Seriousify and prettify our educational system!

ABOUT THE USE OF (SERIOUS) GAMES AND AR IN EDUCATION

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Abstract

In the past, various researches have proven that the use of video games in education has a positive effect on children's results in school, both primary- and highschool. However, the games that were used in these researches were created specifically for a certain topic; few research has been done about the usefulness of already existing (commercial) games in education. This paper tries to come up with two scenarios which both describe how (commercial) games and multimedia could be used in education, also with the help of what is called 'augmented reality': a virtual layer for mobile devices which 'augments' reality visually. We also take a look into the future, detailing some new technology that could be used to make education even more entertaining and fun.

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1 Introduction

Maybe it was the insight of Blue Monday - the most depressing day of the year - that made Hadi Partovi (entrepreneur and investor) realize that primary education did not do anything with one of the most important areas of today's world: computer science. Or more specific: programming our computers. Because after this saddest day of the year, Partovi decided to launch a new initiative, named *Code.org* - a non-profit organization that is dedicated to give a more prominent role to computer programming in education environments [1]. Since the launch of this project in January 2013, Partovi managed to form a large group of influential people who were willing to support the whole idea, among which Bill Gates (founder and chairman of *Microsoft*), Mark Zuckerberg (founder of *Facebook*), Jack Dorsey (founder of *Twitter*) and Steve Jobs (founder of *Apple*). In the documentary *Steve Jobs: The Lost Interview* (2012), Jobs stated one of the main reasons why computer programming should be taught in schools. "I think everybody in this country should learn how to program a computer because it teaches you how to think", he said. This quote also holds an important, more general aspect of organizations such as *Code.org*, which is the vision that they want to change the current world of education in a positive way. These people try to start a revolution which they think is crucial to keep innovative in the future, in this case through teaching students right from the beginning of their school careers to program a computer or - more general - to code.

Partovi's initiative does not stand alone. Back in 1985, the American author Orson Scott Card used his novel *Ender's Game* to argue in favour of the use of video games in education; in the first place to make it more fun, but he also thought that (elements of) video games would do a better job in teaching students a specific concept than teachers. Squire and Jenkins also mentioned this vision in an article, stating that Card's educational system is a utopia in which teachers don't tell students exactly what they have to do in the video games they play, but that they are left on their own to experiment and solve problems in order to develop strategies and tactics that they can use in the 'real' world, outside of the games [2].

This paper tries to propose a new way to improve the current level of education, mainly using Card's proposal of video games. Added to that is augmented reality (often shortened to *AR*), a technique that supplements the 'real' world (the world we see through our own eyes) with virtual objects that seem to coexist in the same space as that real world [3]. Using both these concepts, two scenarios are explained: one using a commercial video game that is already out on the market in combination with AR, the other a tour through a city using AR on a mobile device. Both scenarios are designed to use in educational settings, for example to use as a supplement to traditional education methods.

Before the two scenarios are described, we first delve deeper into the areas of games (more specifically 'serious games', which are video games with the purpose of educating) and AR. After this, the reader knows enough about serious games and AR to be introduced into the scenarios mentioned earlier. Then, we take a look into the future and see what new technologies could add to make 'gamewise education' even better. The paper ends with a 'Discussion & Conclusion' section.

2 Background on serious games and Augmented Reality

In order to get a better understanding of the two scenarios described in this paper, this background section provides a closer look at serious games and augmented reality (AR). Please take note that a full overview of both topics is not the scope of this paper; it only looks at those parts of serious games and AR that are relevant in view of the two scenarios, in which aspects of both topics are used.

2.1 Serious games

Today, serious games are already being used in various environments, for example at schools and business. But what are serious games exactly? This section first discusses that question, and will then continue to look at ways in which serious games can be developed and how far we should go with integrating (serious) games into education.

2.1.1 What are serious games?

Comparing serious games to non-serious games is a good way to understand the former. Non-serious (commercial) games are made for a large audience and are usually distributed by publishers with the main goal of selling as many copies of the game as possible. Another element of non-serious games is that they should be fun to play; a game that isn't fun to play will likely not sell very good. A serious game should include a fun factor too, but it also has goals that reach further than just entertaining the people who play them. One of those goals is to educate people (generally students) in a certain area, for example to prepare them for real practical work. In other words: the seriousness of a serious game deals with the purpose for which the game is developed [7]. However, it is not required that a serious game is initially developed to be a serious game, because also an already existing (commercial) game can be redeveloped into or used right away as a serious game. More about the development of serious games be found in the next section.

2.1.2 Development of serious games

There are various ways in which developers can make serious games. There are roughly two paths that can lead to a serious game. The first path is to develop a serious game from the ground up; this implicates that the developers are intentionally making a product of which they know from the start that the final version will be used as a serious game, so it should be a game from which things can be learned. The second path that developers can choose is to take a commercial game which has already been brought to the market with the main goal of entertaining the people playing it. Next, (elements of) this game can be taken out and serve as supporting material in an educational setting, for example to clarify a certain subject that is taught by the teacher.

To take a little peek ahead: the first path in serious games development will be taken in the scenario about AR in a city described later on; the second path will be taken in the scenario that uses *Assassin's Creed*. The next two sections delve deeper into both paths.

Serious games build from the ground up Both paths that could be taken will be described using an example. Suppose you are a freelance game developer in the luxury position to have a whole team at your disposal. One day you receive an e-mail from one of your regular customers, in which he asks you to build a serious game that deals with an important moment in history (the specific moment is not of importance here). Based on the

ideas and requirements of your customer, you and your team are starting the development process right away and build the game in a few months. When the whole product is ready, you come back to your customer with the finished product, the customer thanks you for your services and leaves satisfied.

This scenario is an example of a process in which a development team builds a serious game from the ground up, based on requirements and ideas that were given to them. The development team knows right from the start that they are building a serious game, including all the ideas and necessary elements that such a game should contain. The biggest advantage of this method is the fact that you know exactly what you have to build right from the beginning, which means that the end product is - in theory - the best possible product that could be build. However, there are also some disadvantages, with the quality of the final product probably being the biggest [2]. Full-blown commercial games are often build with a big team, which consists of many people thinking about the story, the (background) music, the graphics, the gameplay, the entertaining aspects, etcetera. Most serious games, however, do not pay that much attention to all these aspects that give a big commercial game the quality it has. So, the idea behind a serious game can be very good, but if it cannot compete with the quality of commercial games that children today are accustomed to, it probably will not be the success the developers had hoped it would be [4].

Seriousify commercial games The other path that could be taken in making serious games is to take an already existing commercial game and make it - or at least some elements of it - 'serious'. In Squire and Jenkins' paper [2], an example of this approach is given. This paper uses the game *Civilization III*[1] to explain the idea of using a commercial game in an educational environment, in this case history classes. According to the paper, *Civilization III* models various aspects of a civilization very well. The various scenarios of this game are therefore highly suited to use as an example during history classes. Squire and Jenkins found that concepts in history, for example monotheism and monarchy, are introduced by the game in such a way that they are easy to understand for students. Moreover, the game is also a great way to link these concepts together in a larger time frame, because of the big total time span.

Further in the same paper ([2]), more examples of commercial games that could be used as a serious game are given. The main advantage of this approach is clear: it removes the argument that serious games can't compete with commercial games. However, a problem of this approach is the collection of negative effects of video games. Some people - specifically educators - are afraid of the potential of games being violent and leading to aggression, and are therefore not suited to use in educational environments ([5], but earlier mentioned by Provenzo, 1991). On the other hand, other researches into video games and their possible negative effects have mentioned that the scientific evidence to prove this sort of statements is lacking. Even more, Aguilera [6] mentions that experts have shown that negative things like violence and aggression can't be attributed to video games, except when the circumstances are unusual.

Necessity of collaboration Whichever choice is made regarding the path that leads to the development of a serious game, there is one thing that should be taken into consideration at all times. To make a serious game (or to make a game serious), there are always two parties involved in the boxing ring. In the left corner we have the educators, who are experts in the area of teaching and transferring information to the students they teach. The right corner is occupied by the game designers; these guys know exactly what gives a game its quality and

[1] Civilization III is a very popular and detailed game which gives you the command over a civilization for a period of thousands of years, from 4000 BC to somewhere in the future.

level of immersion. But, in contrast to what happens in a normal boxing ring (two people trying to knock each other out), this special instance of a boxing ring is made to unify the left and right side - the educators and the game designers. This is a very important thing to understand, because educators alone will never know in detail what makes commercial games so compelling; game designers alone are not able to design the challenges that are necessary to let students develop various skills and achieve their goals [2]. To summarize, it will always be important to let educators and game designers collaborate, in order to deliver a final product that contains quality in both the area of education and the area of game design.

2.1.3 Level of integration in education

The next question about serious games is: what should be the level of integration of these games in education? Roughly there are two scenarios here. The first is where serious games are only a minor addition to education, using them as supporting material in various ways. The second gives a far more prominent role to (serious) games, namely using them completely instead of the current educational system, so this second scenario displays an educational world that is completely powered by the use of games. The next two paragraphs describe both approaches in more detail.

Games supporting education In his 2003 article ([2]), Squire mentions the possibility to use (serious) games to improve student's understanding of a play (in this case *The Tempest* by William Shakespeare). A game that is connected to a play like this can present some background information about the play in an entertaining and original way. With the help of such a game, students are encouraged to learn more about a specific topic (in this case classic plays) which they may not like initially. By using games, however, this tendency can be turned around in favour of a classic play like *The Tempest*. After playing with such a game for a while (say a few weeks during a school period), the students will understand more of the play when they are going to watch it in real life. Maybe the final words of Squire about this way of teaching summarizes the whole idea the best; he says that games are not intended to be a replacement for traditional resources, but rather a way to motivate students to return to those resources to get better at the game and, more importantly, to learn more about the topic.

This scenario is a good example in which serious games can support the (traditional) way in which education is given these days: games can be used as a supplement to traditional classroom education [4]. Students are quite happy to work with computer games, because it is a more fun and amusing way of teaching than the normal, conventional way in which education is given [4]. So, with the help of something students generally like (playing games), a topic which students do not always like can be presented in a more interesting and engaging way.

Full immersion of games This paragraph will look at the possibilities of completely replacing the educational system by games. Squire uses the science fiction novel *Ender's Game*, written by Orson Scott Card, to give an example of such a world [2]. In the novel we meet Ender Wiggin, a student at what is called the 'Battle School'. Instead of using traditional ways of education (like classroom lectures), the Battle School is completely designed around the principles of game playing. Everything Ender learns in this school is a direct effect from the games he plays; teachers are merely there to coordinate the whole process and change some minor things in the games if necessary. In addition to the virtual games, Ender and his fellow students also receive some form of practical, real life training in order to apply the things they have learned in reality - in this case they fight at some battleground to prepare for the 'real thing', much like marines do in the army.

In short, Orson Scott Card uses *Ender's Game* to describe a world in which no teacher is allowed to exactly explain to the students what they have to do in the games they play. They are just left on their own in a gaming environment to experiment and solve problems in a variety of ways. What those 'variety of ways' exactly are is not predefined, but thought up by the students themselves. The idea is that they will eventually master strategies and develop some skills that are critical in the rest of their lifes and the world beyond the games [2].

2.2 Augmented Reality

It was already back in 1990 that the term *augmented reality* was first used by Caudell and Mizell, who where developing one of the first experimental AR systems [3]. However, only in the last couple of years AR has taken on a more prominent role into our everyday lives. One of the reasons of its popularity is that many people are in the possession of a smartphone, a device which is perfectly suitable to use in combination with AR applications. The question that remains: what is AR exactly, and where and how can we use it?

2.2.1 What is augmented reality?

Augmented Reality is a technique where computer-generated objects are added as a supplement to the real world. Those newly created objects can only be seen through an AR-device, which can be any device that supports the techniques of AR (for example a smartphone). In other words: the *virtual* objects created by the computer and the *real* objects that we can see through our own eyes (seem to) coexist in one single space [3].

2.2.2 How can augmented reality be presented?

There are three ways in which a virtual object can be presented with the help of AR, which are explained below (based on [3]).

Video see-through Video see-through is a technique where AR is first combined with the real world in a pre-processing state, after which it can be viewed by the user. What the user sees is basically a video of the real world, combined with objects that were added to that real world with AR. In other words: this is not a 'live' feed of the world, but a pre-processed one.

Optical see-through Compared to video see-through, this technique doesn't use the real world to make a video feed. It leaves the real world as it is and just adds an AR overlay to it, which can then be viewed live on the screen of a AR-compatible device.

Projective This technique creates an AR overlay directly onto real world objects, which results in projective displays. An example is a paint-job for a car, which can be previewed with the help of AR before definitively applying it to the car.

2.2.3 How can augmented reality be used?

There are a plethora of devices that support AR-techniques. All those devices can be categorized in three different groups (based on [3]):

Head-worn The first group of AR-devices are the ones that are head-worn. These devices can be worn like regular glasses. An example of a device which is head-worn, are the *Google Glasses*. More about this device can be read in the section about future developments.

Hand-held This is probably the group of AR-devices that is mostly used, because it contains the smartphones. With hand-held AR devices, you do not directly wear glasses as in the previous group, but you can hold the AR-device in your hand and watch AR through the screen of the device.

Spatial Spatial devices are placed somewhere in the real world and stay there, like video screens or projectors. The advantage is that you don't have to hold a device yourself; you can just look through devices that are already in place.

The challenge of this paper lies in combining the fun of serious games with the addition of augmented reality. Because many people have a smartphone, the scenarios that are proposed in this paper are based on the use of hand-held AR-devices in combination with a projective display.

2.2.4 Overview of augmented reality software

Today's market features many software that is armed with AR-techniques. Through the large pile of software packages available, there are three products that are best known today. These are *Wikitude*, *Junaio* and *Layar*, all of which are so-called AR-browsers. An AR-browser is, simply put, products that delivers a framework that developers can use to create their own applications, which then run on the pillars of that same framework. In other words: the AR-applications that are being developed run on the technologies that are made available by the organizations behind the AR-browsers. The next three paragraphs take a look at the three AR-browsers mentioned earlier, also comparing them to each other to see for which purposes the respective browsers can be used.

Wikitude One of the advantages of *Wikitude* is that it is cross-platform - it runs on a variety of operating systems: iOS, Android and BlackBerry 10. The nice thing is that developers only have to create their code once, after which they are able to transport it to all three platforms without having to rewrite their code. This is because the applications that are made with *Wikitude* are based on well known web standards, like HTML(5), JavaScript and CSS [11]. Developers are able to host their applications on their own web servers, and can then put the url of their application into *Wikitude* in order to make it work. This can of course be considered as an advantage, because it saves developers some hours work. On the other side, because of this approach the applications that are being developed are never pure native[2] applications, while native generally provides the best applications.

Wikitude provides a couple of ways in which AR can be used:

Image recognition With image recognition, one can use the camera of his AR-enabled device to can his surroundings. When the device's camera detects an image that has been set by the developer to be recognized, it can be augmented with some (3D) objects like text, videos, another image or a 3D model. That augmentation is generally placed directly upon the detected image, but it can also be placed beside, above or beneath the image if the developer specified it that way.

Point Of Interest A *Point Of Interest* (often abbreviated to *POI*) is a location in the real world that the developer has put into the AR-application. Based on GPS- of WiFi technologies, the AR-enabled device can detect if such a POI is nearby. If so, the application can display

[2]Native applications run directly on the framework of the operating system for which they are developed, instead of needing some extra external support in order to make them work. This makes native applications generally faster and more stable than non-native applications, of course on the condition that the application is correctly programmed.

a small label in space, indicating it to the user. A POI is usually defined by *Keyhole Markup Language* (KML). A KML-point defines some information about a POI that is needed in order to know where that point is, such as the coordinates, the name and a short description. *Wikitude* uses *Augmented Reality Markup Language* (ARML) for the same purpose, where ARML is a derivation of KML.

Hybrid solutions Image recognition and POIs can also be combined into one application, making it hybrid. For example, an application could be programmed in such a way that image recognition of a certain picture only works if the user is in the vicinity of a certain POI.

Junaio Like *Wikitude*, *Junaio* runs cross-platform, but only on iOS and Android (not BlackBerry 10). In terms of development, *Junaio* could also be compared to *Wikitude*; the applications made with *Junaio* are not native, but are developed with the use of web languages, mostly PHP. There is no need to make applications for both iOS and Android, but developers can simply but their application online on their own web server and then put the url of their application into *Junaio* in order to make it work. So, this is all quite similar to the way in which *Wikitude* works. *Junaio* makes use of its own *Augmented Reality Experience Language* (AREL), which is more or like the JavaScript bridge from *Junaio* SDK[3]'s API[4] to the web application made by developers [13].

The ways in which AR can be used are the same as with *Wikitude*, added with some extra technologies:

Indoor Location Based This technique makes it possible to use AR indoors. The user can scan a certain predefined tag with his AR-enabled device. This lets the application now where the user is in a certain building, and can then provide him with certain information, for example the route to a conference room.

AR games *Junaio* makes it possible to develop games that use AR. The developer section of *Junaio* features a game where enemy robots are augmented into the real world, giving the user of this application the assignment to shoot them down. More information about this game can be found at [14].

Layar *Layar* is deployed on both iOS and Android, but is a bit different compared to the previous AR-browsers. According to *Layar*'s website, the application is bridging the gap that they think exists between the printed world (like magazines and (news)papers) and the digital world [15]. Developers can use images of printed content, and use them as pictures that can be recognized by *Layar*. If such a page of printed content is recognized by the application it can add augmentations to it, like text and videos. Because of the way *Layar* works, it is often used by magazine publishers to make their content more interactive and entertaining, because it is literally adds extra layers to the normally flat content.

Amateur solutions In addition to the various SDKs and APIs that are made available by the three AR-browsers, they also provide easy ways for amateurs (or non-developers) to make AR-applications. *Wikitude* uses the Wikitude Studio, *Junaio* has its Metaio Creator and *Layar* provides the Layar Creator. These three applications all work in more or less the same way. The user can simple choose which picture to use for image recognition, add a certain

[3] SDK is short for *software development kit*, and is a collection of tools that developers can use to make application for certain software, in this case AR-applications for *Junaio*.

[4] API is short for *application programming interface*, and is usually a library of code that can be used by developers to make connections to the software they are developing for. In the case of *Junaio*, the API offers code that helps developers to use AR-techniques.

AR overlay onto it... and then it is done! In other words, these three applications make it very simple to create AR-experiences in a matter of minutes. More information about the three applications can be found at [16], [17] and [18].

2.2.5 Augmented Reality's opposite: Augmented Virtuality

Before looking at the two scenarios mentioned earlier it is worth mentioning another technique that is upcoming, which can be seen as the opposite of AR: augmented virtuality (AV). AV is defined as a virtual environment that is enhanced by the use of real world objects (compared to AR where the real world is enhanced by virtual objects) [19]. An example of an application in this area is nicely demonstrated in a YouTube video [20] where two players can play the game of *Pong* with the help of bats that are placed upon the screen of an iPad. In other words: a virtual experience (the game of *Pong*) that is enhanced by real world objects (the bats that the players use to hit the ball).

3 Two serious scenarios

The previous sections should have brought you up to speed regarding serious games and AR, at least to the level that is sufficient to understand the two scenarios that will be described now.

The first scenario describes how a commercial game that is already out on the market (in this paper *Assassin's Creed* is used as an example) can be 'seriousified' so it can be used as a serious game in educational environments. The second scenario shows how AR can be used to learn things about a certain city in specific, but also about more general topics that can be implemented in such an application.

3.1 Scenario 1: Assassin's Creed

Assassin's Creed is a video game series in the action-adventure open world genre, where players take on the role of an assassin in ancient brotherhoods. The major part of each game take place in historically important periods, or at least periods in which happened enough to make a game about. If you look at *Assassin's Creed* the way it's meant to be played, you control the assassin through a great variety of mission, often related with or working up to the assassination a public figure. It's obvious that this isn't the way one would play the game if it were used as a serious game, for educational purposes. However, behind these mission structures in each of the *Assassin's Creed* games lies a beautifully designed world that is highly suitable to explore. The developers of the games have ensured that every detail of the city that was put into the game is as accurate as possible compared to how the same city looked during the same time period in the real world. One of the possible uses of these games is in history classes, where the teacher can show his students what a specific city looked like in the past, how the people lived there, what the economy was like, etcetera. Or the students could be challenged to walk into these cities themselves, and explore the history and culture on their own.

To show a possible use of an *Assassin's Creed* game for serious (educational) purposes, we take the second option described above, and let students walk through the game world on their own. The following scenario describes in more detail what such an experience would be like.

3.1.1 Exploring the Colosseum

The *Assassin's Creed* video game series features a great variety of buildings that were very important in history. One of these buildings is the Colosseum in ancient Rome, the place where gladiators fought their battles of life and death and where great and spectacular shows were performed, all for the entertainment of the people. Today there is not much left of what once was one of the most imposing buildings in the world, but in *Assassin's Creed* the Colosseum is recreated as it was in its prime, which makes it a unique opportunity to experience how it would have been for spectators to watch performances there.

One of the missions in the game features a historical play, about the last days and the crucifixion of Jesus Christ [8]. The actual goal of the player in this mission is to assassinate one of the actors in the play, but with a small change in the script this scene could be used for educational purposes. For example, students could learn something about the play itself, or about how plays (or other shows) were performed in the Colosseum. Experiencing the history of the Colosseum in this way is probably a lot more fun, interesting and entertaining than reading it from a textbook. The next paragraph takes a look at how this mission in the game could be transformed into gameplay that is suitable for educational purposes. Plus, there will be some AR added to the game, in order to make it more informative.

Seriousify the Colosseum mission The mission starts with the character you control climbing to the top of the Colosseum, to get a better view from up there. If this would be translated into a script for a serious game, the player's assignment could be used to learn more about the Colosseum as a building. Climbing to the top, your character passes some vital building blocks of the Colosseum, which could be explained in more detail. This can be accomplished with the help of AR: the player can point the camera of his AR-device at a building block, the application recognizes this particular block and can then display more information about it. An impression of how this could look on a mobile AR device is shown in figure 1.

Figure 1: Climbing the Colosseum, passing the main pillars and showing information using AR technologies.

After the long climb to the top of the Colosseum, the player will see a cutscene in which the camera flies around the building, ending the shot with a look at some guards or gladiators (see figure 2). In the case of a serious game the player could be given the assignment to move closer to these gladiators, point the camera of his AR-device at the screen again and get some information about gladiator tournaments that were also being held at the Colosseum in its prime.

Figure 2: A group of guards or gladiators in what looks like a waiting room.

Then, in the center of the Colosseum, people are watching the play about the crucifixion of Jesus Christ mentioned earlier (see figure 3). This is a great example of the various plays that were performed at the Colosseum for the amusement of the people. Again, the player could get more information about this with the help of his AR-device. But, because this is a video game, there are more options than only the use of AR to dive into more detail. The player could, for example, be given the assignment to act along in the play, experiencing what it would have been like for an actor to play in such a giant theatre like the Colosseum (see figure 4). In the normal game mission, the player is given this assignment too, although he acts in the play for other reasons than just acting and snuffing culture.

Figure 3: A play about the crucifixion of Jesus Christ, performed at the Colosseum.

Figure 4: The player acting along in the play at the Colosseum.

After this acting scene, the mission ends. Altogether this scenario shows that with a bit of imagination and thought it is possible to take a mission of a commercial game and 'seriousify' it, in order to make it suitable to be used in educational settings. In this case *Assassin's Creed* has been taken as an example game, but in the end many more games can be used for the same purposes.

3.1.2 Challenges with this scenario

The scenario described above has some (technical) challenges that come along with it. In this section, these challenges are described and possible solutions will be given. Please note that it is possible that there are more challenges about the scenario that are not described in this

paper.

Player's position While playing *Assassin's Creed*, the physical position of the player in the real world is known: in front of his television screen. However, it is also important to know where the player is in the virtual world. This position can be obtained in two different ways. The first one is to programmatically determine where a player is situated at a specific moment. This is something that the developers of the game have already taken care of, so it does not have to be added if you want to seriousify *Assassin's Creed*. The only difficulty here is that you need to have access to the code of the game to determine the players position, but this should not be that much of a problem when you are in the process of working together with the developers to create a serious game out of *Assassin's Creed*.

Another way to determine the player's position is with the help of landmarks; in the scenario described above, we could view the Colosseum as such a landmark. When the player points his camera at the landmark, the AR-application knows where the player is situated. This second way of determining the player's position could however pose another problem, namely that it could be difficult to recognize the Colosseum through image recognition alone. If that problem is too big to handle, maybe it is more convenient to use another way to detect where the player is at a specific moment, namely by using some sort of logo or tag for this purpose. Instead of the application having to recognize a whole building, it now only has to recognize a (small) tag in order to determine where a player is on the map, which is (in theory) a lot easier to do.

3.1.3 Creating the application with Wikitude

This section will describe a prototype application that is based on the *Assassin's Creed* scenario described above. The application will use the framework of *Wikitude*, which is an AR application for Android, BlackBerry 10, iOS and the web [11]. This paper will not explain all the features of *Wikitude* or other possible AR applications that can be used for the same purpose, this is just an example of how an AR application could be created.

Wikitude provides software development kits for all the platforms it is deployed on, which developers can use to create their own AR-applications inside the framework of *Wikitude*. Another possibility is to use the *Wikitude Studio* [16], which is the application used in this paper. The *Wikitude Studio* is a web-based application that makes it easy for users to build their own AR-application and publish them to *Wikitude*. The AR-technique that is used in this application is image recognition; the user is able to provide an image that is to be recognized by a device that uses *Wikitude*'s AR-application. When the image is recognized, the application can show an extra object as an overlay to the real world, for example text, links, images, buttons or even 3D models.

To show the basic capabilities of *Wikitude Studio*, an example application has created. This application can recognize a certain figure and display a button, on which the user can click to get more information. In this case, the button redirects to the English Wikipedia page about the Colosseum. Figure shows the picture that is used for image recognition, figure shows what it looks like when the AR-application is used, with the extra button displayed.

The same design can be used if this application would be developed further to be used in the way that is described in the *Assassin's Creed* scenario above. In theory it is possible to use an in-game image of the Colosseum as a picture for image recognition, but there are some problems involved with this approach. If a player tries to use the camera of his AR-device, pointing it at the Colosseum, he should be in exactly the same position that was used as the picture for image recognition. It would be very difficult for the player to find this exact position, so it is better to use a (small) tag as the image to be recognized. With this approach,

Figure 5: The picture used for image recognition.

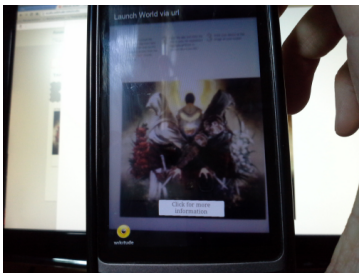

Figure 6: The running AR application on a smartphone, displaying an extra button.

the player only has to find the same tag in the game world and scan it with his AR-device in order to receive more information about - in this case - the Colosseum.

3.2 Scenario 2: AR in a city

In the first scenario, a virtual (game) world was used, but it is also possible to use a location in the real world for more or less the same purpose. This second scenario dives deeper into this other possibility, taking the city of Alkmaar (in The Netherlands) as an example. In the end, just like with *Assassin's Creed* in the previous scenario, Alkmaar is just an example and in theory every city could be used.

We can use certain places in a city to teach students about important historical- or cultural aspects. Each city has its own unique landmarks, but that doesn't mean that we can't generalize them in some way in order to provide the user with more universal content. However, it is also a nice idea to make city-specific AR-applications which also use general content, but in combination with stories and content that are unique to that city. An couple of examples of general content that is found in Alkmaar but also in a lot of other cities in The Netherlands are its Big Church (*Grote Kerk*), city hall, markets and mills. Examples of unique things of Alkmaar are its cheese market and its own local history (for example the *Eighty Years' War* (*Tachtigjarige Oorlog*) against the Spanish. The general content could be integrated in every AR-application of any city, while the specific content would only be released in the AR-application for Alkmaar.

The next sections looks at a scenario in which students explore the city of Alkmaar on their own, with the help of an AR-device.

3.2.1 Exploring Alkmaar

If students are left completely on their own in a city, we risk the probability that they do not learn anything about the general- and specific content which are discussed before - after all, they are students. Therefore, it is probably wise to guide them in some way, for example with the help of GPS or simply a map of the route they have to take (figure 7 shows how this could look like). In Alkmaar, a good starting point is the *Saint Laurens Church* (*Sint Laurenskerk*) or *Big Church*, which is a building that falls under the general content. The student can point the camera of his AR-device at the church to get more information about the church itself, but because we categorized this building under the general content the student will also get

information about churches in general (at least about churches in The Netherlands). Another way to detect if a student is at a certain location is with the help of the earlier mentioned POIs. With the help of GPS technologies, the application can detect if the student is near a certain POI (in this case the *Big Church* in Alkmaar. If so, the application can display some information about this church without the need of pointing a camera at the building.

Figure 7: The map with the walking route on an AR-device.

The walking route goes further, and eventually reaches the *Weigh House Square* (*Waagplein*). The *Weigh House* itself is not something that is unique to Alkmaar, because there are more cities in the Netherlands that have (of have had) a *Weigh House*. However, the cheese market that is being held at the same place is unique to Alkmaar and therefore falls under the category of (city-)specific content. This cheese market is not really a market, but more of a play that shows people how the cheese was traded in the past. Like with the *Saint Laurens Church*, students could point their AR-device to a specific point at the *Weigh House Square* to get more information about that specific building (being general content) and about the cheese market (being specific content). Besides that, you could also think of other ways to learn more about the cheese market, like the examples proposed in the next paragraphs.

Virtual cheese market Until now in this paper, only hand-held devices have been used in combination with an AR-technique that just shows extra information on the screen, depending on where the camera of the device is pointed at. Another way of using AR is with the help of optical see-through in combination with spatial AR devices. Maybe it's not immediately clear what could be done using these techniques, but the following explanation should clarity this. Suppose you are situated on the *Weigh House Square* in Alkmaar, on a day when there is no cheese market show. But, with the help of the spatial AR-devices, you can still see

how the cheese market (or the cheese trade) must have looked like in the past. This is done by looking through these spatial AR-devices in the direction of the center of *Weigh House Square*. Because we use the optical see-through AR-technique, we can project an extra layer onto the real world. That extra layer consists in this case of a video of the cheese market, projected onto the real world (the situation as it is at that moment on the square). Besides a video, such an application could also use 3D models that can achieve the same goal, making the experience even more real.

Be a cheese carrier yourself The scenario with *Assassin's Creed* already proposed a way in which students could become a part of the game, playing as one of the characters in a play. In this scenario with the cheese market the same kind of thing could be done: developing a game of the cheese market in which the player can take the role of one of the people that are involved with the market, such as the cheese carriers, -traders and the people who weigh the cheese. The downside here is that this game has yet to be developed, where in comparison to the *Assassin's Creed* scenario the game is already there and only has to be changed in a slight way. On the other side, it is undoubtedly more entertaining for students to let them experience the cheese market through a game than through reading about it. Another advantage is that students do not have to be on site in Alkmaar, but they can also play the game while they are at another location, for example at school or at home. In other words: with the help of a game like this the position of the students can be faked. Because of the game the students seem to be in the city of Alkmaar, experiencing the cheese market, while in reality they are at some place else. This same idea can be used in other applications, which the following example shows. Image you are on the Dam in Amsterdam, equipped with your AR-enabled device. While looking through the camera of your device, you can fake your position and pretend your are at Times Square in New York, or maybe Leicester Square in London, seeing what happens at any of those places right now without the need of being there physically.

3.2.2 Challenges with this scenario

This scenario could pose some (technical) challenges that will be described in this section. In all cases a possible solution will be given.

Player's position In the scenario with *Assassin's Creed*, the physical position in the real world was not important, but in this case it obviously is. For this scenario, there are also a few ways to determine the player's position in the world. The first one is the most obvious: using GPS techniques to find the location of the player. Almost every smartphone nowadays has the ability to determine its position with the help of this technique, and AR-devices used for these purposes are even more likely to have GPS on-board. Another option to determine the player's position has been described in the *Assassin's Creed* scenario, namely with the help of specific landmarks or tags. Like in this first scenario, the application could recognize whole buildings as a landmark, or else use (small) logos or tags that are easier to identify.

Reading text The way in which the user got his information in this scenario about various buildings or cultural topics was mostly through reading about them. However, in today's world were everything happens fast, standing still and reading text for a few minutes does not sound very interesting and fun. A solution for this problem could be the use of multimedia, for example videos. If videos are used to clarify some topics, the chance to immerse students into these topics is probably a lot higher than when they have to read about it. There are two ways in which these videos can be obtained. The first one is to look for already existing

videos that exist about a certain topic, the second one is to fabricate such videos by ourselves. The first way is the more convenient one, but it could be difficult to find videos that exactly match our needs. This difficulty is removed in the second way, because then it is clear what content the video should contain. The downside of this second option, however, is that there are costs involved when creating a video (finding actors, thinking about the script, filming on location, etcetera). In the end, the advantages and disadvantages of both options have to be weighed against each other in order to make a final decision about which path to take. A special instance of videos are *simple interactive videos*. These videos ask some interaction from the user, for example choosing between two options that decide what (part of the) video to play next. Services like YouTube already provide ways to make simple interactive videos - look at this ([21]) video to look at an example of how this technique can work on YouTube.

3.3 Testing students

In the previous sections where the two scenarios were described, only the way in which students can learn with the help of (serious) games and AR were discussed. However, it is of great importance that the students not only play the games, but also learn something from it. In order to test if the scenarios described above have the desired effect (which is that students have learned at least the same amount from it compared to what they would have learned if they used traditional education material), some kind of test has to be created. This test can be made available in two ways. The first way is 'offline', where students are asked to fill in a form with questions that tests them on the topics from the scenario they played. The second way is 'online', where students are confronted with the same questions, but now through online media - which can also be integrated into the game they already played in the first scenario or in the AR-application they used in the second scenario.

To test if the two scenarios have the desired effect, two groups have to be formed: one that follows the scenarios described in this paper, and another (control group) that learns through the traditional education methods, for example textbooks. After a certain period, both groups should take the same test. Finally, the performances on the tests of both groups can be compared to each other to see if the students that learned with the help of the scenario performed better or worse than the students in the control group.

4 Future developments

The use of AR today largely depends on smartphones, which is one of the biggest platforms on which AR is being deployed. That may sound negative, but it actually is not. Because smartphones become quicker and quicker due to continuous hardware updates, these devices are a great platform for AR. However, the (close) future will bring new hardware on the market which will make it even easier and more interesting to use in combination with AR, but also with serious games. Two of these examples are *Google Glass*, developed by Google, and *Oculus Rift*, invented by Palmer Luckey and developed by Oculus VR. This section will discuss what these devices are and how we can deploy AR (on *Google Glass*) and serious games (on *Oculus Rift*) on them.

4.1 Google Glass, the future of AR?

Smartphones are great devices to use in combination with AR - which has already been stated above - but they also have some disadvantages. One of the biggest is that you constantly have to pick up the phone out of your pockets when you want to use it (for example to look on the map if your still on the right track), and then putting it back afterwards only temporarily

before you have to fetch it again. This disadvantage of smartphones is taken away by *Google Glass*, a new project from Google.

4.1.1 What is Google Glass?

Google Glass has taken regular glasses as a starting point (which makes it a member of the head-worn devices), and added a head-mounted display on the right glass (see figure 8). This small device shows information to the user that is useful for them at the moment they need it, and is out of the way when you don't [9]. Examples of things that could be shown on the display include maps, camera- and video applications, social network updates, etc. Or in other words: everything you usually check on your smartphone has been moved to a small little device close to your right eye. Because the glasses are always there, there is no need to get a device out of your pocket. You simply speak to your device with pre-generated commands (like *"Ok Glass, take a picture"*) or touch it to make it do whatever you want.

Figure 8: Google Glass, with the small head-mounted display on the right side.

4.1.2 How can we use it?

With a little thought, the primary use of *Google Glass* becomes clear: it can serve as a replacement for smartphones in the field of AR. Imagine the same uses of AR described in the scenarios of this paper, but now with the help of *Google Glass*. Instead of pointing the camera of your AR-enabled smartphone at a certain object or building, you can now just look at that building and ask *Google Glass* to display more information about it on the small device right before your eyes. At the same time, you can keep looking at the building through your own eyes, because they don't have to be fixed on a small screen. Also the other application that was mentioned in the second scenario (adding virtual objects to the real world with the help of AR on your smarpthone) can be done by Google's glasses.

4.2 Oculus Rift, making games more immersive?

Video games have become more and more immersive, always trying to involve the player in the best way they can. Many games already achieve this goal, with the help of big television screens or computer monitors that can render images very fast and in high definition (HD). Still, video games all miss something from the real world, and that is due to the controller, joystick or keyboard that is needed to play these games. For example, you can turn your head in the real world to see what is happening next to you or behind you, but in a video game you have to use the sticks on the controller or a mouse to achieve the same thing. And also,

however big your monitor is, you will always see the edges of it and what's next to them. These two disadvantages together keeps gamers from a real immersive experience, but this is where the *Oculus Rift* comes in.

4.2.1 What is Oculus Rift?

The *Oculus Rift* is a headset that uses virtual reality, and is designed specifically for video games [10] (see figure 9). One of the selling points for this device is its very wide field of view, which covers your whole sight. In other words: while you are gaming you only see the game world you are playing in, and nothing else - which would have been the case if you were gaming in front of a normal television or monitor. This is the first property of the *Oculus Rift* that makes gaming much more immersive. The other element that tries to drag the gamer more into the game is the ability to use the movement of your own head to look around yourself. Like said before, you normally need a joystick or a mouse and move that to look around you, but with the *Oculus Rift* you can simply turn your own head (as you would in real life) to look around you. These two main features combined are, according to the developers of the *Oculus Rift*, the properties that will change the way you think about gaming - forever [10].

Figure 9: The Oculus Rift.

4.2.2 How can we use it?

The *Oculus Rift* doesn't work with AR, so unfortunately the AR-features that were proposed in the two scenarios can't be used with this device. Although, not in the way AR normally works, projecting virtual things onto the real world (like extra information about something you are looking at or where your camera is pointed towards). If you think of AR as only the display of some extra information about something, then we can still use the *Oculus Rift*. Imagine yourself playing *Assassin's Creed* with the *Oculus Rift* and like with the scenario, you are situated right in front of the Colosseum. When you look at this building (all in-game), the *Oculus Rift* recognizes that fact and automatically displays some interesting information about the building, just like AR did the same thing in the scenario described before. In this way, the *Oculus Rift* can be used in more or less the same way as AR. But, this is only true

for video games; when looking at the second scenario we can't use the *Oculus Rift* for those purposes.

5 Discussion & Conclusion

To be written...

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