Virtual Reality’s Effect on Engagement
in Educational Games

Pontus Fredriksson and Herman Rödström

Faculty of Arts
Department of Game Design

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Supervisors: Mikael Fridenfalk, Hans Svensson
Examiner: Henrik Warpefelt

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Abstract

This thesis explores how virtual reality solutions affect children in their learning through educational games. The goal is to improve educational games in terms of how engaging they are. Therefore, a game was developed for both desktop monitors and VR, some children played both versions and were then interviewed. The collected data indicates that VR engages the pupils more, however it does not seem to necessarily make them learn more. This may be in part because of VR’s novelty, only gaining a mainstream status in the recent years.

Keywords: computer games, education, HTC Vive, Oculus Rift, virtual reality, VR.

Abstrakt

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1 Introduction

This thesis investigates how childrens’ engagement differ between educational games played in virtual reality (VR) versus the same games played on desktop monitors.

This chapter covers the psychological aspects of engagement and motivation in learning and ties it to game theories. These connections are the basis for the hypothesis that playing games in VR engages pupils more, compared to playing on desktop monitors. The Problem-based Gaming Model is explained as it serves as the template for the game created to test the hypothesis. A summary of VR’s history is presented to show why this is a relevant subject to study in 2017.

As a note, in this thesis, certain references to Internet links presently not included in the Internet Archives, have been enumerated and placed in the endnotes.

1.1 Background

What are the key factors for success in education? There are a multitude of answers to this question. Certainly environment, support from guardians, competent and inspiring teachers and how fast young people learn new things in general are all important aspects. These factors are, however, not something educational games today are expected to improve upon. Some things that educational games do for pupils, and excel at are:

- They explain specific concepts in new ways and providing a higher level of interaction than is available through other forms of learning (Griffiths, 2002).
- They are engaging and make learning more interesting (Malone, 1981; Squire, 2005; Paras and Bizzocchi, 2005), which means that games have the ability to provide intrinsic motivation.

Since this thesis focuses on engagement and motivation, it only briefly touches on the subject of explaining concepts in new ways.

Star Walk (Vito Technology, 2008) and Star Walk 2 (Vito Technology, 2014), for instance, are two smartphone games that teaches the player about celestial bodies. The game does so by using a star chart, showing celestial bodies and star constellations located behind the screen. It does so by using the device’s gyroscope. The players can interact with the star chart and gain additional information of whatever object peaking their interest. The game medium provides the consumer pedagogic means to understand star constellations, doing so independently of bad weather or atmospheric interference.
In 1981, Thomas W. Malone published “Toward a Theory of Intrinsically Motivating Instruction”, where he developed a theory about intrinsic motivation in games by answering the questions “Why are computer games so captivating?” and “How can the features that make computer games captivating be used to make learning—especially learning with computers—interesting and enjoyable?” (Malone, 1981). In this theory, Malone divides intrinsic motivation in three major groups: challenge, curiosity, and fantasy.

1.1.1 Psychology of Intrinsic Motivation: Challenge

Csikszentmihályi (1979, cited in Malone, 1981) identifies keypoints related to the challenge aspect of intrinsic motivation, all of which quite conveniently fits into the concept of games. Csikszentmihályi states that “the activity should be structured so that the actor can increase or decrease the level of challenges he is facing, in order to match exactly his skills with the requirements for action”. Level based gameplay is a very standard format in games to provide the player with an appropriately challenging experience.

Csikszentmihályi (1979, cited in Malone, 1981) also claims that “it should be easy to isolate the activity, at least at the perceptual level, from other stimuli, external or internal, which might interfere with involvement in it”. This fits well with game theory, specifically the concept of the magic circle. Paras and Bizzocchi (2005) describes the concept as “...once the learner is immersed within the world, the learner enters into the magic circle. Once inside the magic circle, outside things do not distract; rather, the learner’s focus is solely on the game and the events taking place within the game world.”. It is easy to see how this aspect of intrinsic motivation could be heightened by the use of VR, since it completely blocks out all other visual stimuli the player would otherwise experience.
Another point is that “there should be clear criteria for performance; one should be able to evaluate how well or how poorly one is doing at any time” (Csikszentmihályi, 1979, cited in Malone, 1981). Since all player inputs and interactions with a digital game are registered by the machine, it is an easy to create a system that provides the user with relevant feedback.

In order to provide intrinsic motivation “the activity ought to have a broad range of challenges, and possibly several qualitatively different ranges of challenge, so that the actor may obtain increasingly complex information about different aspects of himself” (Csikszentmihályi, 1979, cited in Malone, 1981). This correlates with some of the reasons why players find replay value in a game: difficulty, completion, randomization and the experience.

1.1.2 Psychology of Intrinsic Motivation: Curiosity

One of the most important features of intrinsically motivating environments is the degree to which they can continue to arouse and then satisfy our curiosity. (Malone, 1981)

Malone (1981) differentiates between two types of curiosity, sensory curiosity and cognitive curiosity. Sensory curiosity is linked to sensory inputs, such as lights, colors or sounds. In other words, how we perceive the world around us. Whereas cognitive curiosity occurs when a person is presented with inadequate information for them to form cognitive structures used to understand the information to the fullest. One example of how games uses cognitive curiosity to motivate players is logical puzzles, in which the player are presented with the tools to solve a task, but are not given the solution.

1.1.3 Psychology of Intrinsic Motivation: Fantasy

Malone (1981) further divides the fantasy part of motivation into intrinsic, and extrinsic, fantasies. He defines intrinsic fantasies as when the imagined setting, or the fantasy, is thematically fitting closely to the performed task and vice versa. A good example of intrinsic fantasy is if the task is to flee from another player in a thief and police version of tag, since task of fleeing closely resembles the fantasy of actually fleeing from police. The opposite, extrinsic fantasies, are when the performed task has little to do with the fantasy. An example is the gameplay of Math Vs Zombies (TapToLearn, 2013), in which the player “zaps” zombies by solving math problems. The task of solving math problems has nothing to do with the fantasy of “zapping” zombies, which makes it an extrinsic fantasy. Malone claims that “…in general intrinsic fantasies are both (a) more interesting and (b) more instructional than extrinsic fantasies”. He also states that exercising intrinsic fantasies gives a better understanding of how the used skill could be applied in real life, therefore giving the fantasy a higher educational value.
1.1.4 Problem-based Gaming Model

Educational games are often not using their full potential in the sense that they can provide ways to test a player’s assumptions, providing for learning by trial and error. Educational games are instead often used as a way to teach factual information while wrapping it in a game setting to make the task more appealing (Kiili and Ketamo, 2007). In a Problem-based Gaming (PBG) model the player first form a strategy for playing the game, this strategy is then tested and the consequences within the game are observed. A good educational game should provide information relevant to the player from a learning perspective, in order for the player to be able to reflect and revise their strategy. If a player does not revise their strategy, but just continue experimenting, this is called single-loop learning. By contrast, if they iterate and improve upon their previous strategy, it is called double-loop learning. Single-loop learning is considered to be inferior, since it does not encourage the player to improve, which, in turn, means that they do not learn very much. Striving towards double-loop learning encourages the player to reflect and improve their strategy, in essence learning about the subject.

1.2 The History of Virtual Reality

It all started in 1961 when Comeau and Bryan built the first head mounted display (HMD), featuring a motion tracking system, called the Headsight. The input for the video was streamed from a remote, closed circuit camera. It had a magnetic motion tracking system, which rotated the camera based on the HMD user's head movements. The Headsight was built for military use, providing a safe way of observing dangerous situations remotely.

The first HMD that was connected to a computer and showed virtual computer generated graphics, was created in 1968 by the computer scientist Ivan Sutherland and his student Bob Sproull (Sutherland, 1968). It was called Sword of Damocles, named after an old Greek anecdote. According to this anecdote, Damocles praised king Dionysus’ luxury and fortune. King Dionysus gave Damocles permission to sit in his throne, giving him every luxury the king had. He also arranged for a sword to hang from a single hair set in the ceiling, directly above the throne (Andrews, 2016). The sheer weight of the HMD Sword of Damocles was too much for a human to wear comfortably and made it a necessity for it to be suspended from the ceiling, much like the sword in the anecdote, hence its name.
The term virtual reality was popularized by computer scientist Jaron Lanier in 1987 (Burkeman, 2001). In 1989 his company VPL research began selling some of the first commercial VR goggles, EyePhone. They were sold for $9400.

Around 1990 VR games started to show up at arcade halls. The broad public could now for the first time experience VR. Although somewhat popular, the trend died around 1994. In 1995 Nintendo released their new console Virtual Boy (Vincent, 2016). The console was built into a HMD with a 3D system and an ultimate resolution of 384 x 224 pixels (Stevens, 2011). The console was a commercial failure and became Nintendo's second worst selling console of all time. It was discontinued in less than a year after its release.

In the following years VR began to fade from the small amount of attention the consumer market had previously given it. An array of HMDs were manufactured in the 00’s but none which would spark the consumer's interest like what would be coming. The public's attention towards VR completely skyrocketed with the launch of the “Oculus Rift: Step Into the Game by Oculus” Kickstarter campaign in August 2012. While their goal was $250,000, they collected more than $400,000 in the first day of their campaign (Oculus, 2012).
The popularity of VR has grown rapidly since then. Facebook acquired the company two years later, in 2014, for $3 billion.

![Figure 4. The Oculus Rift](image)

Sony announced Project Morpheus, an HMD for PlayStation 4 with a 1080p resolution per eye, now named the PlayStation VR (McWhertor, 2014). Google released their Google Cardboard viewer the same year (Statt, 2014), a head mount made of cardboard with a slot for the users smartphone to be used as the screen. Available for less than $5, it made VR available for everyone having access to a somewhat new smartphone. HTC announced the Vive in 2015. The HTC Vive is a VR solution with an HMD and two hand controllers that are all tracked in the physical space. Samsung released the Samsung Gear VR (Smith, 2015), which is similar to the Google Cardboard, but in plastic and with more features.

![Figure 5. An assembled Google Cardboard Viewer](image)
In 2016, VR headsets became the Swedish “Christmas present of the year” (HUI Research, 2016). It is an award created with the purpose of promoting sales on the Swedish market, and is one of the biggest influences in Swedish holiday sales. This truly marked VR’s entry into the mainstream market in the Swedish society.

As of 2017, the big names of high-end HMDs are successful, far from the days of the commercial failure of Virtual Boy. The PlayStation VR, released in late 2016, sold over 900,000 units in the first four months after its release, far exceeding Sony’s expectations. On the other side of the spectrum, the head mounts that uses the user's phone as the display are even more popular. In January 2017, Samsung stated that their Gear VR are in the hands of five million consumers. Meanwhile, Google has shipped over ten million Google Cardboard Viewers.

![Figure 6. The Samsung Gear VR](image)

As of 2017, the price of high-end HMDs are still high for the average consumer. The PlayStation VR costs $400, an Oculus Rift kit with touch controllers, $708, and the HTC Vive, $799 (Greenwald, 2017) . As with all technology, the same money will give you better and better equipment for every year that passes, and it can be expected that high-end VR solutions will only continue to become more available at cheaper prices.

The market seems to expand even more in upcoming years. SuperData Research (2016) estimates that the global software revenue for VR will grow by 6500% from 2016 to 2020. The VR market is still young and expanding, and it is difficult to estimate the future, but one conclusion seems appropriate. Its impact will likely only grow.
1.3 Definitions

VR

Virtual reality is the concept of using a Head Mounted Display to become immersed in the game, simulation or video that a person is experiencing. Everything that the person sees is part of the virtual world and the physical world outside is not visible. When users turn their heads, the view is changed accordingly. Some devices include special controllers that give users the ability to interact with the virtual world almost as if it was real. They can reach out with their hands and walk around in the virtual world.

![Samsung Gear VR](image)

*Figure 7. Samsung Gear VR*

It is important to note the difference between VR and Augmented Reality (AR). The two concepts are closely related, but still very different. The main difference is that in VR the user mainly experiences the virtual world, while in AR they see the physical world, with a virtual overlay, e.g. annotations or models connected to walls or floors. This thesis solely covers VR.

Educational games

By educational games we are in this thesis referring to digital games for computers, smartphones and other game consoles, designed with the core purpose of teaching one or several school subjects to the user.

HMDs

A head mounted display (HMD) is a display with two lenses just a few centimeters from the wearer's eyes. Some HMDs are semitransparent, made for AR, and some are regular displays, made for VR. The latter are the ones used for this thesis. HMDs can be standalone devices that the user can deploy applications or games on directly, and these are usually battery
powered, or they can be connected to a smartphone or a computer, in order to act like special displays for those devices. HMDs usually include sensors such as accelerometers and gyros, to recognize motions, such as when the users turn their heads.

**HTC Vive**
The HTC Vive is a VR solution, primarily a HMD, but with two controllers and two beacons as well. The beacons emit infrared light that many small sensors in the headset and controllers use to track the relative position and orientation between themselves and the beacons. With this data the devices can calculate their position and orientation within the room. This tracking method is sufficiently accurate to make it possible for the user to see virtual models of the controllers at their current positions in the virtual world.

![Figure 8. The HTC Vive HMD, controllers and IR beacons](image)

**1.4 Purpose**

Curiosity quite neatly translates to motivation – and that’s one of VR’s superpowers. If you ask teachers why they like to use virtual reality, they all agree on one thing: VR grasps pupils’ attention. (Krause, 2016)

With VR headsets gaining popularity, more and more educational VR games are created. There is heavy evidence supporting the thesis that including active learning increases understanding, as opposed to solely traditional reading and listening. Michael Prince (2004), among others, have studied and compared the two cases and have found that the gains of using both in a class is to be preferred. Considering this, it is understandable that educational games using VR is an intriguing concept. VR games in general are successfully evolving into new games where immersion is in focus, with mechanics depending on VR. This opens up to new kinds of learning experiences. But what if the game was not made solely for virtual reality? Does the simple addition of virtual reality in a game improve pupils’, engagement in the task?
The research question for this thesis is to investigate how VR headsets affect pupils’ engagement in educational games where VR is not mandatory. The hypothesis is that VR will heighten the pupils’ engagement. Support for this hypothesis can be derived from aspects of all three categories of Malone’s (1981) intrinsic motivation theory.

It is a fair assumption that the addition of VR in a game will heighten the user’s sensory curiosity the first times a player experiences it. There should also be long term benefits, since it increases the overall sensory input that the game gives the player. It is also reasonable to suggest that VR headsets decrease distractions, since they effectively block out any other visual stimuli. As Csíkszentmihályi (1979, cited in Malone, 1981) pointed out, this is an important part of improving the player’s experience of the challenge part of intrinsic motivation.

1.5 Related research

In “Learning by Doing and Learning Through Play: An Exploration of Interactivity in Virtual Environments for Children”, Roussou (2004) discusses the importance of active as opposed to passive learning and how learning through play is relevant since engagement greatly improves learning. She also discusses different kinds of interactivity in learning situations, especially in virtual worlds. Roussou notes how critical the role of a teacher, or in the case she mentions, the museum guide, in a virtual world, is for the target learner to “gain a deeper understanding of the content while having fun”.

There exists a multitude of studies concerning the use of virtual reality for children with disabilities. Many cover the different fields of learning in which VR is used to help train these children. There seems to exist a consensus among researchers that the field of application has potential. One case study concludes that “…it is clear that there are distinct advantages to the use of this medium in training, skills enhancement, and augmenting social participation” and that it “…can be developed to meet the special needs of the child or the specific goals of practice or training.” (McComas, Pivik, and Laflamme, 1998).

A literature review conducted in 2015 on related publications from 2013 to 2014, was focused on the uses and advantages of VR in educational situations. It states that most studies on educational VR are conducted on people from the age of ten and up, and that little research existed at the time the paper was published.

4
2 Method

The method used to test how VR affects engagement was to let nine and ten year old pupils play two versions of a game. A simple educational game explaining angles, with the working title Archer, was developed for this work. Two separate versions were created, one for the HTC Vive and one for desktop monitors and mouses. Apart from the different inputs and outputs, the games were identical. A structured interview after playtesting, focused on the pupils’ perceived experiences, was chosen as the method for data gathering. Considering the age of the participants in the study, a structured interview, with simple questions was deemed to be more efficient, rather than an unstructured one.

As stated in Interviewing Children (Docherty and Sandelowski, 1999), “children often have difficulty ascertaining what interviewers want to know from them, because interviewers take for granted that children will see the obvious”. This problem would require the test administrator to explain what kind of information was expected, and this could influence the pupils’ answers differently depending on the explanation. Another relevant fact when interviewing children is that “in general, children of all ages will withhold emotion-laden information” (Cole, 1986, cited in Docherty and Sandelowski, 1999), which is a major issue given that this thesis focuses on the emotional engagement. Children are still learning to express themselves, and it might be a challenge for them to give thorough genuine feedback on their experience. Children are on the other hand, familiar with questions where they are giving a grade from say, one to five. It is a standardized way to evaluate how satisfied Swedish pupils are regarding different aspects of their education, making structured interviews a fitting form to gather data about the pupils’ experiences.

Figure 9. Pupil playing the VR version of Archer
2.1 The game

The game was designed as an entertaining way to introduce the concept degrees. It was desirable that the scenario where the game was tested was as close to a real learning experience as possible, and degrees as a concept is taught in the fourth grade in Sweden (Skolverket, 2011a). Since the pupils are in the third grade they should not be too familiar with the concept, while it is still not deemed to be too advanced for their age group. The concept of degrees and angles is presented and explored in the context of shooting arrows.

![Figure 10. The bow with angle indicator, and a sphere indicating the other hand’s position](image)

The game was primarily developed with EON Studio, an integrated development environment used for creating applications focusing on 3D, VR and AR. The game’s models were created with Autodesk 3ds Max. Textures were drawn using Adobe Photoshop and Microsoft Paint.

It is an archery game in which the goal is to shoot arrows as far as possible. To help the players achieve this, they are shown the degree of the angle between the ground and the direction they are aiming for. There was a highscore board showing the player the five arrows that went the farthest, and the distance and angle they were shot at. The purpose of this was to give the pupils a chance to see the effect each shot had. The decision to only show distance and angle was chosen because it encourages the pupil to use double-loop learning and reflect on which angles produces different distances (Kiili and Ketamo, 2007). It is the most relevant data needed for the pupil in order to revise their strategy and try shooting at a more optimal angle. After a few shots it should become apparent that 45 degrees is the most optimal angle to aim for in order to shoot the farthest.
We purposely designed the game to not thrive from the addition of VR. The tests would not show accurate data of player engagement in “any game with added VR” if our test game was built specifically to include it. Therefore, the game was created to be as equal as possible between the VR version and the non-VR version.

2.2 Pupils playing

We tested if the addition of VR affects engagement by letting pupils play an educational game. Written permission was obtained from the school’s principal to contact the children’s guardians. At least one of each pupil’s guardians gave written permission for their child's participation in the test. Ten pupils participated in the play tests and the interviews, eight of them were boys and two of them girls. The participants were nine and ten year old children, all attending the third grade at a Swedish elementary school.

The ten pupils were divided into two groups of the same size, five in each one. The first group started to play the game using an HTC Vive as visual output, and its spatial controls as player input. The second group started off with a desktop monitor as visual output and a regular computer mouse as player input. After playing with their respective settings they were subjected to a structured interview about their experience. They then proceeded to test with the other inputs and outputs, and then the interview continued.

The play test and interviews were conducted in May 2017. Before the test the pupils were told about how VR worked, and when they put on their headsets they were guided in how to shoot
their first arrow. The concepts of angles and degrees were briefly explained through the context of the game as well. The test administrator answered any questions the pupils had about the game and how to play.

![Image](image12.png)

*Figure 12. Pupil playing the desktop monitor version of Archer*

### 2.3 Data gathering

A test administrator interviewed the pupils and wrote down their answers. Google Forms, which is a simple online tool for handling surveys and forms, was used for data management. The test administrator was one of the authors of this paper, as well as the pupils’ recreation instructor. According to the national curriculum (Skolverket, 2011b), the after-school activity is supposed to be educational. This, as well as the fact that the test administrator was already in a teaching role for the pupils, made the after-school activity a good place to perform the test in a genuine teaching environment, which was desirable.

The interviews were conducted in Swedish, since the pupils are not fluent in English. The first part of the interviews, performed before the first play session, contained questions used for data sorting. The questions, translated into English, were the following:

- Do you consider yourself familiar with VR games?
- Do you play games for recreational purposes regularly?
The playing time was limited to seven minutes, although the pupils were free to stop playing at any time before this time limit. The amount of time the pupils chose to play was noted. The interview then proceeded after the first play session. A very basic test assessing the pupils’ understanding of the concept of angles was conducted, and in part verbally executed. The pupils were shown five different angles represented graphically and numerically, and were instructed to match the numbers to the correct graphical representation.

![Figure 13. The test on degrees and angles](image)

The test was followed by questions, to which the pupils were told to answer on a scale from one to five, the answers were then measured quantitatively. The questions, translated into English, were the following:

- How fun did you think the experience was?
- How well do you believe you understand the concept of angles and degrees?
- How interested are you in playing this version of the game again at a later moment?

The pupils answered these three questions, as well as the degrees test, again after testing the other version of the game. The pupils’ general attitude and perceived emotions during both tests were observed and noted.

The interviews were concluded with the qualitative question: “What are your thoughts on using VR considering educational games?”. This question was asked to see if any of the participants could provide some insight or inspiration to other things that might be worth studying or analyzing.
3 Results
This chapter presents the results of 20 interviews conducted after the two play sessions of each of the ten pupils. The original intention was to interview 40 pupils but unforeseen problems with incompatible hardware postponed the play tests which made this practically impossible. Because of the low amount of participating pupils it is not possible to draw any definitive conclusions from the interviews.

The first part of this chapter breaks down the differences between the testing groups and highlights outstanding data. The second part presents the test administrators’ observations, as well as remarks from the pupils.

3.1 The interviews
All the following numbers (Appendix: Interview results in Swedish), not stating otherwise, are on a scale with a minimum of one and a maximum of five. 18 out of the 20 play sessions continued for the full seven minutes. Only one out of the ten pupils considered themselves familiar with VR. That pupil was one of two who gave the lowest score, 3.0, to how fun they thought the VR version was. They both gave the desktop version the same score of 3.0. The one who was familiar with VR was the only pupil who did not play the desktop version for the full seven minutes, stopping after three minutes and 53 seconds. Eight pupils answered that they are playing games regularly for recreational purposes.

![Figure 14. How fun the pupils thought the versions were](image)
When asked how fun the desktop monitor version was, the average score was 3.2. The average for the same question about the VR version was 4.4. Out of the pupils who tested the VR version first the average for it was 4.6, with only one pupil giving a grade different from the maximum, namely 3.0. The average from the group who played the VR version last was lower, 4.2, with only half as many giving it the maximum score.

The combined average between the groups for the VR version was 4.4 on the question “How interested are you in playing this version of the game again at a later moment?”. The corresponding value for the desktop monitor version was considerably lower at 3.1. The test group that played the VR version first provided the biggest gap in future interest between the games, giving the VR version 4.6 and the desktop monitor version 2.8.

![How interested are you in playing this version of the game again at a later moment?](image)

**Figure 15.** How interested the groups were in playing each version again

When asked “What are your thoughts on using VR considering educational games?”, seven answered that it would be fun. Two pupils thought it would be a good idea. One of the pupils who thought it would be fun, expressed that it may make the classroom quieter. One pupil thought that it would not improve anything, but rather make the classroom noisier from pupils begging teachers to play. That pupil, however, did not care and wanted VR in their education nonetheless. Every pupil felt excited about the idea of using VR in schools.

All except two pupils scored perfectly on the test concerning different angles both times. One of them felt that they did not understand the test at all after their first play session, which was in VR, and did not want to take it, automatically scoring zero. After playing the desktop version they scored the maximum of five.
The pupils who played the desktop monitor version first averaged 3.0 on the question “How well do you believe you understand the concept of angles and degrees?” after the first session. The perceived knowledge of angles and degrees in the group playing the VR version first was lower at an average score of 2.4.

3.2 Observed behaviours and responses

The pupils initial reaction after putting on the HMD was generally perceived as a sense of wonder. No difficulty was experienced by the pupils when familiarizing themselves with the VR HMD. The Vive controllers was generally perceived intuitively after a short demonstration by the test administrator. The game used in the test only used one button as input and no problems appeared for the pupils while using it.

Two pupils experienced minor vertigo but both continued to play for the full seven minutes. Two other complained about the strength challenge of holding up the controllers in the air after the test.

The pupils were told before that we explored how VR engages pupils. Even though they knew this, and that the game taught angles, two pupils were astonished when told that this was a game about maths.

During the first minute of the test the test administrator explained “Look at the bow while holding an arrow. It displays how many degrees the angle between the ground and were you are aiming. Aim higher and it goes up” While being explained this, several pupils ignored the instructions while using the VR headset to look around in the world.

3.3 Error margins

The test was conducted on pupils from a single school, so it is impossible to rule out the regional influence on the data. The number of subjects was also smaller than desired which makes it harder still to draw any solid conclusions. Since VR is a new technology, any increase in engagement might be a function of that the pupils are experiencing it as new and exciting. It is not possible to draw long term conclusions on heightened engagement from the addition of VR in educational games if this is the case. It could have been beneficial to gauge the subjects’ performance and general interest in their education. This question was deemed to have too many ethical implications for us to investigate. It is worthy to note that the tests were performed in May 2017. A pupil's general interest in school may vary based on how far the semester has progressed.
The test group was not large enough to give the test statistical significance. It would likely provide more accurate results to have a larger group of test subjects and giving them more questions would provide a broader picture.

The pupils gave both versions a high score on how fun they were. This may be caused by children enjoying games in general. Eight out of the ten pupils played regularly for recreational purposes. It could have provided a better picture of the differences between the versions if the interview was not divided into three parts, but instead questions about both versions were asked directly after each other.
4 Discussion

4.1 VR’s effect on engagement

Support for the claim that VR engages more compared to ordinarily displayed games was found even before the testing phase began. Some parents expressed excitement in their written permission of their children taking part in the experiment. It is beneficial to have engaged guardians, but it does not necessarily have an effect on the pupil’s attitude toward school. The day after the parents received the information about the test, pupils went up to the person who was going to administer the test and asked if they could perform it right away. Disappointment was expressed when they were told that the tests were going to be conducted the following week. This indicates a general interest in VR, and that even the mention of VR in education has the ability to spark engagement in pupils. It may be due to the fact that nine out of ten pupils answered that they did not consider themselves familiar with VR. Them becoming excited fits well with the theory of cognitive curiosity (Malone 1981), since they neither possessed adequate information, nor experience, to form a sufficient mental image of the experience of using a VR headset. However, it is possible that the long term effects on cognitive curiosity level off when the novelty of the technology fades. It is also important to take into account that the argument claiming that VR is interesting because it is new, is an old one. Different versions of “As it stands, virtual reality is still in its infancy” (McComas, Pivik, and Laflamme, 1998), are still commonly used.

The group who tested the VR version last gave it a higher grade than the desktop version, but a lower grade than those who tested the VR version first, this correlates well with the theory of sensory curiosity and sensory fantasy as parts of intrinsic motivation. The sensory curiosity of the pupils who had already experienced the 3D world through the desktop monitor version should be lower than the sensory curiosity of those experiencing the world through VR for the first time, and this is likely the reason for them giving the VR version a lower score. A heightened sensory curiosity overall should have been experienced while playing the VR version, due to an increase of visual stimuli. This should have increased the players motivation, and the results of the structured interview support this.

Eight pupils played both version of the game to the time limit. Since the maximum amount of time was underestimated because of the brief content in the game to explore, it is difficult to draw conclusions from this. The case may be that the addition of VR only engages for a while, and that it should not be planned to be used for extensive time. VR could be just in education briefly in the beginning phases of any field of study to spark interest, before moving on to other educational models.
It is noteworthy that the game the pupils tested was very compact and had little content, and that all the pupils experienced everything the game had to offer the first time they were playing it. Nonetheless, all pupils had a positive attitude towards playing the VR version of the game again at a later moment. The VR version averaged 4.4 out of 5 and the desktop monitor version 3.2 on the subject. These facts weigh toward the argument that it was not the content in the game that was the sole reason for pupils enjoying it. The fact that interest in playing the non VR version again was considerably lower also support this claim. It might be that the VR version provides a better outlet for the childrens’ sensory curiosity (Malone, 1981), which makes them more motivated to keep playing that version. In this game it is also arguable that VR made for a better intrinsic fantasy because of the spatial controllers making it closely resemble using a real bow and arrow.

In what way, and how much, VR will improve the intrinsic fantasy is something that will differ depending on the game, but in this case it likely did so by quite a lot. While the desktop monitor version by no means should qualify as an extrinsic fantasy, as it is not very abstract, it is not nearly as close to reality as the VR version is.

Every pupil said, in some way, that they wanted or thought it would be fun to have VR in their education after playing the VR version. This fact is perhaps the most compelling argument for VR engaging pupils more.

4.2 VR’s effect on learning

The pupils learning was supposed to have been estimated through a minor test on degrees and angles. That nearly all pupils passed the test with the highest marks is worth discussing. It made potential differences in the pupils learning difficult to estimate. A more comprehensive test would have been more optimal. It is curious to note that the group that tested VR first estimated their knowledge to be the lowest, giving it a score of 2.4, which is 0.6 points lower than the group who played the desktop monitor version first. This correlates with some pupils ignoring instructions after putting on the HMD. It also supports our claim that VR heightens the feeling of being in the magic circle, and that the use of VR blocks out other stimuli effectively, increasing engagement. It might also be caused by the novelty of the experience, and could be something that happens often when one is trying VR for the first time.

4.3 Apparent and potential problems with VR in education

Being as it may that VR seems to engage a majority of pupils more, it is worthy to note that it would be a questionable idea to use it as the main form of learning for any given subject. Given that two pupils found the experience of VR causing vertigo, it should be used as an aid, rather than a substitute for other means of educating pupils. It was not considered by the pupils in question as enough of a problem to stop playing, since they both played to the time
limit. This problem may be solved in the future with better technology, but as for now, vertigo is something all educators planning on using VR should take in consideration, and provide alternatives for pupils under the exercises.

The high end VR systems with handheld sensors not depending on the built in processor of a smartphone costs around $600 (Greenwald, 2017). The cost of a computer able to handle VR games averages around $1000 (Ackerman, 2016). This means that a school purchasing a multitude of PC VR stations seems unlikely. In the scenario that a school only gets one setup for VR it would require the teacher to help every pupil taking turns to use it. This could make using VR time demanding, and less likely to be sufficient in a class setting. The use of mobile VR headsets, such as the Google Cardboard, with which every pupil uses their own smartphone and does the given exercise simultaneously, could be a possible solution, given that all the pupils have access to a smartphone.

It is difficult to draw conclusions concerning the learning curve of the Vive controllers. Even if the pupils got used to using the HTC Vive equipment quickly, conclusions should not be based on this. It could still be problematic for teachers to explain complex controls since they can not simply point towards the right buttons since the VR user has an HMD covering their full view. Solutions to this potential problem would rely on game design since one can not rely on pupils remembering extensive briefings before the task.
5 Conclusion

The VR market has grown tremendously in the last couple of years, and trend analyzers estimate that it will grow even more (SuperData Research, 2016). VR HMDs are becoming cheaper and are becoming more accessible to the general video game consumer. How VR will become introduced into more educational games, and how it changes children's learning, is relevant now more than ever. The goal of this thesis was to explore the effects of adding VR to a game not built specifically for it, focusing mainly on how it affects the pupils’ engagement in their education. This goal was reached by creating an educational game with two versions, one using a desktop monitor and mouse, the other using a VR headset, and by letting nine and ten year old pupils in a Swedish elementary school play them and participate in a three part interview about their experience.

Since the test did not have a sufficient amount of participants necessary to make it statistically significant, the results indicate, rather than confirm, an increase in engagement when using VR. The VR version of the game was perceived as more enjoyable according to the data, and not a single pupil thought that the desktop monitor version was more fun than the VR version. The pupils’ interest in playing the VR version again was high. These result strongly suggest that VR does engage pupils more. No improvement of learning can be observed based on the test. The survey revealed that pupils, after only playing the VR version, perceived their knowledge to be lower than the other group and themselves did after also playing the desktop version. The reason for this could be because of the novelty of using VR, since the pupils generally expressed less interest in the instructions, and more interest in looking around in the virtual world.

A problem that appeared with younger pupils was that using motion tracked controllers in VR was tiresome, because of the weight of the controllers. Another problem is that VR can cause vertigo, but this will likely become less of a problem in the future, when the technology becomes more advanced.

In conclusion, we do recommend using VR in educational games. For now, VR HMDs with their own built-in screens are expensive, so it is more advantageous to use smartphone based headmounts such as the Google Cardboard. We do want to point out, however, that it should not be used as a substitute for other forms of learning, but rather as an aid to spark the pupils’ interest.
6 Future research

Due to high costs, VR has only recently been available to the majority of mainstream consumers. It would be beneficial to conduct similar studies continuously as VR technology becomes more widely used and the novelty disappears. Conducting a composite review of several tests using similar setups, but with other educational games, would provide a broader picture and could make it easier to draw a more certain conclusion.

If VR becomes a part of education it would be important to evaluate the actual benefits and shortcomings continuously to gather if it really helps children in their learning process. If educational VR games become popular in the future, it would be a great area of study to research in what extent children are playing these games in their own leisure time. If educational VR games are used in schools at the same time, it would be interesting to look at the similarities and differences between the games children choose to play at home, and the games they are instructed to play by their teachers.

The effects of pupils playing educational VR games as homework without teacher assistants could be studied. If playing these games at home seems beneficial, it would create an opportunity to introduce the games as homework. Then the pupils would play these games not only in school, but they would play them in another setting, which may be an advantage for some pupils. If the results are promising, educational VR games could be made part of schools’ curriculum and pupils could be given tasks in those games to play as homework.

The season and how far into the term the pupil have progressed, may affect pupils general attitude towards school, and it could be interesting to measure and compare results of similar tests to this one performed throughout the term.

There exists a multitude of different aspects and circumstances concerning education that can be evaluated to optimize the use of VR. There may be differences in the pupil’s engagement in different age groups. This could be tested all they way from kindergarten to university level studies. Pupils in different geographical regions globally may respond different to virtual education. How beneficial it would be to use VR in different school subjects is also a question worth asking.
References

Literature


**Internet**


Michael McWhertor. 2014. “Sony announces Project Morpheus, a virtual reality headset coming to PlayStation 4” At *Polygon*.


Skolverket. 2011a. “Kursplan - Matematik (Grundskolan)” At *Skolverket*.


Nick Statt. 2014. “Facebook has Oculus, Google has Cardboard” At Cnet

Tim Stevens. 2011. “Nintendo Virtual Boy review” At Engadget


James Vincent. 2016. “Nintendo is exploring VR again, 20 years after the Virtual Boy flop” At The Verge.

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Vito Technology. 2014. “Star Walk 2”.
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https://commons.wikimedia.org/wiki/File:Virtual-Boy-wController.jpg

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Figure 9. Pupil playing the VR version of Archer

Figure 10. The bow with angle indicator, and a sphere indicating the other hands position

Figure 11. The board showing the arrows that traveled farthest

Figure 12. Pupil playing the desktop monitor version of Archer

Figure 13. The test on degrees and angles

Figure 14. How fun the pupils thought the versions were

Figure 15. How interested the groups were in playing each version again
Endnotes


Appendix: Interview results in Swedish

Resultat av enkäten

<table>
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<tr>
<th>Elev</th>
<th>Först spelad version</th>
<th>Är du van vid VR spel?</th>
<th>Spelar du ofta spel för skojs skull?</th>
<th>Vad tycker du om att använda VR i skolan i framtiden?</th>
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<td>VR</td>
<td>Nej</td>
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<td>Jättebra det skulle vara roligt om man fick göra det varje dag (och fick spela vilket spel man vill)</td>
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<td>Ja</td>
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<td>Nej</td>
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