobile enhances the learning because the learning can happen in small sections daily or even many times a day which strengthens the memory traces.

Mobile as a platform has many limitations: the most obvious one is the varying sizes of the screens. There is only precious little space for anything. To top of that the key features have to be quite big for good usability, since tapping screen with fingers take way bigger portion of the screen than the traditional cursor. The elements have to be big also to ensure their visibility on small screens. (12) Due to different screen sizes, especially when comparing tablets and smartphones, the application has to be responsive. This means that in the prototyping phase the user interface of the application has to adapt to different screen sizes. In the later phases of the project the application will be implemented into native applications of each type of device. Optimizing applications for different operating systems and for tablets and smartphones ensures the best possible performance and user experience.

Other limitation is the rather quick use patterns of mobile. Users tend not to engage using mobile applications for long periods; they peek their phones for short times many times a day. The portability of mobile devices makes them also interruptible. They are not usually used in focused sessions but can be interrupted easily by external events that need our attention. One example of such usage is a person, who uses their phone in bus, and cannot focus fully to the application because they need to pay attention to get off the bus at the right location. That kind of situations makes the use sessions on mobile devices fragmented and short. The approximate time users use mobile applications is only 74 seconds. (8). The small saving space of mobile devices is also limitation. This precious little time and space will also be divided with numerous other applications. (6; 12) Chris Lewis (6) describes this as “The zero sum game”: the time and space that some applications use is away from others. That leads users to remove all applications they do not like or use. This can be only avoided if the user thinks the application is valuable and useful enough that it must be saved when the device is running out of space.

Biggest challenge in game design is the motivation of the users. How to keep users returning to the application and enjoying the use? A game with an enjoyable experience and enjoyable graphics will keep the interest high: it will make the game irresistible. (6) The motivation can be kept if the game is interesting enough, it proves value, it feels useful and just necessary.

All these limitations need to be considered when designing good mobile application. The application must have big enough key elements and it should not be too crowded. It must be interesting and take as little space as possible, and the progress must be savable since the users will most likely use the app for only very short periods at a time. (7)

3.2 Other platforms

Other major platforms for digital games are personal computers, different kinds of consoles, and virtual reality or augmented reality devices. As can be seen from the Figure 2 below, PC is the most commonly supported when asked from game developers which games platforms they support. 52 % of 2000 game developers who answered the survey by Game Developers Conference (20) supported PC, and mobile platforms came as secondary of 42 % support. After personal computers and mobile devices, such as smartphones and tablets came the most common consoles. Virtual reality is also getting more and more common and it is already supported by 16 % of the developers who

answered the survey. Virtual reality might have some great potential for making learning games that require more extensive usage of user movement.

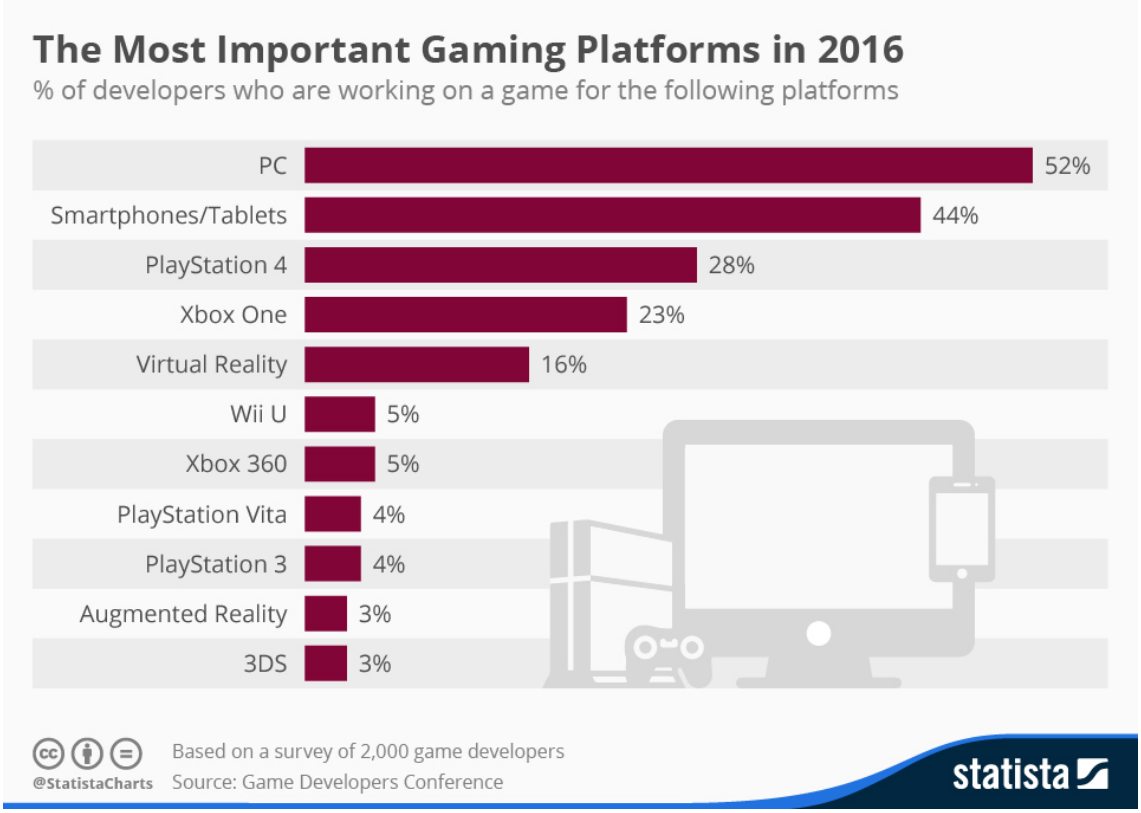

Figure 2. The most important gaming platforms in 2016. (20)

These other platforms have very different kinds of limitations and potential than mobile applications. For example, the ones that are not mobile and used usually in home, school or some other static place, there is not same kind of distractions and time limitations. When sitting down in front of a TV or computer the user usually has more time and the device screens have more space. But in the other hand the usage of such apps is not as frequent and easily accessible as in mobile. In terms of the virtual reality and augmented reality the requirements and limitations are a completely different story when the questions like user safety come in the picture.

Learning games are very present especially in browser based solutions that are meant to be used on a desktop device. There is a good variety of applications on learning coding and mathematics. On desktop, there are less limitations on the screen size and time

users have in their hands. Usually desktop computers and laptops also have more processing capabilities thus better performance and more complicated applications can be run.

Quite often, when making a game it could be considered to make a multiplatform game. Many mobile games have at least websites and there are mobile applications made from browser based games. Having a multiplatform game provides larger user base but also much more costs when all the limitations and challenges of each type of device and platform must be taken into consideration. In the case of the amino acids example project, the choice of platform was obvious. The game idea is simple and meant to be accessible any time of the day easily, so the students can practice the structures anytime anywhere.

4 Benchmarking

Benchmarking is comparing the processes and performance metrics to the ones general in field and the ones of other companies. In means of mobile design and development benchmarking generally means researching and comparing the existing applications in the market. Before starting the design process of any mobile application it is a good practice to start with benchmarking. (13) Comparing existing apps will help: no design is an island, and it saves time and energy when reusing good practices other developers have implemented to their applications.

When doing the benchmarking for design we focused on two goals: how does the other chemistry learning games look and how does applications with beautiful design and good user experience look. When researching the other chemistry learning game applications I noticed that most of them looked very outdated and they were not very user friendly. One example of such application is seen in figure 2.

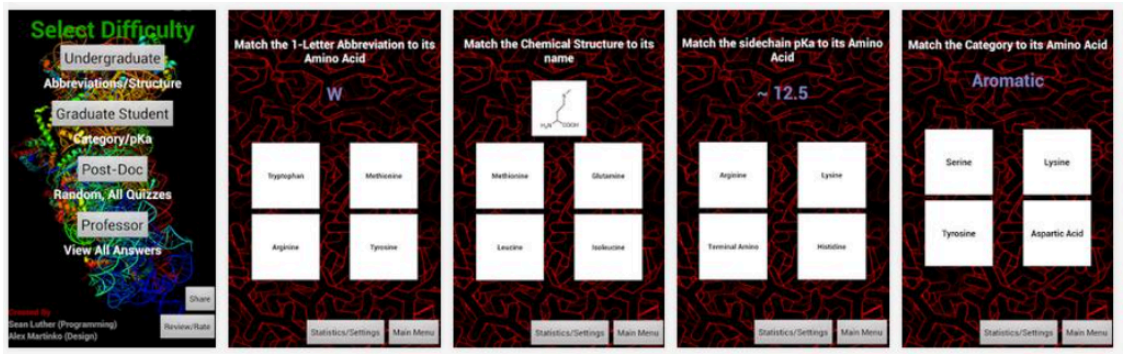

Figure 2. Screen captures of similar application, Amino Acids Quiz

However, despite the outdated looks the benchmarked game, Amino Acids Quiz, gave us some ideas what can be included in the app. In the game, there is three difficulty levels, undergraduate, graduate student and post doctorate. In addition, there is an option for professor to verify all the answers of the quiz. The game itself is quite simple, it consists of questions and four options to choose from. As seen in appendix 1, in the flow chart of the different displays of our prototype, we chose similar approach of having four different options to choose from.

Other approach to benchmarking was to find applications that look good, are easy to use and genuinely feel useful. The main point for looking these examples was not the functionality of the applications but more the usability and design of them. Since we were unable to find great examples of the same specific genre we were working on a broader approach was needed. As I was mainly responsible for the design of the app I did most of the benchmarking from this point of view.

One good example of such application that I found is Duolingo: an application for learning new languages. Duolingo has very modern and clean look and feel with a hint of playfulness. It is very easy and fun to use and I personally found the application very useful. We wanted to achieve same level of great user experience and clean modern look. Duolingo was announced as the app of the year in 2013 by Apple and I do not wonder why. It has gotten very high review in apple store, 4.5 stars and many users describe it as a motivating, fun and rewarding way of learning languages. The app uses many ways for learning; it has pictures, tests, text, dialect, pronunciation exercises, vocabulary exercises and even a possibility to have real life kind of chats with bots. In the figure 3 is shown the menu of the different tasks which also shows the current progress of the user. (21)

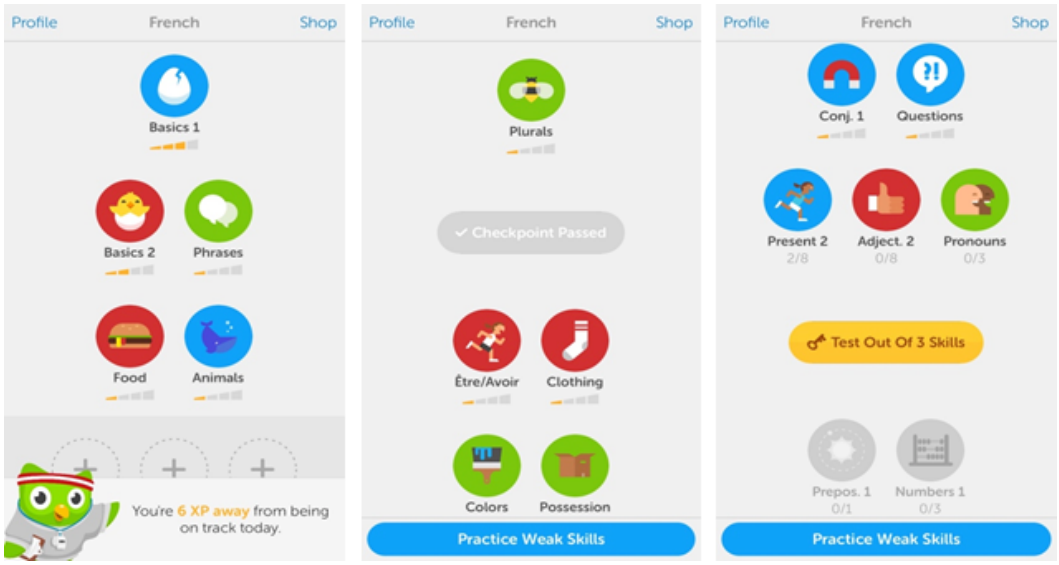

Figure 3. Screen captures of Duolingo, the language learning game (21)

Duolingo has received some critique as well. The heuristic evaluation by students of University of Ottawa pointed out many places for improving the user experience of the application. (21) If you by accident choose a wrong language to learn you must log in to the desk top version of the app to be able to remove the extra language you are not interested in. Other point that I found a good comment from the study, was a critique for it is not possible to save progress when user is going through a single quiz, progress can only be saved after the quiz is completed. Due to the mobile usage, users do not have a specific time and space for using the application and outside world might need their attention at any moment. It might be frustrating to have to quit the app in middle of a quiz and have none of your progress saved. Lessons learned from the evaluation: use consistent naming of different sections and enable saving the progress in as many places as possible.

5 Case: Chemistry learning application

As mentioned before, the case that I worked on was a learning game for learning amino acid structures, targeted especially for chemistry students. The purpose of the game is to help the students to remember the structures well in order to have better results in tests and in other places where a good knowledge of the amino acid structures is needed. The game will facilitate the students to learn the amino acid structures by heart, which makes learning the more complex chemistry easier.

The application was planned by a team of chemistry teachers of university Grenoble Alpes. They wanted to make an application that would be an interesting way of learning this subject. A learning game was concluded to be the perfect way of making the structure learning a bit more fun and the aspect that the game could be played anywhere was a strong argument.

The main requirements for the application were

- Clean modern look
- Good performance on mobile devices
- Good user experience, easy to use
- Enhancing students' skills

These requirements were selected because a clean modern look would be appealing to the students. The application was wanted to seem modern and not look out dated like the example application we found in the benchmarking process. The application should as new and exciting as the other apps in the market. Good performance on mobile devices was an obvious requirement as well; the application must perform well that the users will not get frustrated because the slowness of the application. This is also a part of the requirement for good user experience and the easiness to use the application. The app should be intuitive to use and the average user should understand the basic usage of the app without requiring any additional help. This can be achieved using the good visual ques, clear naming conventions and the usual placements of menus and other key elements of the application.

The project was done using scrum sprint model, which meant there was meetings with the customer and target settings for every two-week sprint. In the meetings was decided what was wanted to be achieved in the next two weeks and what was already been achieved in the previous sprint. This is a common way of project management in software development and it ensures that the targets can be adjusted in an agile manner. This means there can be changes made in the project plan if some part of it does not work out as well as initially planned.

5.1 The game structure and game story

The game flow is simple and it is illustrated in figure 4. The user starts the application, waits for it to load, and in the main screen chooses a game and plays it.

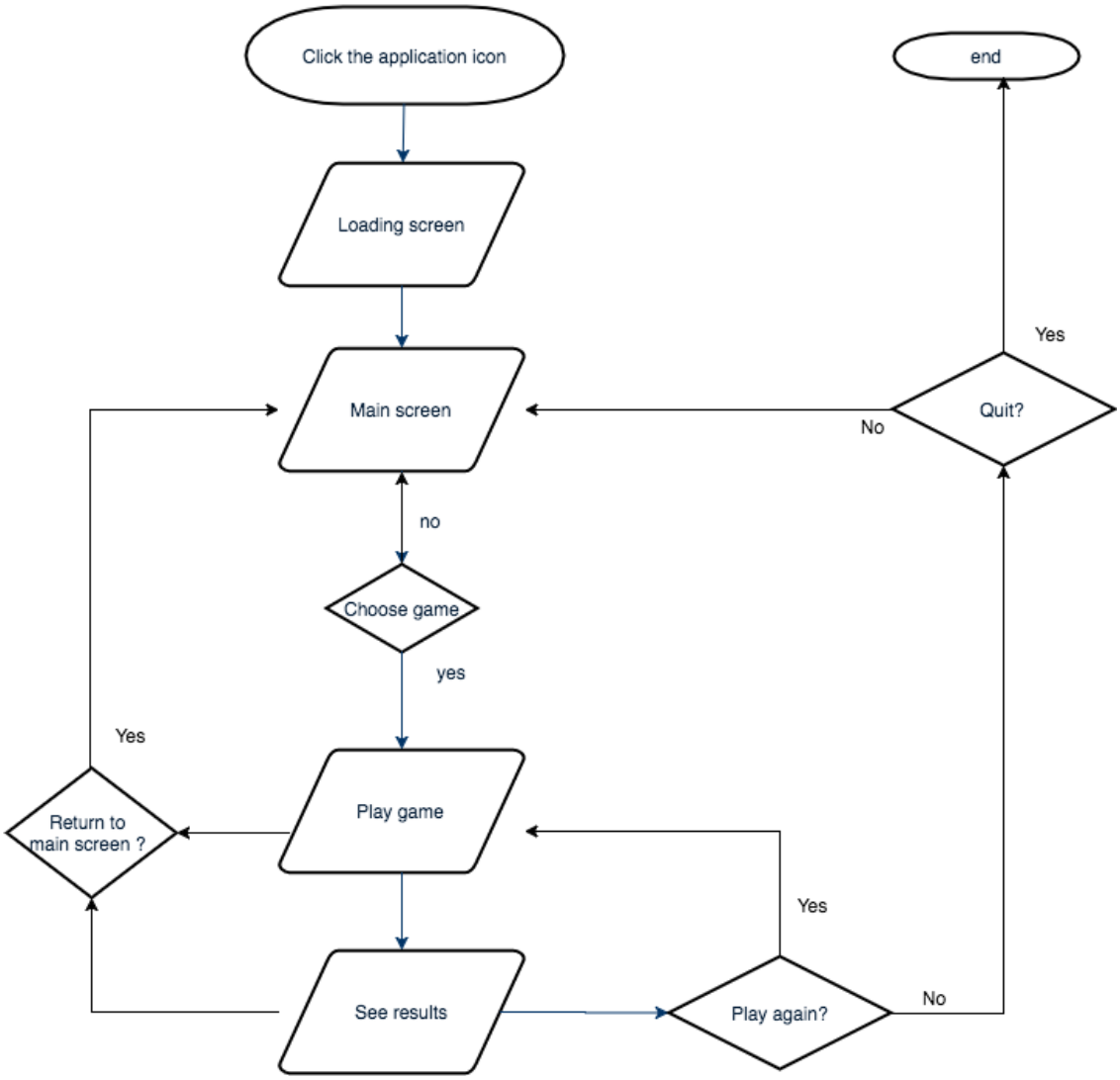

Figure 4. Flowchart of the gameplay

After every game the user has the possibility to see his or her results, and has a choice to either play the same game again, return to the main screen to choose a different game, or quit the application. In later development, the application flow could have more actions, for example screen for points and comparison with other users, a profile page and more different types of games. Never the less for the prototype phase we wanted to create as simple application flow as possible to perform as the backbone of the app.

In the prototype phase the game was decided to consist of two parts. The first part consists of recognizing and naming the amino acids. The second part consist of assembling

amino acids by dragging and dropping the correct elements to their right places in the amino acid structure.

Originally the first idea was to make only the assembling game. When the project developed and after sprint meetings with the customer the second part of naming the amino acids was added. At first, we planned the naming game to be consisting of two parts: writing the amino acid names and selecting the correct names from a list. Later the game for naming the acids by typing was decided to be left out for the sake of clarity. The final parts can be seen in appendix 1 in the flow chart of the game screens – the left-out part is crossed out.

5.2 Planning the user interface and design elements

The design process started with benchmarking. After doing research on designs of different applications we agreed that we want the appearance to be clear, modern and easy to approach. We also did some research on what kind of different screens are needed and settled on following ones:

- Loading screen
- Main menu / select a game –screen
- Screens for the two different games: assembly and recognize
- The result screens for both games

Other types of screens that were present in other applications were for example profile view, more complicated menu structure and scoreboards of users. These can be implemented on the game on the later phases of production, but we decided to keep the first version as simple as possible and focus on the main functions of the game.

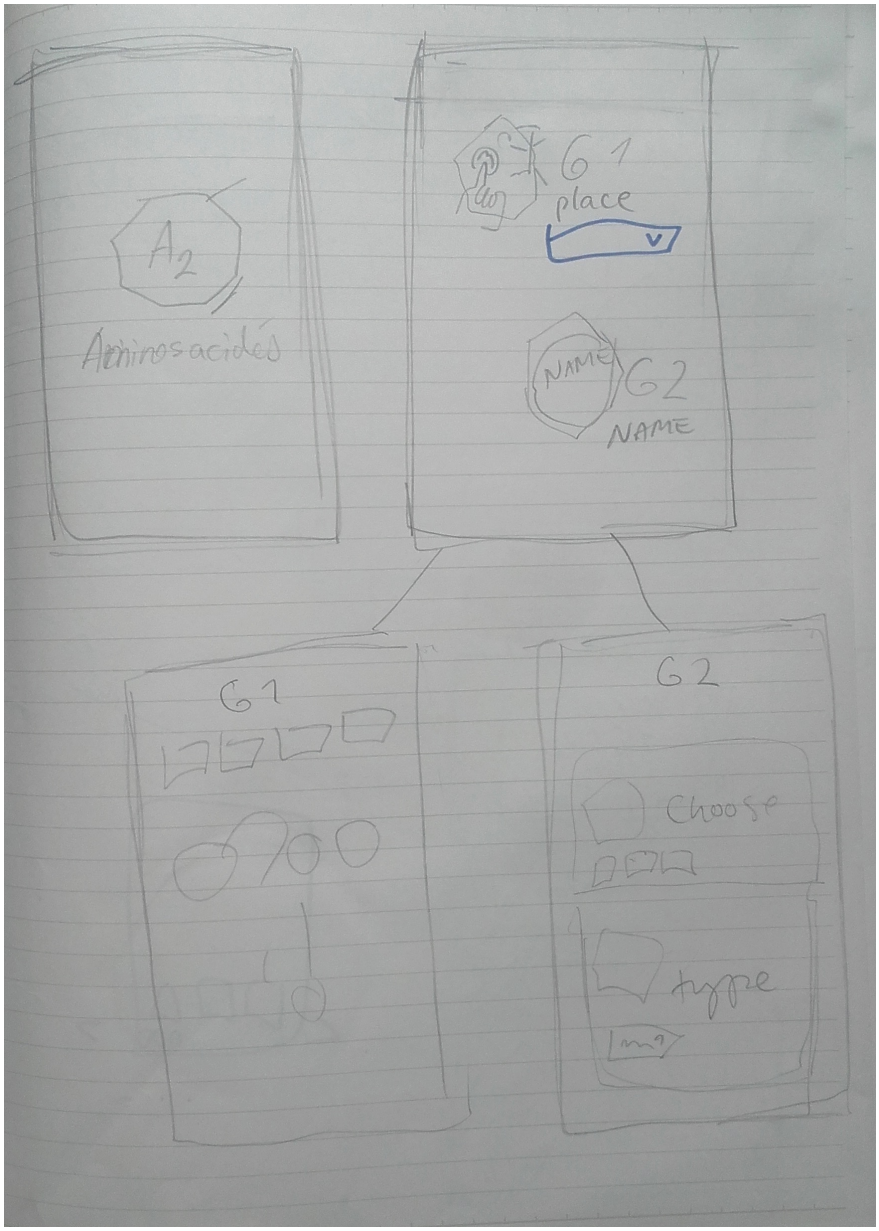

Figure 5. The first sketch of the user interface

After the needed views were decided I did sketches of the user interface, first version is seen in figure 5. In addition of planning the different views I thought about the different elements needed in the game. They were the buttons, different icons for each game, little icons for the results screens and the application logo. In the sketch are following screens: loading screen, the main menu screen, the assembly game and a menu screen to choose between the two different naming games, which was later left out. Rest of the screens illustrate the final flowchart of the screens (appendix 1). When designing the layouts, I had the goals, simplicity and easiness to use in mind.

5.3 Graphical guidelines and design implementation

After planning the structure of the game and researching the needed elements I started the design process. Selecting the colors of the application felt like a good start for the design process.

We ended up choosing for main color light blue with a hint of gray. Blue is used by many big online companies like Facebook and Twitter for a reason. It is popular among many large companies outside the IT field as well. It is associated with traits such simplicity, efficiency and clarity. It looks neutral and professional. (14) These are all qualities we want our application to reflect. Blue is easily approachable neutral color, and since it is one of the main colors it is pleasing and preferable for most users compared to artificial ones. (14) Blue evokes trust and is a calming color of intelligence and creativity. It is one of the rare colors that look good in any shade.

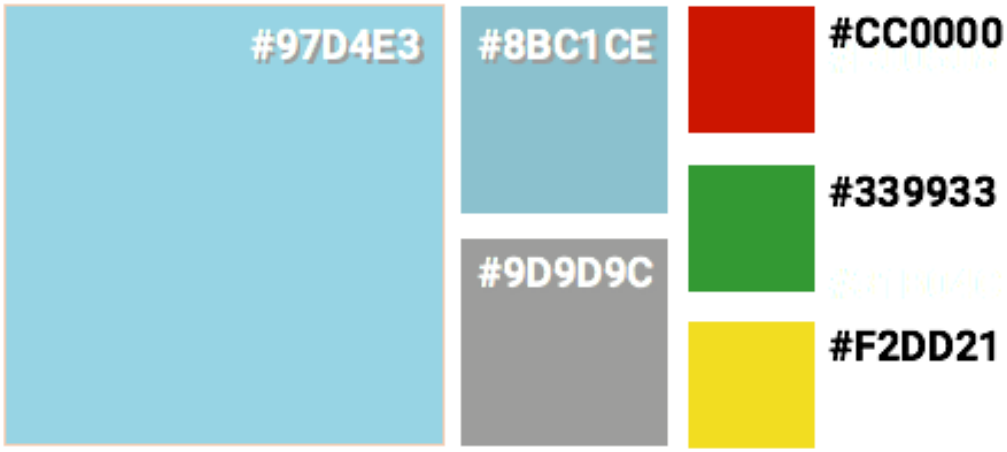

Figure 6. The colors of the application

After we had chosen the primary color we decided to have bit darker shade of blue and neutral gray to accompany and accentuate the primary light blue. In the figure 6 is a chart of decided colors. The red, yellow and green were chosen to be message colors in applications. Red presenting error or mistake, green presenting success and yellow presenting partial success or a warning. These are very traditional choices, and they are easy to understand since they are widely used in same meanings in many other websites.

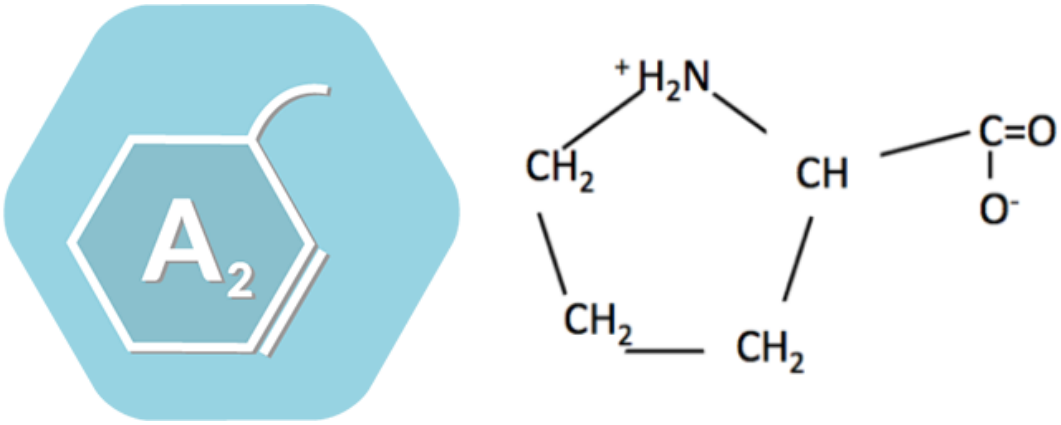

Figure 7. The logo of the app and example of amino acid, proline

We continued the process by designing the logo. Logo design started with the main color we chose. After few sketches we soon ended up choosing the logo to be in shape of hexagon. We chose the shape to reflect the topic of the application: the hexagon is present in many amino acid models. The final logo and the amino acid that inspired the shape are seen in figure 7.

5.4 Illustrating

After deciding the overall appearance by of the logo I used Adobe Illustrator to draw final version of the logo and other icons. Illustrator is used to create scalable vector graphics, SVG. That ensures the possibility of creating endless different size versions of the graphics for different uses.

First I made the base shape of the logo using Illustrator's hexagon shape tool and added rounded corners -effect to the shape to achieve a softer look. Then I applied another hexagon, but this time without the rounded corners. To this shape we decided to add a little tentacle and a double line to its down right corner to make it resemble more like a chemical symbol. Then I added a shadow effect to make the inner shape pop from its background. For the text, we made two different versions: logo with two A letters (from the name of the game, *acides aminées*) and another version with one A letter and a small 2 to signify the two A's of the application name. The latter version was judged to be better because it makes the logo reflect the chemical models even more.
I used the ready logo as a base for other icons such the menu icons. The logo is seen in figure 6 and the menu icons in figure 8.

Figure 8. Different versions of the hand icon

For adding bit of playfulness, to make the game look more fun, and to the design I came up with an idea to use hand icon, a bit like the pointer cursor to demonstrate the drag and drop feature in the menu icon of the assembling game. As a base of my illustration I used and freely usable hand icon made by Katarina Stefanikova (16). I was not completely satisfied with the icon as it was so I made few adjustments. The changes can be seen in the figure 8: I changed the lengths of the fingers in order to make the hand seem more natural and the gesture more pointing. This pointing hand is used in my design of the assembly game icon.

I developed the same hand as base even further and created a clapping hands icon: I re positioned the fingers, made a reversed copy of the hand, and added black bars to signify the clapping sound. This icon is used in result screens when the user has finished a game successfully.

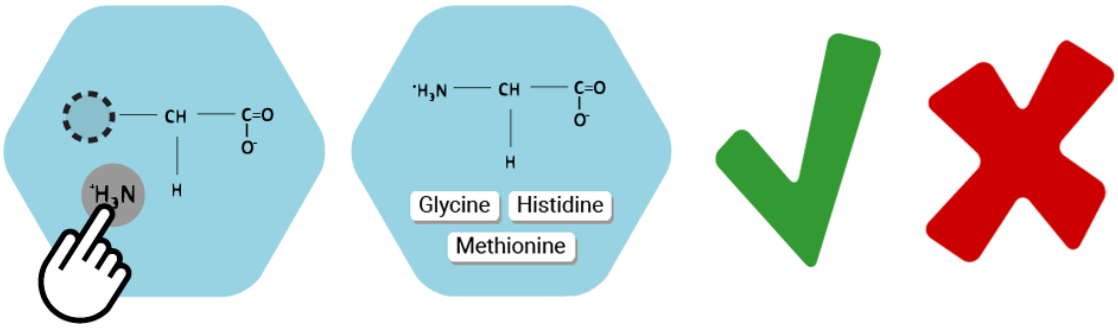

Figure 9. Examples of the icons of the application

In figure 9 the hand icon is in use in the main menu icon that represents the assembling game. In the same figure is seen also the recognizing game icon and success and error

icons I illustrated freehand with Adobe Illustrator. The success and error icons are used in the result screen.

5.5 Layouts

When implementing the sketches of layouts in to digital form, I decided to make them of a flow chart so the application structure is easy to comprehend. This means visualizing connections between different screens using arrows. For making this I use flowchart maker called Draw.io. It is a completely JavaScript based tool for making flowcharts, layouts and prototypes. I chose this tool because it is developer centric meaning that it is fully documented, works in every browser and uses google drive for sharing the end result. It renders the result as SVG images so the chart can be exported easily in any form including image files, PDF and HTML. (17) It was very convenient for sharing the layouts with my team members, since Google Drive makes it possible to do changes to the same files simultaneously from different computers.

Using this tool was very efficient also because it provides lots of free to use graphical elements, such as phone frames, arrows and buttons, which sped up the process notably. Combining the ready-made elements with icons that I draw using Adobe Illustrator the result looks professional and the structure of the application is seen easily with one glance. Example of one of the layouts is seen in figure 6 and the complete flowchart is seen in appendix 1.

Below, figure 10 presents two different versions of the results page of the naming game. The layouts are similar otherwise but the buttons options are bit different. In the version on left there is option to replay the game and in the version in the right the option is to continue playing or return to the main menu. In the final version, we decided to use the one in the right, even though the possibility to return to main menu already exist in the top left corner. We thought that for some users the small arrow might not be strong enough indicate for returning to the main menu.

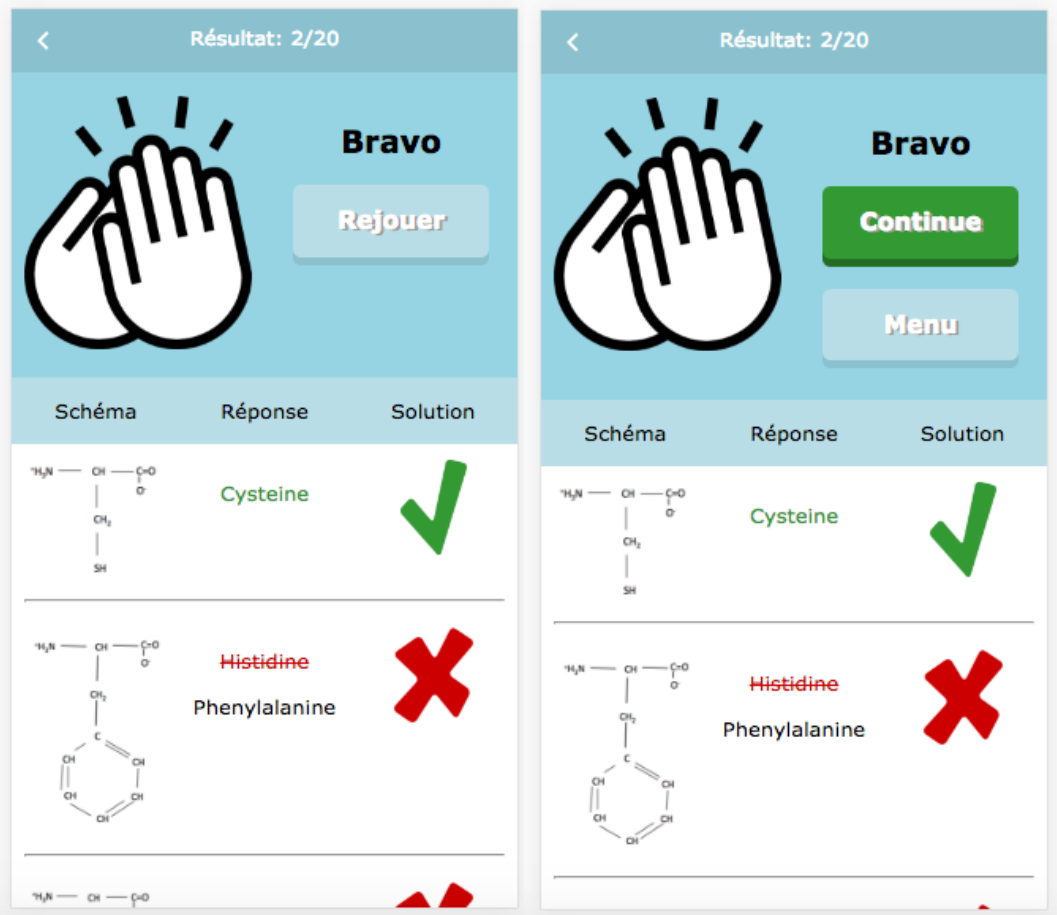

Figure 10. Two different variations of the result page of the game 1

5.6 Technical implementation

The game is made using web technologies: HTML, the styling langue CSS and SASS and Angular JS JavaScript framework. The logic, the backend, of the game will be produced with Angular and the overall appearances and user interface, the frontend, with HTML, CSS and SASS. The application will be adapted to mobile use in later phases of the project using phone gap. Phone gap is a framework that allows to develop mobile applications using techniques and languages that are traditionally used only in browser based applications. With Phone gap applications developed like websites will work like native mobile applications. If this version of the application proves to be useful the application will be possibly adapted and optimized to mobile devices as native applications using the corresponding development languages of each operating system – Swift for iOS and Java for Android.

Since my job in the team was to focus on the user interface and experience I did only CSS and Sass. Sass is a CSS preprocessor that adds functionality, inheritance and nesting to writing style files. (15) Using Sass enables more structured style sheets and separate files for different parts of the application, which makes the navigation through the styles way easier. This makes the development faster and helps with the further changes since everything is in order and easy to find. Sass is also great for inheriting styles which makes the writing more efficient and precise. The following code extract (figure 11) is a good example of this.

```
button, a.button {
    background-color: $button-bg;
    border-radius: 5px;
    border: 0;
    box-shadow: 0 5px $button-shadow;
    color: $button-text;
    display: block;
    font-size: 2.7vh;
    font-weight: bold;
    height: 8vh;
    margin-bottom:10px;
    outline: none;
    text-shadow: 2px 1px 0px $gray;
    width: 100%;

    &:active {
        box-shadow: 0 2.5px;
        transform: translateY(2.5px);
    }

    &.btn-light {
        background-color: $button-bg-light;
    }
    &.btn-red {
        background-color: $button-bg-red;
        box-shadow: 0 5px $button-shadow-red;
    }
    &.btn-green {
        background-color: $button-bg-green;
        box-shadow: 0 5px $button-shadow-green;
    }
}
```

Figure 11. CSS code snippet; button example

The highest and most general rules are applied to all button elements and anchor links with a class “button”. That ensures that all buttons look alike. After the general rules there

is three additional classes: “btn-light”, “btn-green” and “btn-red”. These are different color variations of the buttons. The &-sign before the class names means elements in addition. In other words, it chooses the elements that are buttons and have a certain class in addition, for example “btn-red”. Instead of writing the same rules to every variation of button, with sass inheritance only the divergent rules need to be applied to the code.

The code extract demonstrates the use of variables. Using variables in color definitions instead of plain hex codes makes it possible to make changes to everything that is the same color just by changing the variable value. For example, the shade of “button-bg-green” could be changed anywhere in the code just changing the variable value, and having no need to look from the code every instance with that color value.

6 Project results

The project was a success to some extent and the goals for the prototype were reached. We made a version of the game that met the requirements of the client at this stage: there are two mini games, one for naming and one for assembling the amino acids. The design of the game is simple and modern but it is easily approachable and suits well the purpose of the game. All the limitations of mobility and screen size were taken in to account and the space in layouts is used wisely.

Unfortunately, the game is not available or visible in public. The game works only in the browser, but it can be adapted as a native mobile application later. I think this is a great base for future development and for adding more features to the game.

There is some room for improvement. I got feedback from the design that the contrast is not high enough in some elements and that is very true. Having a good contrast is essential for better accessibility and that needs to be taken in to better consideration in the future. An example of a button that does not have enough contrast is visible below in figure 12.

Figure 12. Example of an element that would benefit from more contrast

In the final game has the assembling game and the recognizing game. In assembling game the elements of different amino acids needs to be dragged to the right positions. In the naming game, there is a picture of different amino acids and they should be recognized and the name of the right acid be tapped. The game structure is visible in Appendix 1.

The project still felt very unfinished when we did the wrap up session. I moved out of France and as far as I know the project has not continued yet. It is a start and I believe it will be a good game after further development. In the future, the game needs to be implemented as a native mobile application. In addition, the game could be made to many different platforms, there could be for example a desktop version.

The game could be extended also making more different kinds of mini games and more levels to the application, so the users will not get too familiar with the content and they could develop being longer engaged in the game. The game could have pointing system, so there would be clear data collected from the playing. The progress of the users could be visible in their personal profiles where they could see clearly and visually how they have improved and what are their raking compared to their friends. The application could also have a daily quiz or a lesson so the user would always have new challenges and opportunities to improve.

7 Conclusion

This thesis presented some theory on learning games and different gaming platforms, mobile platform in particular. The study is also a project report of a learning game prototype for chemistry students. I believe learning games are a way of bringing more fun and ease to education and learning.

Learning games is a field that has only recently started to gain its full potential. As a topic learning games has intrigued many scholars for some time. Previously, games were seen only as distraction and entertainment. Several studies have demonstrated that games teach players many valuable skills, for example better language skills, even though the main target for the game would have been just entertainment. To be successful, a learning game must be well marketed, have interesting content, discuss the change it will make in the users and be irresistible. Successful learning games makes learning a

subject easier and essentially more enjoyable. Games give the opportunity to get immediate feedback and collect exact statistics so the progress can be easily followed. I strongly believe this accelerates learning.

I was part of a group that made a prototype of a learning game. I learned a lot during this project, not only about the designing an interface of an application, but also the mechanics of learning and how games and playing are a growing part of all this. I believe education will take more and more advantage of games and in the future as there will be an increasing amount of interesting and fun games for learning different kinds of things. Games are already a way for many people for learning languages, tactics, reaction speed, logic and social skills. The attitudes towards games have changed and I cannot wait to see what kind of possibilities the future brings in this area. Maybe in the future even the most paper tasting things can be learnt in a more rewarding, colorful and progressive way; by playing.

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Appendix 1. The flow chart of the different screens of the application