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THE METHODS OF PROTOTYPING USER INTERFACES IN EDUCATIONAL APPLICATIONS WITH AUGMENTED REALITY TECHNOLOGY

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LIITREAALSUSE KASUTAJALIIDESE PROTOTÜÜPIMISE MEETODID HARIDUS RAKENDUSTES

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Author’s declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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Abstract

New technologies changed our daily life. There are new techniques that we use to make our world more interesting and useful. With new technologies appeared a need of user-friendly user interfaces (UI) and user experience (UX) for smartphones.

The aim of this paper is to analyse already existing methods of prototyping attractive UI for applications (apps). And do the research for the new methods and testing of UI design to learn school subjects by using Augmented Reality (AR) technologies.

For this aim different types of prototyping methods of applications were taken. Thus, after selecting and evaluating two of them, the outcome will show what could be beneficial for designers to make educational apps with AR. The main concerns will be in regards to the fast prototyping methods, app functions testing with the target audience.

For simplification and faster understanding of the needs and principles of the prototype building for application with AR technologies for user interface and user experience (UI&UX) for designers, the main stages of user-centered design and usability itself will be described in this paper. As have been described in [1], "to be usable, the product or service should be useful, efficient, effective, satisfying, learnable, and accessible." All outcomes of the research will be processed, and the solution will be made, through evaluation of the feedback and personal research.

As a result of the study, methods of UI prototyping will be evaluated in the scope of the educational purposes with implementation of AR technologies. The solution will be provided using an example of an application designed to help learn chemistry for students of 8^{th}-11^{th} grades.

This thesis is written in English language and is 72 pages long, including 6 chapters, 12 figures and 4 tables.

Annotatsioon

Liitreaalsuse kasutajaliidese prototüüpimise meetodid haridus rakendustes.

Uued tehnoloogiad muutsid meie igapäevaelu. Uute tehnoloogiate tulekuga on ilmnenud vajadus kasutajasõbralike kasutajaliideste ja kasutajakogemuste jaoks nutitelefonidele. Selle lõputöö eesmärk on analüüsida juba olemasolevaid rakendusprogrammide kasutajaliidese prototüüpimise meetodeid, leida uusi meetodeid ning testida neid liitereaalsuse tehnoloogial põhineva õpperakenduse peal. Nende eesmärkide saavutamiseks sai mitmete erinevate nutirakenduste vahelt välja valitud kaks, mille hinnangust võiks kasu olla liireaalsusel põhinevate õpperakenduste loomisel disaineritele.

Peamised huvipunktid on kiire prototüüpimise meetodid, rakenduse funkatsioonide testimine sihtgrupiga. Selles töös on kirjeldatud kasutajamugavuse ja kasutajakeskse disaini põhietappe. Lõputöö on mõeldud aitamaks disaineritel kiirelt ja lihtsalt mõista kasutajaliidese ja kasutajakogemuse prototüübi ehitamise vajalikkust ja ehitamise põhimõtteid. Just nagu on kirjeldatud [1]: “Et olla kasutatav, toode või teenus peaks olema kasulik, tõhus, rahuldust pakkuv, kiirelt õpitav ja ligipääsetav.”

Kõik uurimustöös selgunu saab läbi töödeldud ja kokkuvõte saab tehtud läbi tagasiside hindamise ja isikliku uurimuse. Kasutajaliidese prototüüpimise uuringu tulemused saavad hinnatud omades eesmärki nende kasutamiseks haridusalases rakenduses koos liitreaalsuse tehnoloogiaga. Lahendusena on loodud rakendus, mis aitab õppida keemiat kaheksanda kuni üheteistkümnenda klassi õpilaste.

Lõputöö on kirjutatud inglise keeles ning sisaldab teksti 72 leheküljel, 6 peatükki, 12 joonist, 4 tabelit.

List of abbreviations and terms

UI	User Interface
UX	User Experience
AR	Augmented Reality
VR	Virtual Reality
MR	Mixed Reality
app	Application
UCD	User-centered design
HCI	Human Computer Interaction
GUI	Graphic User Interface
OS	Operating System
SUS	System Usability Scale

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1 Introduction

The computer technology becomes more efficient with time. The best advantages of the development that we used help us to become more successful in our daily life, work achievement, and communication. The User Interfaces (UI) become more incredible and attractive for users. Through years designers and programmers worked on elaborating of the most useful approach, building, and testing prototype system, which directly connected with users. The question always was which system or methods start to use to build different applications (apps) and moreover how to do it faster and fully. Nowadays, the technologies step forward and start collaborating with Virtual Reality (VR) and Augmented Reality (AR) environment. Both of these "future" types require more attention to UI design and methods of creating the prototypes.

1.1 Problems overview

The technologies require new attempts to follow to create new methods of building new and more interactive UI for the apps. The different techniques should be provided to achieve the aim which will be accepted by the both sides. Usually, the first stage is user-centered design (UCD), the process outlines the phases throughout a design and development life-cycle all while focusing on gaining a deep understanding of who will be users of the product [2]. After that, the problem for designers is questions how to show the prototype and test it with their target audience, how to show them how the technologies of AR will work with apps and interact directly with users. Thus, the main issue for the designers is what are the right methods and tools for app prototyping with AR technologies for educational purpose.

1.2 The necessity of new researches for the app prototyping with AR technology

The UI&UX designers used to work with tools and software suitable for different apps. For example, the tools and methods which they usually use are suitable for apps which

are connected with game industry, educational sphere, promotion purpose, etc. The different techniques and attempts help them to achieve the main goal, to make the product successful in marketing. The usual attempt for the designers and the people who work in this industry is to use the UCD approach. The UCD includes multiple principles that underlie user-centered design. The design is based on an explicit understanding of:

- users;
- tasks;
- environments.

As in [2] described, that mainly it is driven and refined by user-centered evaluation. That by itself is connected to the whole user experience. The process involves users throughout the design and development process, making the process more iterative.

The interaction between UI and users is very narrow. Thus, the general process of the UCD should be followed, and these steps are:

- **Specify the context of use:** Identify the people who will use the product, what they will use it for, and under what conditions.
- **Specify requirements:** Identify any business requirements or user goals that must be met for the product to be successful.
- **Create design solutions:** This part of the process should be done in stages, building from a rough concept to a complete design.
- **Evaluate designs:** Evaluation - ideally through usability testing with actual users - is as integral as quality testing is to good software development [2].

The UCD process can be used for the both types of the prototyping/mockups, for usual apps building and for the apps with AR technology. The benefit of UCD process is based on the state that a designer can use parts of the process depending on his needs.

The ways of prototyping the apps are a very important part of explanation, presentation, and testing of the idea or product to potential users and customers. The advantages are:

- faster visualisation of the product that you are building;
- identification of the key interactions;
- consideration of the user experience and attitude to your product;
- quick feedback;

The AR technology applications are connected to smartphone/tablet cameras. Scanning of pictures/text through this application helps users to see 3D animations or additional information provided by the application.

The main question for designers is which of the methods to use for better mockup and testing of applications with AR technology. As for users, the main problem consists of: how to use an app which mockup has been made by usual principles of UI design, and to test the AR technology itself. Thus, the requirement to study new methods of prototyping has risen.

1.3 The methods of creating UI applications

In [3] the UI is described as a collection of techniques and mechanism to interact with something. In a graphical interface, the primary interaction mechanism is a pointing device of some kind. The graphic design has indeed revolutionised design and the UI. Screen navigation and commands can be executed through menu bars, pull-downs, etc. Graphic presentation of information utilises by persons much more effectively than other presentation methods. Visualisation of information allows faster data transfer between mobile devices/laptops and humans [4]. Today more attention is focused on the different approaches to creating and demonstrating the AR applications. And the main problem is what are the most efficient and quick ways of app prototyping.

The already existing classical methods of UI prototyping [5] are:

Sketching

Helps you extract numerous ideas out quickly before you enter into a graphics editor to start designing the look and feel. Sketching ideas is the first step in the design process and is something every designer should do. Sketching is not just limited to design, it occurs in many areas that require something to get built. The beauty of sketching is that one is not required to be an artist to produce them. Sketching is only useful to help explore and explain design concepts. Sketches can be easily created using pen and paper or a whiteboard. Using something permanent like a pen or marker is best. The idea is to keep your sketches fast, rough and dirty. This helps you worry less about design aesthetics and focus more on quick formulation of ideas [6].

Storyboards

It can also go along with the sketching part. For the storyboards method [5], the designer should focus on the problem and the solution. Ideally, each step (dataflows, ways of solving the problems, etc.) should be written in the workspace. It will help to expand the reality of the usual way of thinking or go deeper into the question solving and to set the primary goal of solution creating.

Persona

A persona is a representation of a user, typically based on user research and incorporating user goals, needs, and interests. Each has its own advantages and shortcomings [7].

UI wireframes

The creating of UI consists of the collaboration of carcas ideas for an app, sizes, position, the content (boxes, buttons, etc.) which will be in the application [5]. Unlike that in a mockup, the wireframes might not contain the part of the colour decision and the whole conception of the look of an app.

UI mockup

The mockup is built on top of wireframes [5]. It consists of colours, shapes, buttons ideas, etc. Usually, the UI mockup has to look like the real application for testing or example to the users.

Video prototype

The interactive video [5] of your mockup idea with interactions and actions. Allows users or watchers to the concept of your app and ways to use by watching a video.

Interactive prototypes

It is a simulation of the final product. It’s like an interactive mockup that can have any degree of fidelity. The main purpose of building prototypes is to test whether or not the dataflow of the product is smooth and consistent [8].

Final native application

A native application is an application program that has been developed for use on a particular platform or device [9].

1.4 The shortcomings with existing methods of prototyping of apps with the AR technology

The shortcomings of the typical methods of the app prototyping are relevant for the new technology like AR. The inability to use the app in a right way makes users and designers unable to reach the goal. The purpose for designers is to show how exactly a prototype will work with AR and for users to understand, test and use the app. The interaction design process consists of tasks analysis, UI specification, application graphics development and prototyping. The components, tools, the application itself and the use-experiences should build the final product in the end.

Thus, the shortcomings are:

- Lack of UI prototyping for AR application experience;

The demand for apps with the AR technology is increasing. But the experience of app prototyping and testing is not on the highest level in design sphere.

- Lack of feedback from users;
- Inability to make a whole prototype in one mockup;

The essential problem which creates obstacles in making the prototype full of features like AR and 3D animation. It makes it impossible to design the mockup and test it with the target audience. Therefore, the designers have to do the research and find outcomes for their apps. Moreover, they need to combine different methods and mobile Human Computer Interaction (HCI) principles [10] for creating UI apps with AR technology.

The significant part of the UI prototyping is transparency. Each step of using an app should be clear and obvious. The goal for the designers is to minimise the input of the information required from the users, avoid unnecessary interactivity and to provide the feedback upon the user's request.

Moreover, the difference between typical UI and UI for apps with the AR is obvious. The principles of prototyping methods should be clear, the quality of the 3D information have to be on a scale that will be simple for customers. Otherwise, the AR technology will not be that part which helps to learn.

2 Educational approach with AR technologies

2.1 Introduction

Augmented reality means to add or to amplify (to grow). Based on this, AR means that it is a way to enhance or amplify user's sense of the real world with synthetic information. Augmented reality has been included as a part of Virtual Reality (VR). A better categorization is given by Milgram and Kismo. They defined it as part of Mixed Reality (MR), a more proper term to describe the blending of two worlds, virtual and real. Azuma used their taxonomy and representation of the 'virtual continuum' (Figure 1.) [11]. The MR is between two parts, where the virtual and real techniques are mixed. AR is closest to the real world, having the virtual objects overlaying the environment. By having the surrounding environment as real, AR is much better suited to the requirements of mobility for a system. The user is capable of operating virtual objects while seeing the real environment around.

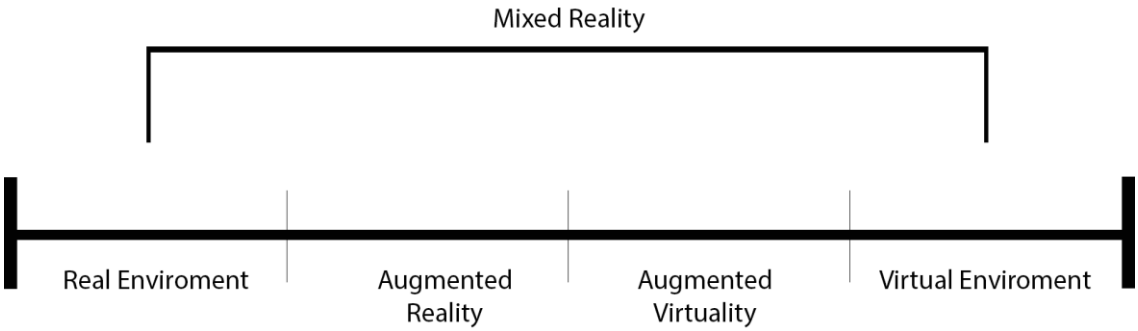


Figure 1. The Miligram's representation of a "virtual continuum."

The scope of apps for AR is a huge. It is useful in medicine, entertainment, manufacturing, technology, and military [11]. Artificially combined information can be easily and dynamically manipulated. This ensures that the UI is less constrained by a real and solid design. Moreover, the normal characteristics of the UI, if they are limited

by material nature, should develop more freely, which is facilitated by the new virtual character provided in the AR environment.

The cooperation of the UI based on AR is less abstract than the typical UI or Graphical User Interface (GUI). The parts can be real, but they could change the state of virtual ones - that's why they could become a source of intuitive interaction. This type of interface referred to in the literature as the User Augmented Reality interface could control physical objects as synthetic [12].

Thus, the AR technology started to be of the huge entertainment of the new era of human's life. New possibilities of reconsidering the classical GUI for the new way of building apps appeared. Different entities try this possibility of involving the AR technologies into recognition and learning of their products and subjects. Also, an opportunity to learn the new ways of prototyping and researching will help designers to create a new environment, education sphere, and to involve users to live with AR technologies.

2.2 Augmented Reality technology

In [13] the definition of AR is defined as “the technique that enables a user to see artificially generated objects on top of real ones. AR is restricted to sight or visual perception and not to the others human senses like hearing, touch, taste or smell, which also could be artificially augmented. Hence, AR here from of VR that supplements the real world with virtual information rather than creating a completely synthetic 3D graphic experience.”

Shortly, AR is a technology which will add information to the surrounding environment with the help of 3D animations. The AR is not replacing the reality, but the VR does.

2.3 Augmented Reality in Education

A lot of different ways to help learn and explain subjects exist. Each target audience chooses their own acceptable way to study. Thus, for now, many ways of learning exist. It includes lectures, trainings, workshops, and classrooms, with and without devices or additional technologies. The choice of innovations in training depends on the access of

individuals to different technologies and the accessible infrastructure environment of the surrounding community. If recently the studying could be done in specialised classrooms (for chemistry or biology), the AR may completely change the way of studying and understanding the information beyond the borders of casual classrooms, lectures, etc.

The first mention of the AR technology for education was made back in 1990 by a team that made a research of Boeing. They were Thomas Caudell (he also co-editor of book "Fundamentals of Wearable Computers and Augmented (sic) Reality") and David Mizell. They had the challenge to find different ways to show expansive diagrams and to develop a marking device used to guide workers on the factory floor. The result of the research was a head-mounted apparatus with instructions about the cockpit surroundings on a display. The users who wore this glasses were able to see the instructions virtually. After that, they became one of the first researchers that connected their names and life to the AR.

After that, the AR received huge attention from scientists. Another part of researching the benefits of AR in education happened in 1997 when Dr. Ronald Azuma published the "Survey of Augmented Reality." In 1998, the first International Workshop on the AR (IWAR '98) was sponsored by IEEE [14].

Through the research [15], several scientists advised that students and teachers could develop knowledge and motivation to study through the VR and the AR. Despite the new technologies being already used in education, the AR is still very hard to integrate into schools and training programs, because of a lack of people that are ready to accept the new way of learning. Costs and maintenance of the AR are also considerable factors. Nowadays the AR claims to be a new approach to learning, as it becomes easier to use, phone adaptive and mobile-friendly, while and also becoming more popular. Today, the AR is more adaptive and useful in education, it has a cleaner approach to the information and doesn't isolate people from the real life.

The AR in education was first mentioned in 1960 study by George Malcolm Stratton. This technology was used in glasses, and the study has been finished. After that, Ivan Sutherland made a research with an aim to mix computer-generated images with real objects, which was called the HMD (The Head Mounded/worn Display) [12]. Today,

the VR and the AR became more like competitors than partners. One of the reasons is that the AR is closer to the real world, allowing you to add information. In the VR, however, you need more equipment, an isolated room and a good vestibular apparatus.

In the work of Kerawalla [15], he mentioned that the AR has the potential to make learners more engaged and motivated in discovering resources and applying them to the real world from a variety of diverse perspectives that have never been implemented in the real world before.

The AR can also be used in schools and business environments. The equipment for the AR to be possible is available for developers and users. Now it is more capable than ever before, and even more compact. The AR can be used with mobile devices, which are small and are available to a very broad public. The AR might also be used in academic venues through mobile devices. There are already some education areas where the AR is effectively applied to learning, for example, Anatomy 4D which have been provided by DAQRI [16] to learn about human's body parts and organs. With simple pictures with body and organs on it through scanning the user by this app can see the different functions of the 3D animation on his phone or tablet screen. The wireless in cooperation with mobile devices, such as smartphones tablets, HoloLens, etc. helps the AR become more available for different categories of people. The AR and smartphones help students to understand different subjects faster. The integration of AR into the mobile space offers the greatest solutions and opportunities to learning.

Also, wireless mobile devices, such as smart phones, tablet PCs, and other electronic innovations, are increasingly ushering this technology (AR) into the mobile space where the AR applications offer a great deal of promise, especially in learning and training.

The opportunity to integrate the AR technology into the educational space may lead the scientists, teachers, and students to the astonishing environment. It could be the most reasonable step in learning. Among the most suitable subjects for the AR technology are chemistry, physics, mathematics, biology, astronomy, etc.

The important obstacles which Shelton emphasised on were that the AR has not been much adopted into academic settings due to a little financial support from the government and a lack of the overall awareness of needs for the AR in academic settings [17].

2.4 Conclusion

The potential power of AR as a learning tool is its ability "to enable students to see the world around them in new ways and engage with realistic issues in a context with which the students are already connected" [17].

The opportunity of the vision-based AR promises students and teachers to establish attractive learning experience in cooperation with the real world, by providing educational information through the mobile phone. Its results predict the beneficial study opportunity. Lessons supported visually have an overall of 25% more effectiveness in learning [18]. Difficulties of the VR, when it comes to immersion, are related to poor animations and possible health-related issues, making the user less capable of "believing" the surroundings. This may act as a serious distraction, making the AR a better candidate for education purposes. In the case of bad animation (3D animations) with AR technology, the user will not be out of the real world, definitely understanding the border between the unreal and the real world.

Studies [18] have shown that immersion in a digital environment can enhance education in at least three ways: by allowing multiple perspectives, situated learning, and transfer. Furthermore, the AR leverages the affordance of context sensitivity, enabling the mobile device to "know" where it is in the physical world and to show the digital content to the user.

Scientists and programmers work to adapt and develop the programs to help implement the AR technology into education, which in turn, can help achieve better results in learning. Applying this knowledge to education can widen the perception of the existing things. Through compatibility and applicability of the AR technology, students can use it everywhere and take the full information from that.

3 Data collection

3.1 Introduction

Explored the different types of qualitative research, the work contains methods of data collection which are used in qualitative research. There are many types of methods which exist for qualitative data collection in different researches, including questionnaires, interviews, observations, etc.

The questionnaires method of data collection is used for this work. Generally, the questionnaires method can be used for different types of researches. It is an inexpensive method of data collection. Questionnaires are used to research the answers, different points of view, experiences of designers in UI app prototyping sphere with AR technology. Further, will be examples of questionnaires type [20], there are:

1. Structured questionnaire

It contains concrete questions which are prepared in advance. Also, it can checks and additive the data which have been previously accumulated. Can be used in different subjects of study, researches and business problems.

2. Unstructured questionnaire

Usually, it used during an interview. It becomes a help-list for the interviewer. Can be used in studies, in personal experiences, etc.

The types of questionnaires can also be divided into the nature of the question. The are divided on:

1. Open ended questionnaire

People free to express their views. This type of questionnaire can be used in intensive studies parts where answer options are not limited.

2. Close ended questionnaire

Existing only alternatives with YES or NO answers to questions.

3. Mixed questionnaire

Includes open ended and close ended type of questions.

4. Pictorial questionnaire

For the options of the answers are used pictures. Usually used in social questionnaire and in working with children.

The type of questions have been chosen; the effectiveness will be enhanced by mixing up of the questions. The effectiveness of this type of questionnaire in time, concentration, integrity form the responders.

3.2 Purpose of the research

The purpose of the questionnaire research is to find, understand, make the outcomes and compare the answers from the responders, which will be UI designers who work or probably will work with AR. The different types of the questionnaire, I mentioned above, help to achieve the best results and collaborate different aspects and localisations of designers. With questionnaire, the data will be provided faster and concrete than others.

Also, the survey for Tartu's teachers in Estonia who are currently working in schools which have been provided by Subatomic OÜ to know will they allowed to use the electronic device during their classes and do they need opportunity of the educational app with AR technology for students.

Choosing the right type of questions will make the fully understandable questionnaire. Also, it is important to use right abbreviations and professional language in this sphere. It will help people to clarify the purpose of the questions and get the right feedback from designers and teachers. The questionnaire will be posted on "Facebook" social network to the target audience. Also, it will be provided personally on the event which called "Tallinna innovatsioonipäev 2017" in Tallinn, Estonia.

The benefit of this research will help to be closer to understanding of the needs and shortcomings which are existing now with general types of software, program or tool with which designers faced.

3.3 Collecting and storing the data

Several ways of collecting the data have been chosen. The questionnaires can be provided remotely (online) and personally. Thus, both types of the survey have been provided. The online questionnaire was providing with the designers target audience. Some of them are currently working like UI&UX designers in Estonian companies such as MobiLab, BigBank, etc. The tools for collecting the data can be paper-based and online (Google Forms, Survio, RoboformIO, etc.). For this paper, I have chosen the online Google Forms for the questionnaires providing. The reason why this type of online tool have been chosen that is of variety forms and types of tool that can be used there, the safety of storing the data and ease of use for everyone. All types of questions can be provided there. Also, it helps you to collect the data at one place and make the statistics by the target audience, age, professional experience, etc. The appropriate form for using it on different devices everywhere and anytime. The way of collecting the data personally will be during on "Tallinna innovatsioonipäev 2017" and in other places. For online questionnaire will be implementing during 5 days for collecting the data online, the time will be suitable for everyone.

The responses collected on the Google Forms statistics and later used for analysing. The well adapted questionnaire for designers with a structured type of questions and logically constructed for future easy analysing, well understanding of the responses and a good gathering of feedback.

3.4 Preparing the data for analysing

The Google Forms survey has the opportunity to collect the data at one place, with already formatted data into the spreadsheet by different ranges of numbers and columns to make it faster for the analysis part.

Usually, some others companies require for manual coding of data, because of questionnaires were provided on paper. Thus, for better understanding and collecting

the data all information transfers into the single grid [21] depending on the number of questions and responses which are making into the sheets. Data coding [22] “the process of combining the data for themes, ideas and categories and then marking similar passages of text with a code label so that they can easily be retrieved at a later stage for further comparison and analysis. Coding the data makes it easier to search the data, to make comparisons and to identify any patterns that require further investigation.” After that, evaluating data which can be visualised categorised. Usually, for it use an Excel spreadsheet.

The analysis of data collection and results will be provided in Chapter 5.

3.5 Conclusion

Data collection, preparing and the storing of the answers are described in this chapter. The number of the responders on the social page of Facebook and personal online is not expected so much because the experience of UI with AR is not that much. But the survey contains the typical and essential questions which should provide the ways of decision-making if they will face with this task.

The Google Forms survey has been chosen for this paper because of functionality, mobility, and easiness. Google Forms will help to collect data and to storing it into the forms. These form will structures connected and divided into different parts, which contain the age, localization, the percentage on categories, etc.. The Google Forms do it automatically.

This data collection method and sorting in this research help to sort out the vital information and collect the feedback from interviewees. The sorted data helps to examine information and define the outcomes more precisely in this paper.

4 Interview analyses

4.1 Introduction

The important part of providing questionnaires is identifying the necessity of the new way of methods of app UI prototyping with the technology of AR. To identify the gaps in existing methods of prototyping for apps with AR technology from designers who are currently working with UI. To make the connections between already existing theory for UI and making the prototype. To identify all principles of making the prototype, including testing part when app switch to scan mode. How to make this part possible for prototyping and user testing. To give the start for future studies.

This chapter includes the data analysis procedure of the answers from the questionnaire. The survey analysis is the important part to recognise the benefits and shortcomings of the existing methods of prototyping. Moreover, to know if the designers are familiar with the technology of AR and do they have a willingness to work with it. Furthermore, do the society need to make the researching about new methods of the mobile UI prototyping for educational purpose with AR technology. Also the questionnaire by company Subatomic OÜ which has been provided with teachers of Tartu's schools in Estonia, to collect the data and analyse for designers and future studies. The important information about technologies that they use and the most common current problem in the study program. Will they accept the new technology like AR in their study program?

4.2 The interview methods

The important part of the survey is the consideration of the purpose of your research. Also, the segmentation of the audience will help to achieve the best results. The questionnaire contained general questions and connected with designer's general work sphere as well. The target questions which are important for this research was marked as "*" what means that the responders cannot skip the questions. The survey contains

open-ended, close-ended and mixed types of questions; the questions types were described in Chapter 3. These types of questions help to express responder's meaning in the proposed answers, or they can provide their own response. The own meaning from the responders is important for the research.

In this chapter, I will use the graphical data analysis. The graphical representation of the answers will show the attitude of the respondents to the questions. The visual representation of the answers, numbers help to analyse and to compare the results of the survey faster.

The benefit of the Google Forms questionnaire that the online tool collects, saves and systemizes data automatically. The benefits of it that you have the access anywhere, anytime and all data in save. Also, the opportunity to collect the data from different regions and places.

For this work have been provided a survey with 15th questions, the number of participants was 21. The survey for teachers by Subatomic OÜ have been provided with 46 participants in Estonian language. To clear analysis of the answers and use it in this work the translation into the English language was provided.

4.3 The results of questionnaire

The results of the survey have been automatically collected by Google Forms; all data categorized and visualized in graphical representation forms in Appendix 1. The results related to each question will be described here. The second survey which has been provided with Tartu's teachers by estonian company Subatomic OÜ in graphical representation forms in Appendix 2.

Q1 results A.1.1 Figure 2

Which operating system do you use?

From the first graphic the respondents were presented to answer about the operating system (OS) which they use, the answers were provided with multiple choices, thus providing the results of it, the most common OS on what designers are used to work is MacOS. Therefore, for future software and online tools development for app

prototyping should be concentrated on MacOS. Today, the MacOS is more common and useful for designers, because of reliability, usefulness and colour reflection (retina display). Retina has higher pixel density, so you are not able to see them on Apple screens. Before Windows OS [23] in 1988, the software for graphics works, namely Adobe Photoshop has been created on Macintosh Computer by John and Thomas Knoll, because of colour display and capacity of handling the program. Moreover, the Digital Typography was born on Macintosh Computer in the 1980s.

Q2 results A.1.2 Figure 2

Do you work/worked with User Interface for mobile devices or websites?

Considering the answers from survey question number 2 and the results the all responders are designers or work periodically with UI&UX as freelancers.

Q3 results A.1.3 Figure 3

If yes (or sometimes), do you follow the principles of UCD basis (User-centered design)?

The important principles which should be followed by designers to create the attractive and user-friendly interface for apps or web page. The principles are constipated on the context of your work, to specify the requirements for UI, creating the solutions related to the requirements that have been established, and evaluate your work after by testing with a target audience. The 85% of the responders pay attention to it and use it when doing the research and making prototype of UI. The essential part UCD principles that it will enhance a quality of the first prototype before final part.

Q4 results A.1.4 Figure 4

Which software do you use for UI?

Despite on typical graphical software which has been used for creating of UI by many designers years, for now, the most useful is Sketch and only next are Adobe Photoshop and Illustrator. The 61,9 % of responders using Sketch for UI for mobile and web devices.

Sketch [24] the graphical software for UI&UX for MacOS. All the features which are the help to create the prototype in an easy way, with all important parts and information inside. One of the benefits is the use of different formats (SVG, PNG, JPEG, etc.) which can be easily transmitted from Adobe Photoshop or any other graphical redactor. The precise colour information, user-friendly interface, convenient navigation, understandable menu and features for creating UI&UX for mobile or desktop.

Q5 results A.1.5 Figure 5

Which online tools for prototype do you use?

This question has been provided with multiple choices. The half of the designers chose the answer "Other" and their choice that the Marvel online tool for providing online prototyping of app UI. One of the responders' answer was about advantages and disadvantages of the different online tools. The positive feedback was on Marvel side. Thus, the results of this question we can pick out for prototyping of the app UI in InVision and Marvel online tools.

InVision [24] the web-based prototyping tool that allows the creation of high-interactive apps or web projects for designers. The ability to upload the pictures from Sketch, Adobe Photoshop and other graphical software will allow to make the interactive prototype with swiping, tapping, scrolling, etc. The features that make InVision a good tool is its ability to create hover states for any design element. That allows to create approximately the real app/web for presentation to the target audience or even testing with them. Also, you can share, comment or work in a team on one project remotely. Moreover, the InVision has his own app for mobile phones, where you can log in to your account and test the app prototype in real life and make the comments as well. The acceptable prototyping formats for the web and mobile Android or iOS.

Marvel [24] a browsed-based prototyping tool for UI. That tool can work with different picture formats as well, like JPEG, PNG, GIF, etc. It doesn't offer the colour editing capabilities, but you have 17 templates for prototyping to optimize your work on different devices. Marvel has mobile friendly tool for creating the prototypes. Also, if the designers like to work with paper, all sketchers can be turn out to the prototypes just by taking the photo of designers works and downloaded into the Marvel program. Also, it can be synced with Adobe Photoshop or Sketch graphical software like in InVision.

The easiness and simplicity of the program, that is why almost all designers with this browser-based tool for creating the app or web page UI. The acceptable prototyping formats for the web page and mobile Android or iOS.

Q6 results A.1.6 Figure 6

Do you make the paper sketches for your App prototype?

From the graphic diagram results, only 28,6% or 5 designers make the paper sketches of UI before software based tools and 42,9% or 9 designers who sometimes make the paper sketches. But to follow the UCD and GUI principles of the prototyping and making the UI, all of them should to consider this rule. To make a clear vision of work, to have the ability to make a decision before using the web-based or software prototyping tool and to eliminate time spending of decision-making of different tools and features for the app or web page. In the end, the technologies progress can offer the tools which can easily make the paper or photo of the sketches into the graphic format.

Q7 results A.1.7 Figure 7

Do you usually test your prototype with the target audience?

The result of this question the responders' answers divided approximately into the two groups, who testing the prototype with the target audience and who do it sometimes. The essential part of the app and web prototyping it is a test part as well, the knowledge of basic structure for prototyping will lead the designers onto the deep of issue solving. The prototype will be structured by basic principles of UI prototype (e.g., Chapter 1), and the final project will satisfy the order.

Q8 results A.1.8 Figure 8

Which tools do you use for it?

The almost all designers use online tools for prototype testing with the target audience. The online tools like Axure, InVision, etc. That helps to achieve the results and make prototype finally better. The essential parts and benefits about tools have been described in Q5 results A.1.5 Figure 5, page 30. And for additional part designers can use the programs which give the results about user interaction on the website testing or app for

mobile, like Loop, Crazy Egg, User Testing, etc. The benefit of this additional tools is that the “user’s journey” on the website or app will be shown in the program. The definition of the “user’s journey” can be described as the whole presence of the user on the web page or in the app, the scenario in which a user can interact with it.

Q9 results A.1.9 Figure 9

Have you ever made app prototype for application with Augmented Reality technology?

An essential question of this survey and the most of the whole audience of responders (85,7%) answered that they willing to work with AR and make the app prototype in the future. And only one responder made the app prototype with AR technology.

Q10 results A.1.10 Figure 10

If yes, what tools do you use for it?

The results of this question are that designers have not faced with this yet, and do not have the practice to make the app prototype for it, except one. The next question of the survey is connected to this one, and it is about what tools will be beneficial for this type of apps. This answer was an open question; the responders have to answer with their own opinion. The results of the answers are about to use typical software tools for and paper based prototyping or to use the already built app for presenting to users.

Q11 results A.1.11 Figure 11

Do you think there are any gaps in existing (typical) methods of prototyping for apps with Augmented Reality technology?

Although some designers have not worked with app prototype with AR technology yet, they think that the typical methods of prototyping are not enough for apps with AR. And most of them do not know, because of nescience and no practice yet. The next question is connected with this one, and it was open question about what are that gaps, the responder can answer with their own opinion, the 75% are that they do not know which gaps and problems exactly, but the 25% answered that maybe, there no any possibilities to show in prototype's scan mode 3D animations for AR technology.

Q12 results A.1.12 Figure 12

What do you think will be better for pupils of 8-11th grades for learning subjects?

The question was provided with 3 answer options. The first one is about the mobile apps with Augmented Reality which add new and fancy information to the subjects like physics, biology, chemistry, astronomy, etc. Those do not separate students from reality, what is good for health (in the case of a bad Vestibular apparatus), making reality astonishing. The second one is the mobile apps which have to connect to Virtual Reality glasses and make the full immersion to another reality of students for learning subjects (can be not very good for students who have bad Vestibular apparatus) and third is "Other" where responder can leave his feedback. The designers' opinions divided into two groups, the 67% of the responders think that for students who learn subjects in school the AR apps will be better, the 23,8% thought that VR would be more attractive and 9,5% think that the both technologies are exciting for pupils.

Q13 results A.1.13 Figure 13

What do you think, is there a necessity of research of new methods of the UI app prototyping with Augmented Reality technology?

The outcome of this question is that the designers' opinion (55%) is that the necessity of researching new methods for app UI with AR technology is needed. The rest were not sure whether it is an essential requirement for it (45%).

The second survey (see Appendix 2) has been provided by Subatomic OÜ with school association of chemistry teachers in Estonia. The results of the questionnaire will be described here.

Q1 results A.2.1 Figure 1

What problems in educational system can you emphasise?

Most of the responders working like teachers more than 10 years. The question was provided with multiple answers. The 43,5% chose the lack of financing; the 80,4% answered that the kids have low interests to study, especially to chemical classes, because of lack of equipment and materials for labs classes (47,8%).

Q2 results A.2.2 Figure 2

Would you use app which helps to visualize chemistry elements and reactions during chemistry lessons?

The outcome that the teachers want to make their subject interesting for students and they are ready to use additional equipment, like the visualisation of the materials, which helps to explain the subject. The 93,5 % of answers is "Yes."

Q3 results A.2.3 Figure 3

Would you allow students to use educational games during the classes?

Most of the respondents (87%) would allow using educational games apps to study subject during the classes.

4.4 Conclusion

To sum up the report, the questionnaires have been provided by Google Forms, with that system the answers completely transformed into the visual graphics. That helps to analyse the data and to formulate the outcomes faster, clear for readers and future studies.

During this research, the relevant data for this paper have been received from responders who are working with prototyping of UI&UX and school association of chemistry teachers in Estonia.

In the results of the research and to emphasize the data above, the aim was to identify the necessity of the new methods of app UI prototyping with AR technology. The results of the designers are meaning, that the new ways of making the prototype are needed nowadays, to make the professional view of the product from the sketches part, prototyping till the testing and final part. The willingness to work on app UI with AR technology is on a high level. People who work with UI&UX know that they should be familiar with all aspects and be able to make a prototype for educational purpose with AR technology and test prototype with everyone on the earliest stages of mockups to achieve the best results. The outcome of the making the design of the app is almost the same as for typical app, like Adobe Photoshop, Sketch, Marvel, but the one of the

problem for designers is how to make the whole scenario of the prototype plus user testing as well, from login till the scan mode and showing the 3D animations, which is the most essential for apps with AR. For now, it is not too common for typical designers of UI&UX, but in the future to have the skills and ability to work with all types of tasks, to be able to make and test app prototype with AR technology with the target audience is important. The future is already here, the results of the survey which have been provided to chemistry teachers in Tartu, about their readiness for the use of new technologies like AR, which help to visualise the chemistry elements during the classes have been approved. The need for new ways of studying and explanation of the subject to the students. The whole data in Chapter 4 can be used for future studies and designers works, which help to analyse what OS better for making the UI&UX, which software or web-based tools for prototyping helps to achieve better results of prototyping.

5 The methods of creating UI for educational app prototyping on example of MoleQL

5.1 The methods of prototyping have been used for educational app UI with AR

During the research in this paper, the essential questions have been provided to UI&UX designers; the relevant data were collected and analysed. The outcome of Chapter 1 and 4, the designers should pay attention to theory, like UCD principles, and typical UI principles of prototyping.

After found gaps of the methods for educational app UI prototyping with AR technology, the decision was to combine two steps of creating app's UI prototype. It will help to make the whole scenario of app UI prototyping and to test it in real time with users and animated materials, figures in scan mode.

In the first step, I have chosen the graphical editor who helps me to create app UI and the paper-based visual effects for animations in scan mode testing (an example of 3D animations). As for the methods of app UI prototyping, the better for UI&UX designer will be the graphic editor for app UI part and paper-based animations to make AR technology accessible and understandable in prototyping and testing parts.

I decided to make the app UI in Adobe Photoshop [25] is editor which is capable to make the graphical prototypes for different apps. The Adobe Photoshop is common for everyone and is also suitable for different OS. It helps to create different parts of app's UI includes numerous graphical pictures which will help to make the attractive app for different target audience. To make the app UI interactive for people I decided to use InVision web-based program (e.g., Chapter 4.3 The results of questionnaire). This web-based tool helps to create an app with all essential interactions and functions. This tool has the advantage of the mobile-based InVision app, where the designer can get the

access by login and use the interactive prototype which he/she already made in the web-based version, on his own phone and use it as an app for testing or presentation.

The second step, to have an ability to make the whole app prototype with scan mode and to provide the testing to the audience, I have chosen the visual effects which will be demonstrated by paper-based figures next to the phone or materials which have been scanned. The paper-based visual effects can help achieve the part where app's scenario is switched to the scan mode with AR technology. Also, the paper-based pictures are always the best explanation of the work which is connected to visual effects and demonstration of the abstract and non-abstract things.

The visualisation is essential of human's perception. According B.G. Ananyev's statements [7], through the visual system, the perception goes on three levels: sensation, perception and presentation. The hearing system has only one level, the level of representation. This means that when a person is reading information his perception of the better. Thus, through visualising, the users can understand better and remember this information longer. This is the important part of the AR technology, to enhance the ability to learning different subjects.

The benefit of these methods of prototyping for designers will be the face to face contact with the target audience, receive the direct feedback and clear testing prototype work of app UI with AR technology, special if it connects with learning through the app.

To sum up, for this paper and demonstration prototype part, I chose methods which consist of a graphical editor like Adobe Photoshop, a web-based tool for making the educational app interactive like InVision and paper-based sketches for making the visualised effects of the materials.

5.2 Target audience

In the beginning it is necessary to choose and analyze the target groups with which you will test your product. Knowing your target groups will help determine the key characteristics of a future system, given the preferences of the intended users. The

definition of target groups will help to create a portrait of a typical representative of the target group a person.

Target audience it is a group of people which are collected with approximately the same signs and parameters for one purpose. With target audience, the issues which are important for prototyping and testing will be investigated.

For this paper, I have chosen three target audiences who learn chemistry subject in the school of Tallinn, Estonia. Students are from 8-11th grades, the age between 14-18th years-old.

The first target audience:

Kids who are 14-15 years-old and start to learn chemistry in the 8th grade. This subject is new to them and too abstractive. Students like to make homework faster and go out with their friends. They want to learn subjects in an attractive way. They already have smartphones and like to play games during the breaks between classes. To attract their attention new technologies like VR might be used. But some of them may have bad vestibular apparatus, making them feel bad after using it. They usually use the internet to get the tasks for homework from a personal account in the school system. They usually use computer and smartphone for it.

The second target audience:

Students of 15-17th years-old, who are in the 9-10th grades. They like to use smartphones during the classes when they are allowed to. They like to play games which are developing the logic system. Usually, they need to attend practical chemical classes. For some of them they are not enough materials which are usually provided by schools. They have additional classes for future studies but no labs classes. They also use the internet to get the homework and check it.

The third target audience:

The audience is of 17-18th years-olds, who are studying in the 11th grade. They are more concentrated to learn and know more, some specific knowledge. They always use smartphones during the classes and the breaks. Some of them like to use social network instead of games, but if the app is interesting for them, they will use it. The most

ambitious group of people. They are concentrated on their future, high education, etc. They like to use technologies which help them to understand and to do homework quicker. Also, they will prefer to know additional information about some of the subjects in schools.

5.2.1 Persona's example

The definition of the persona was provided in Chapter 1, page 15 . The persona has his/her advantages and disadvantages, personal habits and character. For providing more specific research and making the prototype, the persona will help to understand the general principles of what an app has to contain.

In [26] the effective examples of personas contain:

- to describe the major segment of the group who will use the app;
- to concentrate on needs and expectations of the users;
- to give the clear understanding of user's needs and what they expect from the app;
- to describe real persons with needs, wishes, etc.

Thus, based on target groups, the personas have been chosen Kadri, Michael, and Rose.

	Target audience 1, persona 1
Name	Michael
Age	14
Hometown	Tallinn, Harjumaa
School's name	Tallinna Mustõe gymnasium
Grade	8th
Smartphone user	Yes; iPhone 5s; advanced user
Description	Michael is an active boy who like play different games. She

	plays basketball and likes to walk with friends. Her family is strict and prefer that he does homework first of all. He knows a little about chemistry because this is a new subject in his school. He uses his smartphone during the classes for mathematics and other subjects if teachers are allowed it.
Smartphone user's aim	Always use during leisure time and learning. Prefer to use it to do the homework and to get information about different things.
Requirements for the education app	The app has to be easy to use. He wants to know how the different chemistry materials look like. Prefer English or Russian language.

Table 1. Persona's description 1, group 1.

	Target audience 2, persona 2
Name	Kadri
Age	16
Hometown	Tallinn, Harjumaa
School's name	Tallinna Mustõe gymnasium
Grade	9th
Smartphone user	Yes; Android, Samsung galaxy s7; advanced user
Description	Kadri likes all things which are connected with technologies. She always likes to play app games which have logic structure. Her favourite subject is physics. She always attend chemistry practical labs classes when it is possible; her school does not have own labs. Thus, they have not a time for experiments, practice. She is curious about abstract

	subjects, like chemistry. She wants to know how do chemistry reactions of the elements look like.
Smartphone user's aim	For logic games. Always know more with internet accessibility.
Requirements for the education app	User-friendly interface, logical structure of the tasks, learning aspects. Prefer English or Estonian language.

Table 2. Persona's description 2, group 2.

	Target audience 3, persona 3
Name	Rose
Age	18
Hometown	Tallinn, Harjumaa
School's name	Tallinna Mustõe gymnasium
Grade	11th
Smartphone user	Yes; iPhone 6s; advanced user
Description	Rose likes to chat with her friends by using a smartphone. She prefers to use her phone for social pages like Facebook and share her achievements with friends of her. She is concentrated to finish the school with good grades and go to the University. But the abstract subjects like chemistry is hard for her visualisation and perception. She knows different aspects of chemistry but wants to know more. She uses numerous apps for her study.
Smartphone user's aim	To use the apps which are help to do the home tasks, to share interesting information with her friends

Requirements for the education app	Logic, attractive, modern. An app should helps to understand an abstract subject like chemistry. Prefer English or Estonian language.

Table 3. Persona's description 3, group 3.

5.2.2 User scenarios

Scenarios [27] describe the stories and context behind why a specific person use the app or website. They note the goals and questions to be achieved and sometimes define the possibilities of how the user can achieve them on the site.

Shortly, it is the way which should be done during the testing of the app or website by the user. In general, the future app testing based on the scenarios which have been made by designers. It will help to identify the end-user who will be using this app.

There are the scenarios for each persona:

Persona 1 is Michael. He wants to play with an educational app and to see how the molecules of chemistry reactions combine and how they can look like in material form. He knows some of the formulas from the home tasks, but for better understanding, he wants to see how some of the chemical reactions can look like.

- For this aim, she opens the app on his phone, takes the special cards with pictures of chemical elements on them chose "Play" option and switch to the scan mode. He tries to combine some of the cards, to take the animations of sulphur dioxide, water, and carbon dioxide.

Persona 2 is Kadri. She wants to know how do chemistry reactions of the elements look like. She and her classmates have the practical chemistry classes in the special place with labs, but she is not sure that she understand it fully how do the formulas and elements look like in nature.

- She opens the app, takes the special cards with pictures of chemical elements on them, chose "Study" option, selects 9th grade. In the storyline, she chose the first step, after received task on pop up screen she goes further and makes the combinations with the cards. She does it right and pushes the "Next" button on the screen and received the next task. In the end, she knows how to do carbon

dioxide and water look like.

Persona 3 is Rose. She wants to pass the chemical exam in 11th grade, thus she needs help to realise how the chemical elements reactions work with each other. Also, she needs additional information about the formulas which she considers complex and hard to visualise.

- She opens the app, takes the special cards with pictures of chemical elements on them, chose “Play” option and switch to the scan mode. She chooses the cards with chemical elements which she needs and starts to scan them. After the combinations are done, she wants to know about this formula more and share this information with her friends. And in the scan mode, she taps “More,” reads about it and shares. In the end, she wants to know specific information about some of the chemical elements and combinations with app’s help.

Thus, to sum up, user goals have been described for each persona above. The goals contain in Table 1., Table 2. and Table 3., page 39.

To sum up, the user's goals for an education app are focused on relevant and logical content for students, a user-friendly interface, and a way to understand abstract things of the subject with visualisation help. The app which is modern for society and helps share relevant information with others.

5.3 The result on an example of MoleQL educational app prototype

As a result, the two methods of prototyping have been chosen. These are the graphical and paper-based sketches for animations which will be the example of AR technology part. It will help to make the whole prototype part. The outcomes which have been received from the questionnaire with designers and teachers are applied to the final work of the prototype.

For the high-quality prototyping for this work the graphical editor Adobe Photoshop has been selected. To make the app interactive I took advantage of InVision web-based tool, in which the app will be modernised with interactive buttons, screens. For the AR visualisation part in the scan mode of the molecules and substances, I will use the example paper-based sketches.

As an example of the educational app, I will present the MoleQL app prototype. For the AR technology part in scan mode, the app needs special paper cards with pictures of chemical elements on them (Figure 2.). The cards can be scanned separately and together, to make the chemistry's equation and to get 3D animation on user's smartphone screen. For the simplification of making the examples of 3D animations for designers, the solution has been chosen as the example of paper-based sketches (Figure 3.).

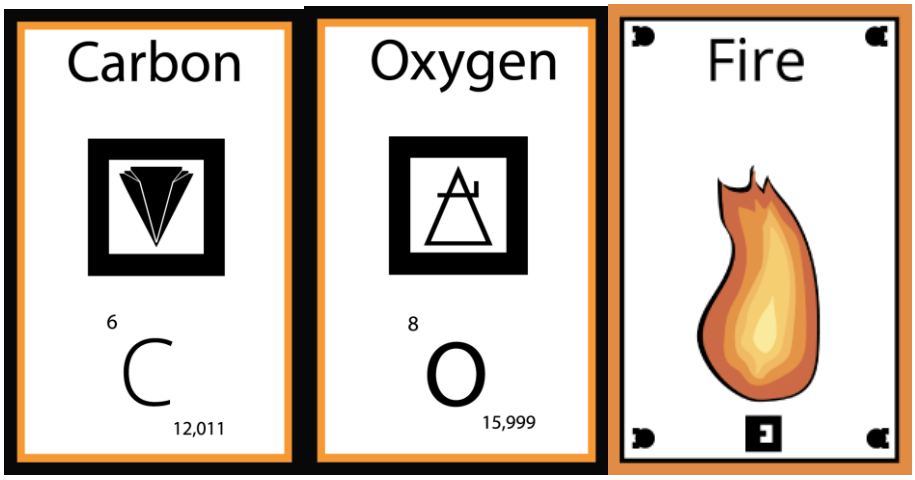


Figure 2. An example of a special paper card with chemical elements.

The choice of the cards' design was made on an example of the Mendeleev's table. The name, serial number and molecular mass of the chemical elements are depicted there. The special image targets in the middle and the bottom of the cards are meant for camera detection in the scan mode. For comfort use, I decided to make the cards sized 85x55mm as a standard of EU credit cards. After downloading the app, the user receives the document with all the examples of the cards by email, and can print them out by him/herself.

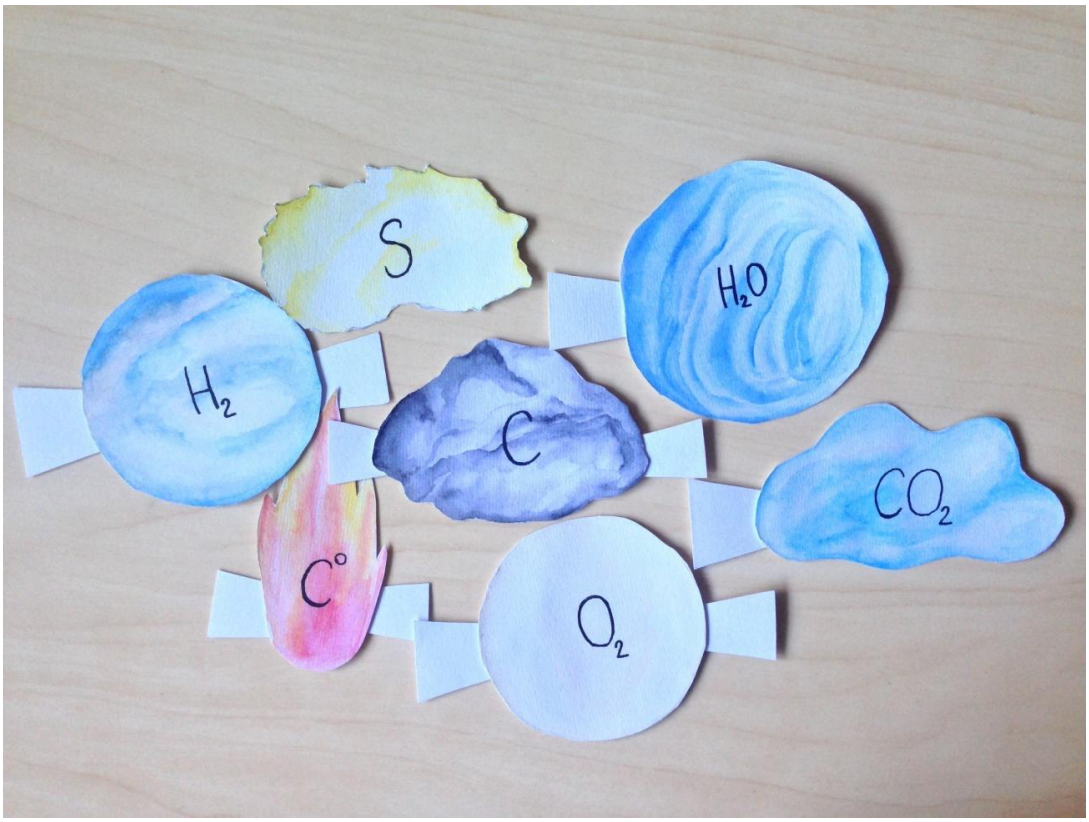


Figure 3. An example of paper-based sketches

The aim of the paper-based sketches for visualisation part in app's scan mode with AR technology is to simplify designers' work on app's prototype decision of the full scenario. The person who makes the UI prototype design should have an ability to provide the whole example of how the app with AR will work including the scan mode part as well. The paper-based sketches prototype is a good decision to demonstrate abstract and non-abstract things, to make the scan mode part real during the testing. To show all aspects and benefits of an educational app prototype with AR technology. In Figure 3. demonstrated the examples of some abstract element like oxygen, the carbon example, I decided to make it like a black stone, and the temperature (fire) when combustion reaction, water, sulphur, hydrogen, and carbon dioxide. The decision making regarding the sizes of the paper-based sketches lays on the shoulders of the designer. For this example of work, I have chosen a size between 80-100mm.

As for the example of UI prototyping, I will present it in this paper with graphical pictures of MoleQL app screen. The design of the prototype has been made from the beginning, cards example and the scan mode part will be described in this Chapter as well.

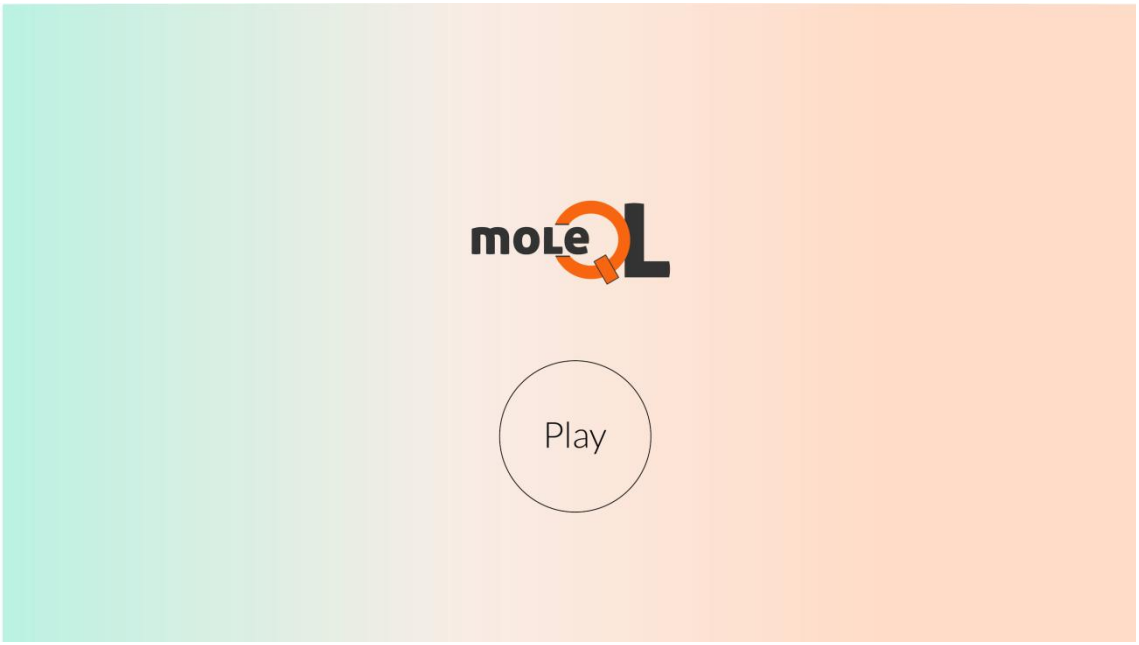


Figure 4. Welcome screen.

For this design have been chosen the soft colour palette. The basic colours are mint and flesh colour. They have been selected to combine logo's colours[1]. All next colours examples for the buttons and screens opinions, pop-ups will be derivatives of these. At the first time of app using the user has additional information next to the each icon, a tutorial about the means and things you can do with it. In the end, this information disappears.

The app prototype is created for all types and sizes of smartphone screens. The app prototype has been made in the English language. The welcome screen contains the logo of the app and the "Play" button which switches the user to the next screen (Figure 5.).

[1] ColorScheme.Ru. Tool for colour matching and colour scheme generation

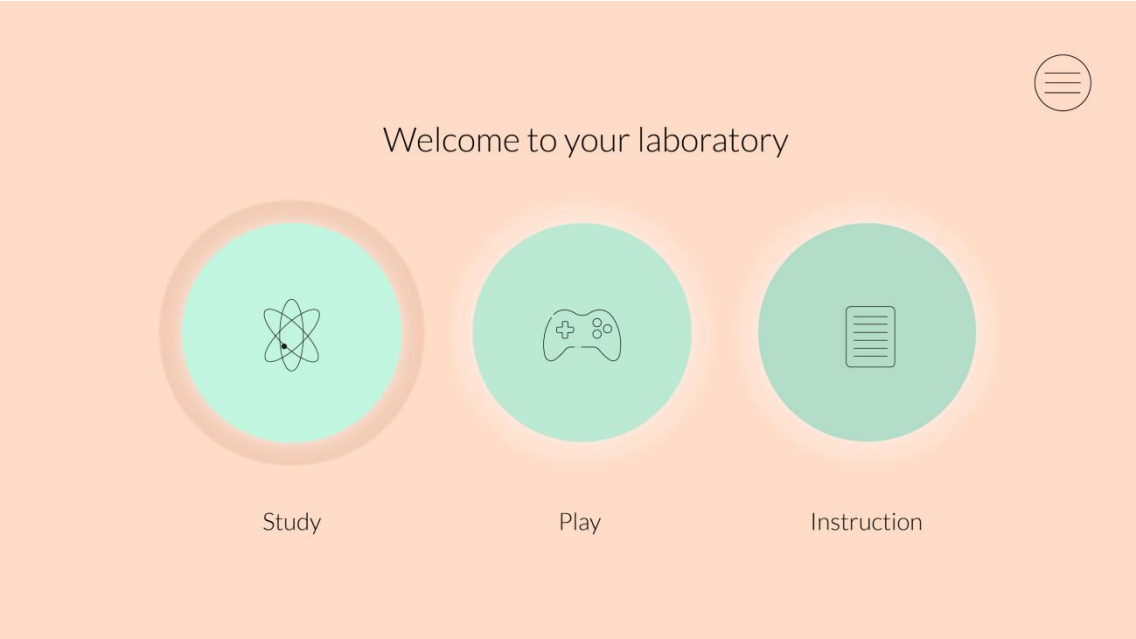


Figure 5. Main screen app prototype.

The screen contains three options, which are the Study, Play and Instruction. The button at the top of the right corner is the menu where the user can find sharing options, info about some of the formulas in scan mode, screen-photo, and the results of his/her achievements.

The “Study” option switches the user to the selecting the user’s class of study (Figure 6.). The “Play” option switches the user to the scan mode of the smartphone and the “Instruction” option switches the user to the text and pictures of how to use the app. On the “Instruction” screen there are two guides to how to use the app. The first black circle is “How to use” where the user can see three steps with main functions of the app. The second one is an explanation and definition of the colours which will be added to the each hint task of different categories of the questions. For example, the combustion reaction is a red circle, that means that user should take the card with a picture of fire and scan three cards.

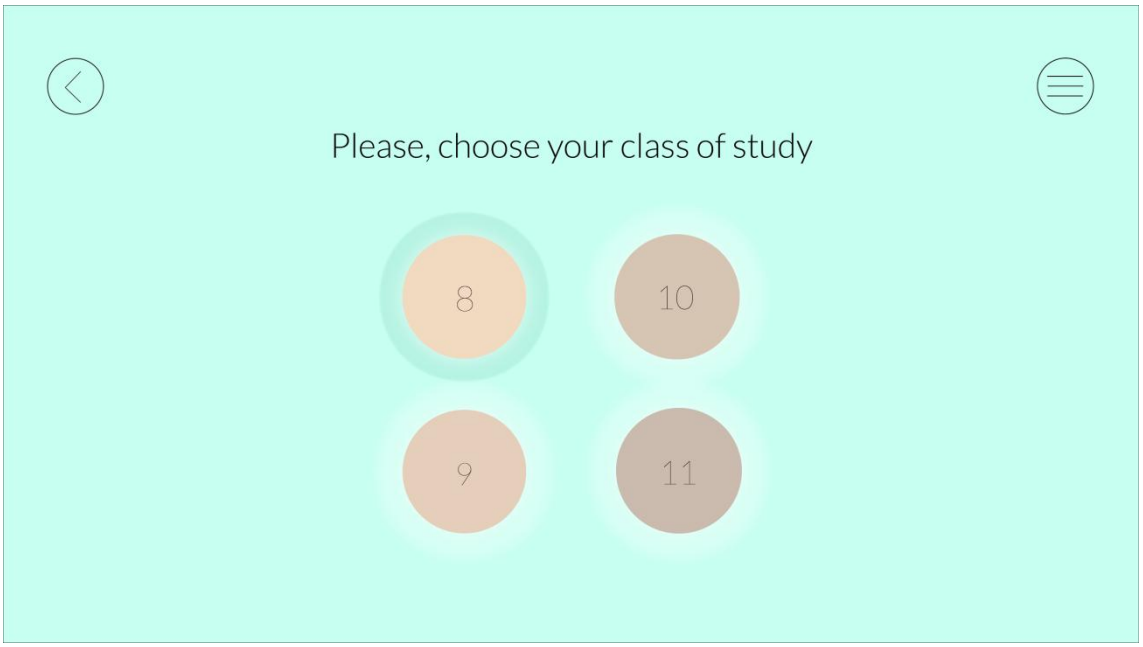


Figure 6. The screen to select the grade of study.

This screen contains four options of classes. The button at the top of the right corner is the menu where the user can find the sharing options, screen-photo, and results of his/her achievements. The button at the top of the left corner is the “Back” to the app’s previous screen. After the selection of the grade number eight, the user is switched to the storyline screen with tasks from the eighth grade's education program (Figure 7.).

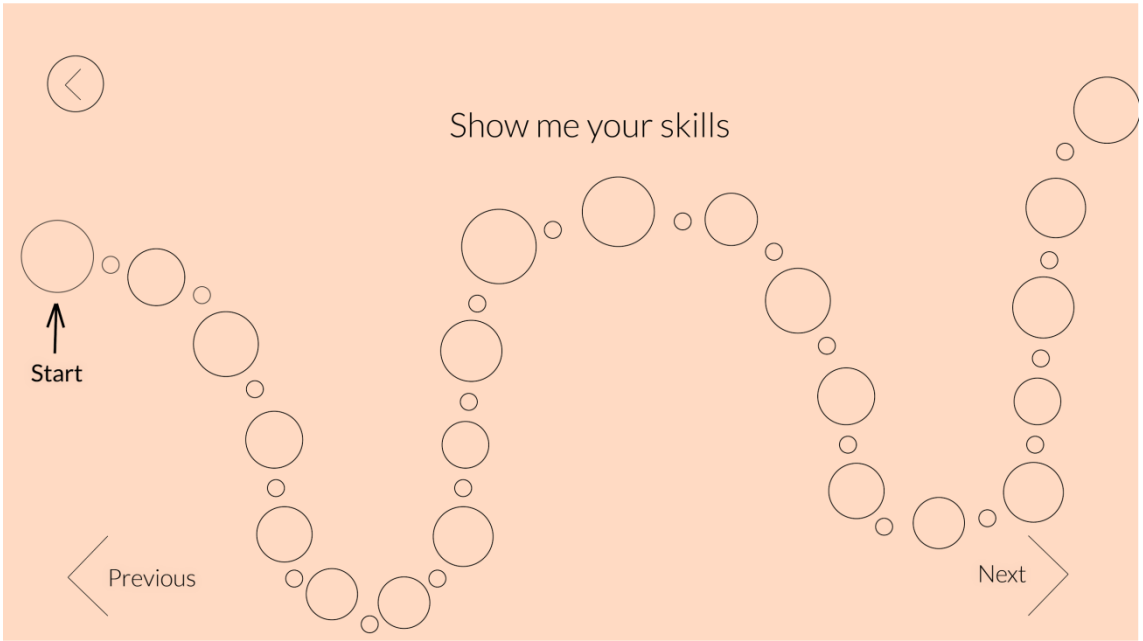


Figure 7. The storyline with tasks of the program.

The screen prototype contains the storyline of tasks which are represented by big circles. The locked tasks do not have any colour, except the pointer of your position on

the storyline. Step by step, a user can open the tasks and names of the formulas, which will appear above each circle by scanning the right cards with pictures of chemical elements. For comfort use, the arrows can move the user through the storyline. First, the user selects the first circle and then receives a pop-up screen with the task (Figure 8.).

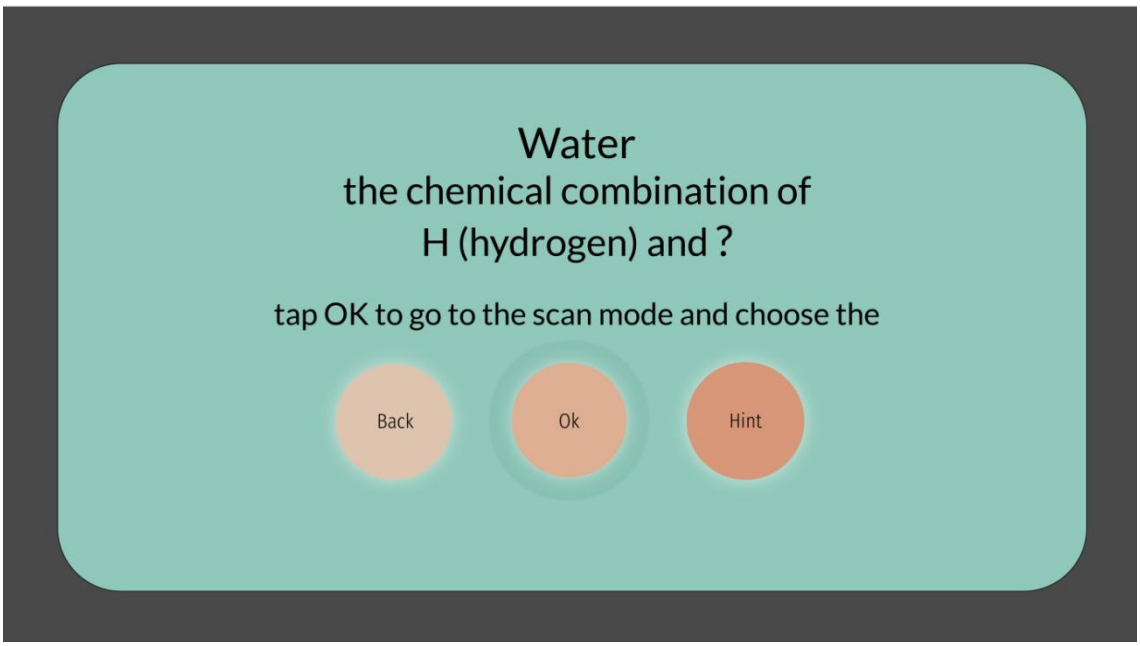


Figure 8. Task screen.

At this stage, the user receives the task and can choose the “Back” option to return to the app’s previous screen. The “Ok” option means that the user is ready to switch to the scan mode (Figure 9.) and the “Hint” option, which contains specific tips for the user, is meant to help to understand the tasks.

Figure 9. Scan mode in testing

On the scan mode screen, the user tries to solve the task from the storyline. The black screen means that the user is in scan mode during the testing. Behind the phone screen, the user can choose the cards and combine them, while the designer should present above each card which has been chosen by the user with paper pictures of animations. It helps the user to understand how exactly the app with the AR works, and the visualisation helps the student to imagine different molecules. To see whether the user did it right, he/she has to tap on the animation which appears after the combination. To know more about the formula from the screen, the user should choose the option at the top of the right corner, in the menu (Figure 10.).

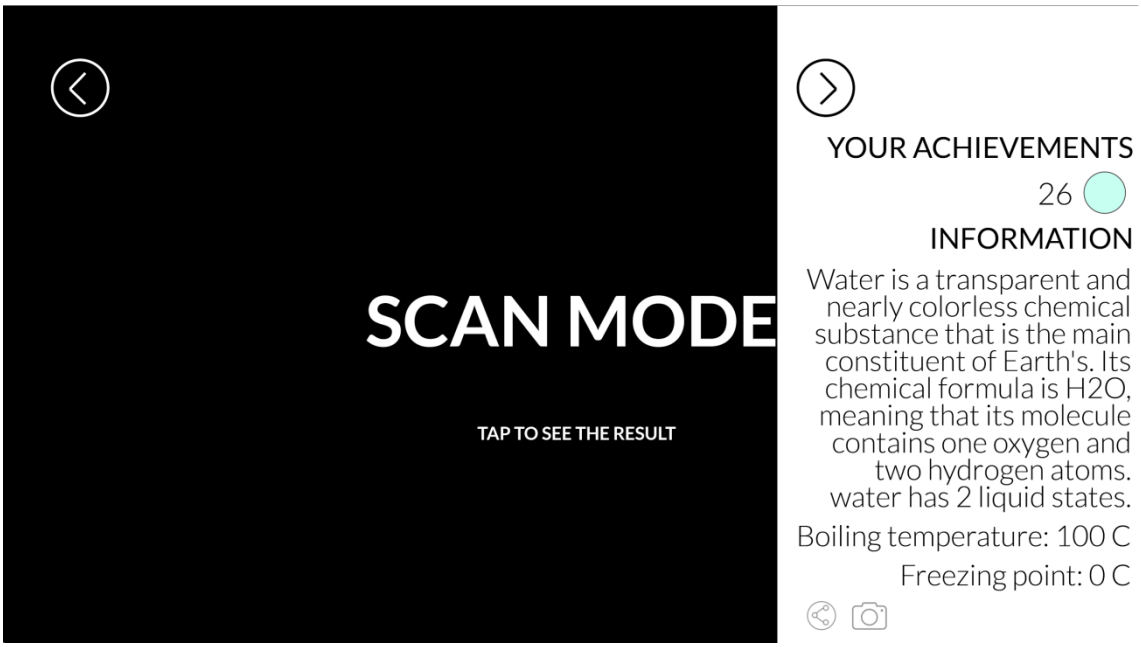


Figure 10. Scan mode with more information about the substance.

On this screen, the user has the ability to see the achievements. Relevant information about substances appears after the combination of the scan mode. The user can share this information with anybody or make the screenshots of the animations which have been appearing on the screen after the scanning of some cards or their combinations. The button at the top of the left corner is the "Back," that switches the app screen to the previous one. To know whether the user did it right, it has to tap on the animation which appears after the combination. The screen of approval appears on the screen (Figure 11.). If not, the user can do it again. Here is an example of how the scan mode approximately looks like (Figure 12.).

Figure 11. The screen of approval.

At this screen the user can get up to three stars, meaning that the task is done correctly. He has four options, such as: “Try again” if he wants to do it again or did something wrong, “More” to see additional information about the achievements, etc.,“Map” that switches the user to the storyline mode with second unlocked task and “Next”, the option which directly switches the user to the next task screen.

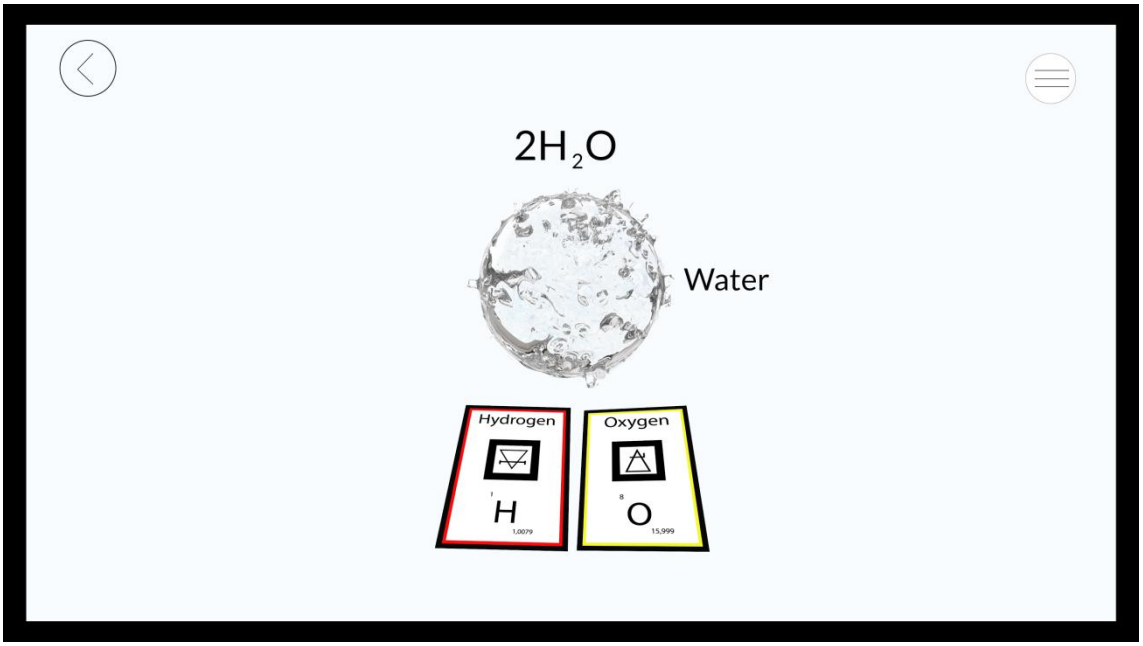


Figure 12. An example of the scan mode in action.

Scan mode with an example of a combination of cards. For this task two cards are needed, for instance, one of oxygen, and another of hydrogen. When the cards are next

to each other the 3D animation, the formula and name of the substance appear above the cards.

The option “Play” includes scenarios of the Figure 9. and Figure 10. After choosing the options, the user is switched to the scan mode screen and can do different actions, such as scan the cards or make different combinations. The “Back” button at the top of the left corner switches the app screen to the “Main screen app prototype.” (Figure 3.). It helps the user to investigate the chemical formulas combinations by himself, without essential knowledge.

5.4 Testing with target audience and results

5.4.1 Design assessment

After the prototyping part, the design assessment has to be provided by UI&UX designer or a person who is related to the UI sphere. The aim of this part is to receive the feedback from the users who participated in educational app testing with the AR technology.

5.4.2 Usability testing

The important role of testing by these methods is to get the feedback from the users. Do they understand how educational app with the AR technology works? And for designers is it the right way of presentation of the app with the AR for user's testing?

The UCD principles have been applied at this stage, the evaluation part of the UCD contains the testing of the prototyping as well. Its aim is to have direct conversation with potential customers and to work with the AR part by paper-based pictures of the substances and elements help. Thus, to show users how educational app with AR will work in real time. To follow the user's movement during the testing part to realise the shortcomings of the future app.

For apps with the AR technology it is required to have a personal meeting with the user in order to make the AR part with paper-based pictures of animations and to have direct feedback from the user. 5 students took part in the usability testing of the app with the AR. Each of them corresponds to a certain person, compiled earlier in the Chapter 5.2.1

Persona's example, page 39. The Jacob Nielsen [28] has a statement that 5 users is enough for usability testing. With 5 users, you almost always get close to user testing's maximum benefit-cost ratio. Each participant has never seen this app before, facing it at the first time during the testing part. Moreover, 3 participants have been provided with scenarios which have been provided in chapter 5.2.2 User scenarios. Two of them have tried the 2nd and the 3d scenarios.

Like it was mentioned earlier in chapter 2.3 Augmented Reality in Education, the AR is a new technology and most of the people do not know what it is yet. At the beginning of the test, I have had a short introduction for participants about what is it and how it does works.

Participant number	Man/Female	Age	Persona number	Target audience number
1	female	15	2	2
2	male	14	1	1
3	female	18	3	3
4	female	17	3	3
5	female	16	2	2

Table 4. Participants of educational app testing with AR technology.

Participant 1:

During the testing part, the participant opened the app, selected the "Study" option, selected the class of study and reached the storyline screen mode. Then, she selected the first option and received the task about a water formula. After the task, she switched to the scan mode and selected hydrogen and oxygen cards and put them next to each other. The paper-based animation of the water above the cards is provided, and a pop-up screen of approval means that she made it right. She can then choose the "Next" button and switch to the next task about carbon dioxide, and repeat the steps with other cards. During the testing part, she understood the meaning of the AR technology and gave positive feedback.

Participant 2:

Upon opening the app and tapping “Play” on the main screen, the 2nd participant was switched to the scan mode. He played and combined special cards to make formulas like hydrochloric acid, water, and carbon dioxide to see the animations. He was excited to see how the AR technology could help students learn chemistry. He liked to see the testing part with papers based examples of elements’ animations. He reached the aim, understood how the educational app worked with the AR and watched the animated paper cards behind his phone. Also, he gave feedback and suggestions to increasing the capabilities and overall usage possibilities of the app.

Participant 3:

She opened the app, chose the “Play” option and switched to the scan mode. After she has selected the cards and started to scan them by the app, she saw the animations by paper-based examples behind her phone. However, she wanted to know more about one reaction with sulphur dioxide. She opened the “Menu” option during the scan mode and read about it there. Also, she has shared this picture with her friend by using the “Share” option. She reached the goal and found additional information about sulphur dioxide.

Participant 4:

Participant has tried the 2nd and the 3d scenarios. At the first time of app using, she easily opened “Play” option, made sulphur dioxide, saw the paper-based animation and read more about it on the pop-up screen. After that, she went back to the main screen and chose the “Study” option. She selected the 11th grade of study, moved forward to the storyline screen with tasks, selected the first task and received the question about the water formula. After switching to the scan mode, she understood that during the prototype period the camera mode would not be active. She took the right cards and made the formula of water. She saw the paper-based animations above the cards and was completely satisfied. She received the pop-up screen of approving that she successfully completed the task and she could move to the next one. From her feedback, I received that she liked this educational app with AR because she does not understand how the elements can combine with each other, but after the animations, her visual

memory started to work. She thinks that educational apps with the AR technology will help students to remember and study better.

Participant 5:

She opened the app and started at the "Study" part. After choosing the grade of study, she was forwarded to the storyline screen, where she selected the first task. She received the question about water and switched to the scan mode, for better understanding she opened the phone's camera and started scanning the cards there, she saw paper cards and paper-based animations, which were provided by a designer. After finishing, she went back to the scan mode in the app, found the screen with more information about the substance, and received the pop-up screen of approval, saying that she had completed the task and could move forward. But she went back to the main screen and selected the "Play" option, switched to the app's scan mode, took different cards and started to scan them. She received paper-based animations next to her phone, understood how do the sulphur dioxide and carbon dioxide look like. Moreover, she found the sharing option easily.

5.4.3 System Usability Scale

The System Usability Scale (SUS) is a tool to measure the usability. It was created by John Brooke in 1986. The survey consisted of 10 questions and was provided to 5 participants. The responses ranged are from "Completely disagree" to "Completely agree." There is the example of those questions [29] which I used to collect the feedback from the users after the testing. It helped me to complete the evaluation part of the UCD principles.

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.

9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

The SUS survey helps to analyse user's understanding and app's perception after the usage. To determine the SUS score, you first need to note the scale position for each statement. Scale position values range from 1 to 5 with strongly disagree equating to 1 and strongly agree equating to 5 (see Appendix 3).

Then, to calculate a score contribution for each statement. For odd numbered statements (1, 3, 5, 7, 9), the score contribution is equal to the scale position minus 1. For even numbered statements (2, 4, 6, 8, 10), the score contribution is equal to 5 minus the scale position. Each score contribution will fall within the range of 0 to 4. After all 10 scores, multiple the sum of the scores by 2.5 which will produce the overall system usability value. These values will range from 0 to 100. Any score above 68 is above average is a good result, and any score below 68 means that your option does not have any advantages for users [30].

The results of the survey with 5 participants showed an average score of 95. This score means that users liked to test an educational app prototype with the AR technology. They completely understood how the AR technology works with paper-based pictures help, instead of real 3D animations and what the aim of the app is. The results of the survey are shown in Appendix 3.

If the app testing participants are satisfied, then the designer’s methods of prototyping have been chosen and implemented correctly.

6 Conclusion

The aim of this work is to analyse the existing methods of app UI prototyping, and to create an example of an educational app UI prototype with the AR technology by unconventional means of prototyping and testing.

To reach this aim I have done the research about all existing methods of UI prototyping and chose two of them for the creation of the app UI prototype with the AR technology. The important aspect of the app UI prototyping and testing is to find the ability to make all scenarios of prototyping including the AR part for designers and the interaction of the user with the AR technology in the app's scan mode.

The main methods of creating and testing of educational app prototype with the AR technology have been chosen. There are the UCD principles and paper-based sketches part for animations to make scan mode with AR real during the testing part and evaluate user's interaction with it.

For creating an educational app, MoleQL has been chosen as prototype example. In this paper, I have made the UI prototype from the beginning till scan mode part with AR. The MoleQL app's aim is to teach and explain chemistry using the AR technology to students in 8th-11th grades. The content of the app will be created by using the schools' program. To complete the task in the app a user should have special cards of chemical elements, which it can print out by itself at home. Therefore, a user who will use the app will be able to see 3D animations of the elements and substances on the smartphone screen, which will appear during the scan mode.

As the methods of app UI prototyping are directly related to the UI&UX designers, the questionnaire has been provided to collect and analyze the data in Chapter 4.3 The results of the questionnaire, page 28. The UCD principles have been followed to create a graphical UI prototype for the app. The target audience has been selected, and three personas as well. It will help to determine the requirements of the app and the user's

goals. By using all information which has been found, collected and analysed, the decision was made to use or to combine two methods of prototyping for apps with the AR technology. The app UI prototype has been created with Adobe Photoshop graphical editor. For the animations, the picture has been drawn and cut from the usual paper. To make the app interactive I used the InVision web-based tool. When the app prototype had been completed the user testing part was providing with potential users. Then, the last step in the UCD, the evaluation part was provided by the SUS survey for determination of the app usability.

To sum up, the results of SUS survey are positive. The app prototype was successfully approved by users. Thus, the combination of two methods of graphical and paper-based animations sketches for app UI prototyping with the AR technology is the better decision for UI&UX designers.

The data and results which have been collected and analysed in this paper can be used for future researches.

References

1. Rubin, J., and Chisnell, D. *Handbook Of Usability Testing, Second Edition: How To Plan, Design, And Conduct Effective Tests*. 2nd ed. (2008): 4.

2. U. S. Department of Health & Human Service. *What and Why Usability. User Centered design*,[Online], available at: https://www.usability.gov/what-and-why/user-centered-design.html (Accessed 07 May 2017).

3. Galitz o. W. *The Essential Guide to User Interface Design: An Introduction to GUI Design Principles and Techniques*. (1997): 13.

4. Galitz o. W. *The Essential Guide to User Interface Design: An Introduction to GUI Design Principles and Techniques*, (1997): 4.

5. Billinghurst, M. (2016) *Rapid Prototyping for Augmented Reality*,[Online], available at: https://de.slideshare.net/marknb00/rapid-prototyping-for-augmented-reality (Accessses 07 May 2017).

6. Tufts, K. "*Why sketching is an important part of the design process (2014)".* [Online], available at: http://www.dnnsoftware.com/blog/why-sketching-is-an-important-part-of-the-design-process (Accessed 07 May 2017).

7. Ilama, E. (2015) "*Creating Personas"*,[Online], available at: http://www.uxbooth.com/articles/creating-personas/ (Accessed 07 May 2017).

8. Banerjee, A. (2014) "*What a prototype is and what is not"*, [Online], available at: http://uxmag.com/articles/what-a-prototype-is-and-is-not (Accessed 07 May 2017).

9. Rouse, M. (2013) "*Definition native app"*, [Online], available at: http://searchsoftwarequality.techtarget.com/definition/native-application-native-app (Accessed 07 May 2017).

10. Billinghurst, M. (2013) "*Augmented Reality: AR User Interface design guidelines"*,[Online], available at: https://de.slideshare.net/marknb00/2013-lecture-6-ar-user-interface-design-guidelines (Accessed 07 May 2017).

11. Antoniac, P. *Augmented Reality based User Interface for mobile applications and services*., University of Oulu. (2005): 22.

12. Antoniac, P. *Augmented Reality based User Interface for mobile applications and services*., University of Oulu. (2005): 23-24.

13. Antoniac, P. *Augmented Reality based User Interface for mobile applications and services*., University of Oulu. (2005): 37.

14. Antoniac, P. *Augmented Reality based User Interface for mobile applications and services*., University of Oulu. (2005): 26.

15. Kerawalla, L., Luckin, R., Seljeflot, S., & Woolard, A. *Making it real: Exploring the potential of augmented reality for teaching primary school science. Virtual Reality*. London, United Kingdom: Springer-Verlag London Ltd., (2006).

16. DAQRI (2017) "Anatomy 4D",[Online], available at: http://anatomy4d.daqri.com/ (Accessed 07 May 2017).

17. Bers, Umaschi, M. *New Media and Technology: Youth as Content Creators*. (2010): 86.

18. Товажнянский Л.Л., Романовський О.Г., (2005), *Основы педагогики высшей школы: Восприятие визуальной и речевой информации., Харьков.,* [Online], available at: http://buklib.net/books/36683/ (Accessed 07 May 2017).

19. Klopfer, E. and Squire, K. *Chapter 67: Augmented reality*. (2002): 5.

20. Singh, KJ. (2010), *"What are the types of Questionnaire?",* [Online], available at: http://www.mbaofficial.com/mba-courses/research-methodology/what-are-the-types-of-questionnaire/ (Accessed 07 May 2017).

21. University of Bristol. (2013), *"The process of designing and implementing questionnaires: 2.3. Analysis of Questionnaires",* [Online], available at: "https://www.economicsnetwork.ac.uk/handbook/questionnaires/23 (Available at 07 May 2017).

22. Graham, R. G., and Taylor, C. (2005) *"How and what to code"*, University of Huddersfield., [Online], available at: http://onlineqda.hud.ac.uk/Intro_QDA/how_what_to_code.php (Accessed 07 May 2017).

23. Blake, R. (2015) "*Is Mac or PC Better for Graphic Designers?",* [Online], available at: https://creativepro.com/is-mac-or-pc-better-for-graphic-designers/# (Accessed 07 May 2017).

24. Heaton, S., (2015) "*5 of the Best Prototyping Tools to Test Out Your Web and Mobile Designs",* [Online], available at: https://www.shopify.com/partners/blog/62745923-5-of-the-best-prototyping-tools-to-test-out-your-web-and-mobile-designs (Accessed 07 May 2017).

25. Softonic Editorial Team, *Adobe Photoshop*., [Online], available at: https://adobe-photoshop.en.softonic.com/mac#app-softonic-review (Accessed 07 May 2017).

26. U. S. Department of Health & Human Service. "*What and Why Usability. Personas.",* [Online], availabe at: https://www.usability.gov/how-to-and-tools/methods/personas.html (Accessed 07 May 2017).

27. U. S. Department of Health & Human Service. "*What and Why Usability. Scenarios.",* [Online], available at: https://www.usability.gov/how-to-and-tools/methods/scenarios.html (Accessed 07 May 2017).

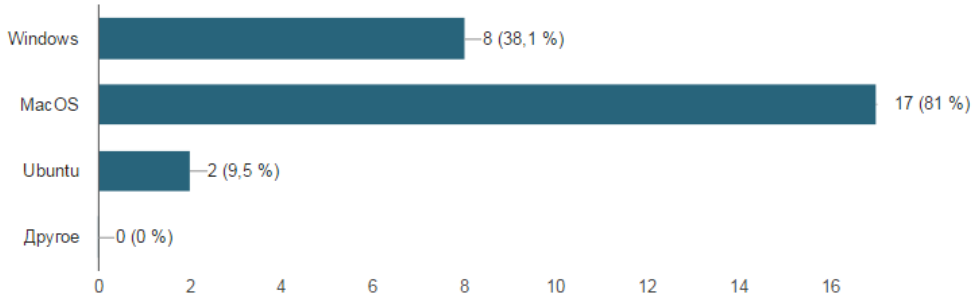
28. Nielsen, J. (2012) *"User testing. How Many Test User in a Usability Testing?",* [Online], available at: https://www.nngroup.com/articles/how-many-test-users/ (Accessed 07 May 2017).

29. U. S. Department of Health & Human Service. "*What and Why Usability. System usability scale",* [Online], available at: https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html (Accessed 07 May 2017).

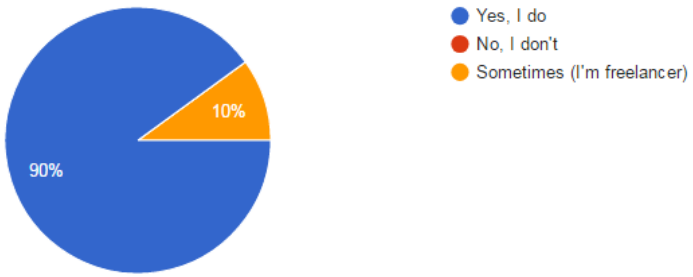
30. Frieze, S. (2015) *"John Brooke scoring SUS system usablity scale UX&UX research UX research methods: System Usability Scale: A Quick Usability Scoring Solution"*, [Online], available at: http://satoriinteractive.com/system-usability-scale-a-quick-usability-scoring-solution/ (Accessed 07 May 2017).

Appendix 1 – Designers questionnaire results

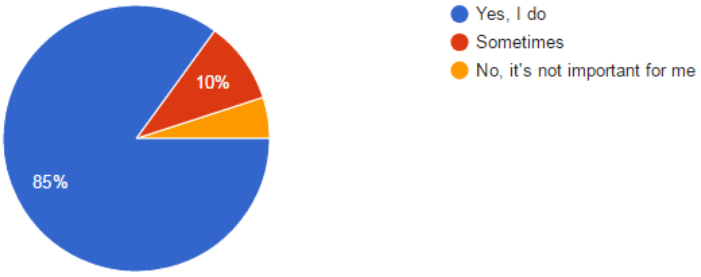
A.1.1 Figure 1 Which operating system do you use?



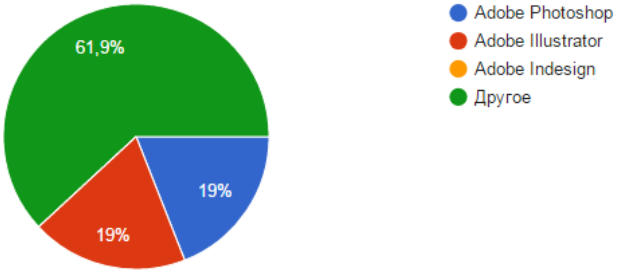
A.1.2 Figure 2 Do you work/worked with User Interface for mobile devices or websites?



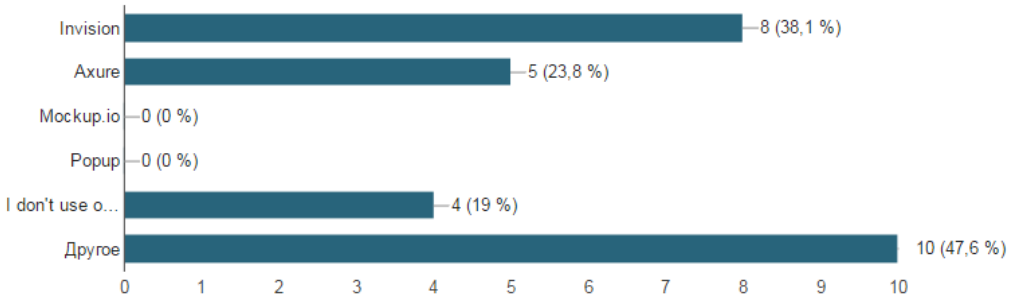
A.1.3 Figure 3 If yes (or sometimes), do you follow the principles of UCD basis (User-centered design)?



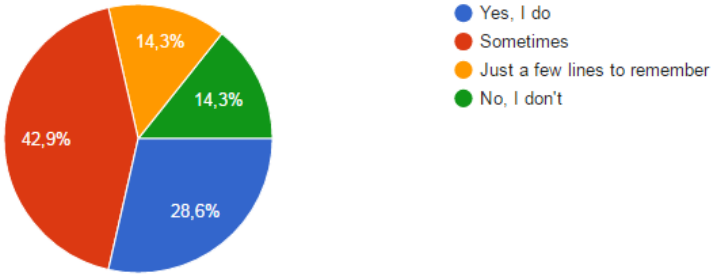
A.1.4 Figure 4 Which software do you use for UI?



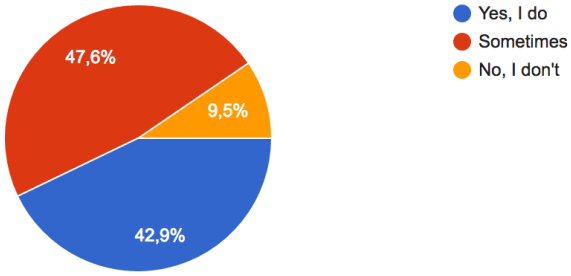
A.1.5 Figure 5 Which online tools for prototype do you use?



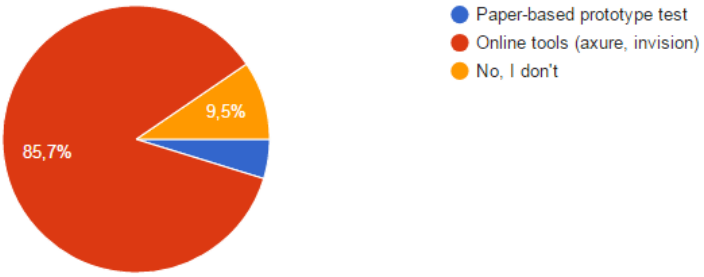
A.1.6 Figure 6 Do you make the paper sketches for your App prototype?



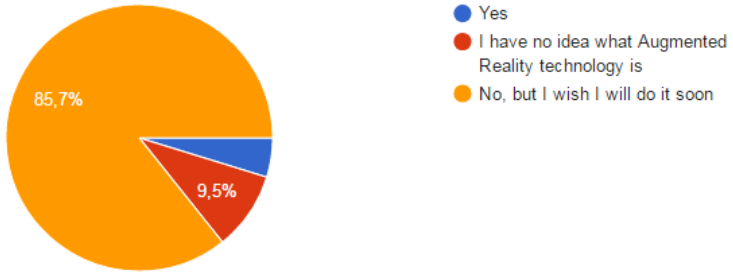
A.1.7 Figure 7 Do you usually test your prototype with target audience?



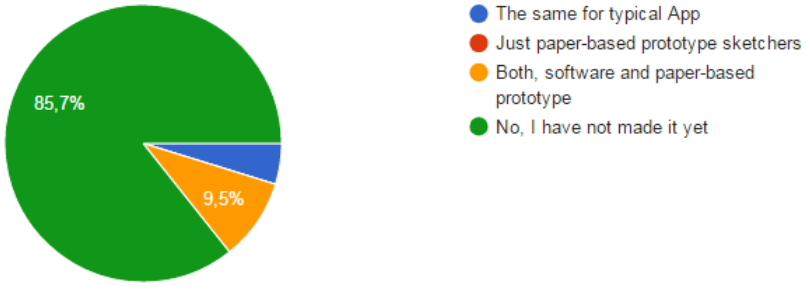
A.1.8 Figure 8 Which tools do you use for it?



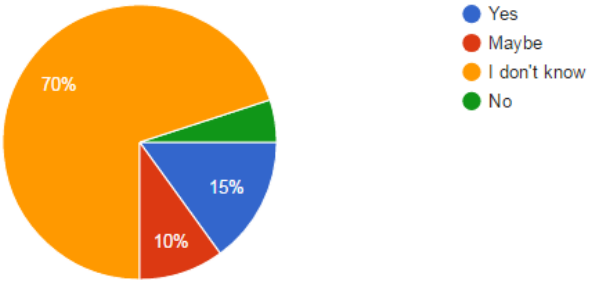
A.1.9 Figure 9 Have you ever made app prototype for application with Augmented reality technology?



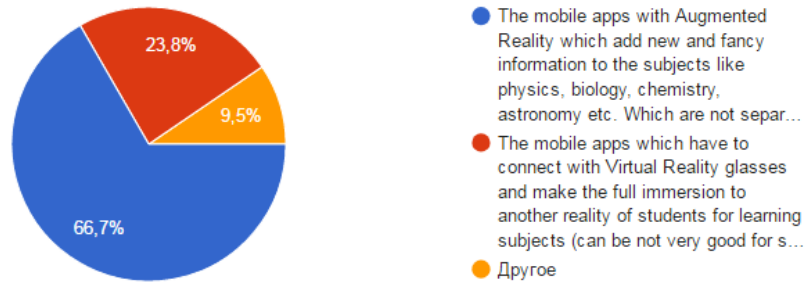
A.1.10 Figure 10 If yes, what tools do you use for it?



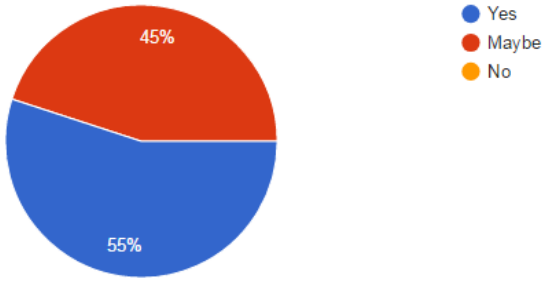
A.1.11 Figure 11 Do you think there any gaps in existing (typical) methods of prototyping for apps with Augmented Reality technology?



A.1.12 Figure 12 What do you think will be better for pupils 8-11 classes for learning subjects?

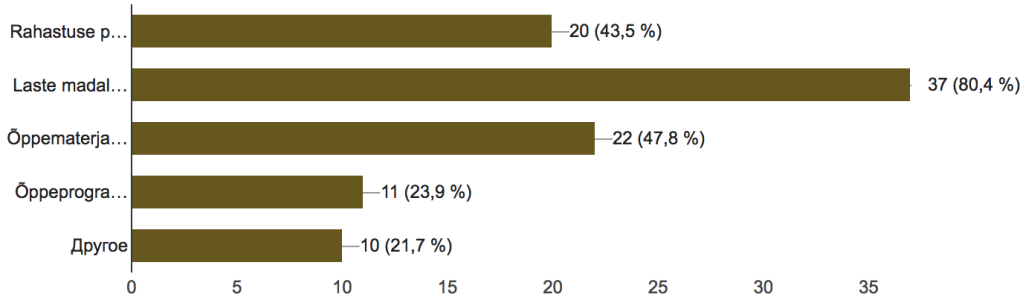


A.1.13 Figure 13 What do you think, they are a necessity of research of new methods of the UI app prototyping with Augmented Reality technology?

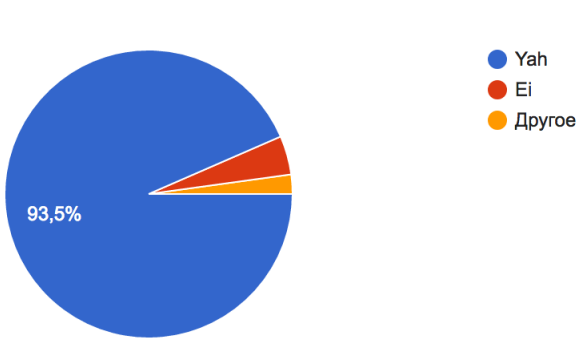


Appendix 2 – Teacher's questionnaire results

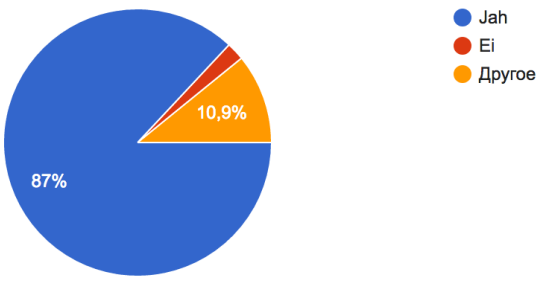
A.2.1 Figure 1 What problems in educational system can you emphasise?



A.2.2 Figure 2 Would you use app which helps to visualize chemistry elements and reactions during chemistry lessons?

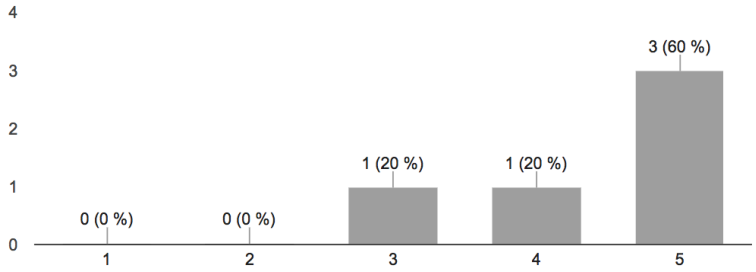


A.2.3 Figure 3 Would you allow students to use educational games during the classes?

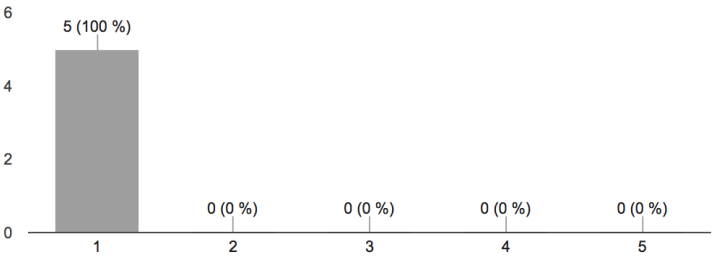


Appendix 3 – System usability scale (SUS) survey results

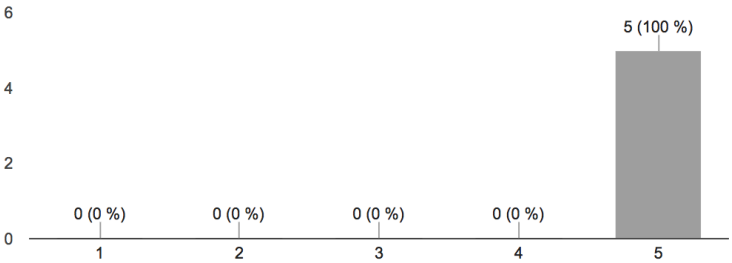
1. I think that I would like to use this system frequently (Я думаю, что использовал(а) бы данную систему постоянно.)
(5 ответов)



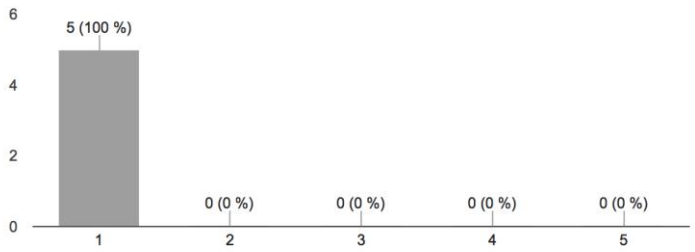
2. I found the system unnecessarily complex (Я нахожу данную систему неоправданно сложной.)
(5 ответов)



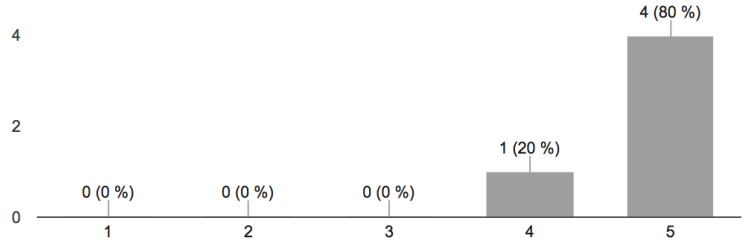
3. I thought the system was easy to use (Я думаю, что данную систему легко использовать)
(5 ответов)



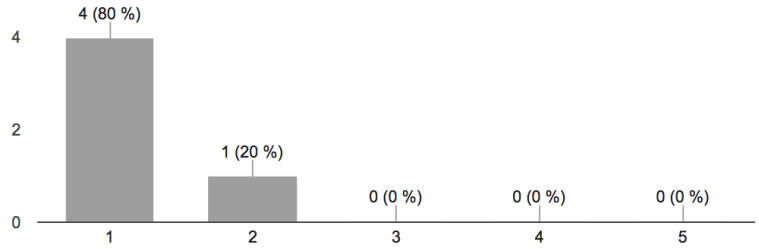
4. I think that I would need the support of a technical person to be able to use this system (Я думаю, что мне необходима помощь технического специалиста/консультанта для работы с данной системой)
(5 ответов)



5. I found the various functions in this system were well integrated (Я считаю, что система обладает многими полезными функциями)
(5 ответов)

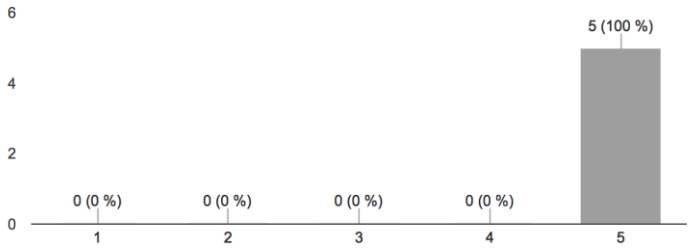


6. I thought there was too much inconsistency in this system (Я обнаружил(а) много противоречий в данной системе)
(5 ответов)



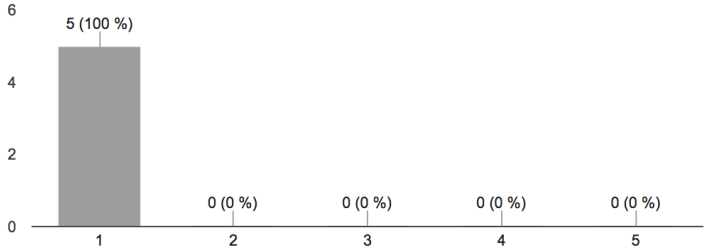
7. I would imagine that most people would learn to use this system very quickly (Я полагаю, что большинство людей с легкостью освоят данную систему)

(5 ответов)



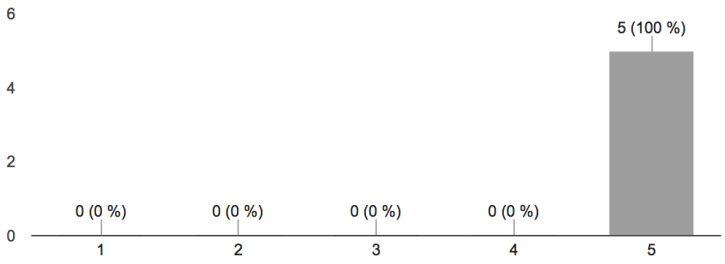
8. I found the system very cumbersome to use (Я нахожу данную систему очень громоздкой)

(5 ответов)



9. I felt very confident using the system (Я чувствую себя уверенно, используя данную систему)

(5 ответов)



10. I needed to learn a lot of things before I could get going with this system (Я должен(а) был(а) сперва изучить много нового, прежде чем начать работу с данной системой)

(5 ответов)