THE IMPLEMENTATION OF VIRTUAL ENVIRONMENTS IN EDUCATIONAL CONTEXTS

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Abstract

This study is meant to test what the beneficial properties of using virtual environments as a teaching tool for history are and how it affects the users. To test this, a prototype of Forum Romano was built to see how well test subject could perform on a prewritten test that included questions about the history of the place. The study also includes new found data from the experiment that comes from comparing an old plain text version of teaching with a virtual environment one. This can later be adopted further to help with new developments focusing on making students more engaged in their own learning.
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1 Introduction

Ancient history is one of the broadest spectrums that we can study, but with every new discovery we often end up with more questions than answers.

The Romans were not only a vast empire that ruled Europe with immense military strength, they also discovered the architecture foundations we use in most buildings today. Therefore it is important to take in what we can from what history can teach us. It gives us a greater understanding of how we can evolve, but with such a big subject, it can be hard to get people interested in the topic. With the exponential advances in technology today, we have the possibility to reform the current ways of teaching. Traditionally the study of history mostly includes books and long texts on the computer, and for the internet generation who use far more advanced media than books, this kind of media may seem tedious and not an effective way to help them learn.

My goal was to create a new kind of interactive learning tool that would use a virtual environment using 3D software to represent a historical monument in its original state. There are a lot of places around the world that are worth using as a prototype but the current prototype was focused on the Forum Romanum, Rome, Italy. The current state of the forum is mostly in ruin with some exceptions, and therefore a great monument to rebuild at its original state using 3D software. Rebuilding ancient roman architecture in 3D is not a new phenomenon; there are a few examples. The Rome Reborn, Bernard Frischer (president, Fricher Consulting, 2013) and the Progetto Traiano project by Dario Scoccimarro (2014) are both focused on the reconstructing of Rome in the era of 300 A.D. Rome Reborn is intended to be a guided tour but the use so far has mainly been directed towards video format. What I mean by this that is there is no deeper interaction for the user. One simply watches the video and can’t interact with the environment other than looking at it. The Progetto Traiano is a far smaller project, but here you are able to look at the Foro Romano in 360 degrees across all axes. This gives the user a chance to explore the site from a distance by rotating and zooming in and out, but one is not able to move from the specific point in the virtual world. The closest resemblance in my opinion would be Rome Total War II, a game made by Creative Assembly and published by SEGA (2013). In the game players can walk around with legions across the city and explore the environments if they choose to. However, because this is a game it restricts the level of detail and is intended to replicate the military attributes of the Romans and not the architecture itself. It is not intended to be used in a classroom or for lectures but instead is designed as a military strategic simulator of a kind. My prototype was focused on the user’s ability to move around freely, and not be restricted to a certain perspective. I discuss this in more detail further in my text.

Creating new learning software intended to coexist with the current learning methods would be a way to enhance the learning experience for students of History, primarily focusing on a high school level of learning. This will not be as effective as actually visiting the site or monument, but it will offer a cheaper option for people who don’t have the convenience of living nearby it. In my research I focus on the uses of 3D environments for subjects such as History and Civics to allow students a detailed visualization and experience based on the topics they are currently studying.
2 Background

In my research I focus on methods and theories that allow me to see if it is possible to improve the current learning methods used for history in schools with the help of 3D based software. This includes many noteworthy factors, some of which are listed below. These examples show the many different subjects related to such a study and demonstrate how interdisciplinary the approaches to such research must be.

In “Transactions on Edutainment”, Shaleh bin Suja (2008. p190-191) explains how videogames and technology have become a daily use in children’s life and how one should try to transfer that media in to the classroom to further enhance the learning possibility. With interactive learning one can not only enhance the student’s engagement but also have a tool that does not require the same amount of concentration as a book might. As mentioned earlier this would bring out further equality out through the classrooms, not require the same level of concentration as reading but also a cheaper alternative then actually visiting the site with a whole class.

In 2014 at Google I/O developer’s conference they announced their newly developed VR (virtual reality) called “Google Cardboard”. Virtual Reality is built upon the idea to bring the user in to the 3D dimension. Basically it is a pair of glasses that gives you the ability to see virtual environments directly and not through a screen. The ”Google cardboard” is a combination of cardboard pieces with two lenses attached, resembling binoculars. With this you use a cellphone and install different programs to give the desired purpose of the device. Schools around the world are trying this out as it is a very cheap alternative compared to other VR technologies.

In “Teaching and Learning in the Digital Age”, Louise Starkey (2012, p95) claims that it is the teacher’s responsibility to use the knowledge they have gathered under their own experience and relay that to their students. This is certainly true, but this might cause problems if these specific teachers haven’t been keeping up with the technological advancements allowed by the digital media forms. Using games or simulators in schools is not the most conventional way of teaching and like all new approaches to learning, it has both pros and cons. Harris and Hayden (2013) explain how interactive teaching has many grand benefits towards students’ learning curves and also increases the enthusiasm they show in school. It can also be used as an alternative for students that have difficulties with other teaching tools such as books for example. The benefits with books are that one does not need direction on how to go, you simply go to the next page. 3D tools give the users more options but will require some type of guiding when using it. With technology exponentially advancing there is no reason not to experiment with the new learning mechanics and technologies that are currently available.
2.1 The Physiological Aspects

The reason I chose to study this topic is due to all of the students having difficulties in school, it is important that we acknowledge that current learning tools might not be optimal for all individuals. This brings up some examples and why one should engage in more interactive learning methods. Using interactive learning tools to help students with their struggles is not uncommon in today's schools. Games to help students with math and other subjects have been around for years. The prototype is not a tool made to throw away the current teaching tools but rather a tool to coexist with them. Dr Håkan Nyman (2011) explores some of the most common cases of learning disabilities and the challenges students struggle with. He states that in most cases it can be hard for students with disabilities to seek out the special help they might need. If the student doesn't understand his or her problem, it can result in them feeling unsecure and different. Therefore the educational surrounding is a big factor in how teachers should handle these situations. The most common types of learning disabilities are, Reading (Dyslexia), calculation (Dyscalculia) and movement (Dyspraxia). There are also other disabilities connected to school difficulties like ADHD, ADD, Autism, Asperger's and Tourette’s-. There are also cases where a diagnosis isn't needed to decide if a student needs extra help or not. In these cases, it can still be referred to as a learning disability if the student seems to have more difficulty keeping up with the other students for whatever reason. Nyman also discusses the importance of not excluding children but instead finding other ways to engage them in the classrooms. This is why an interactive learning tool would not only help visualize and stimulate curiosity but also give a common way of educating the students and include as many as possible.

Dr Nyman’s earlier background around the subject involves being a president at the Swedish Psychology Association (Sveriges Psykologförbund). The Swedish Psychology Association is a trade union association for psychologists, students of psychology programs and doctorates in psychology and education. They are consultants in matters regarding community, ethics, education and science related to psychology issues.

2.2 Technology

In 2016 Oculus VR will release the new Oculus Rift, a new form of virtual reality that evolves 2 screens put in front of your eyes and with trackers that mimic your head movement. Oculus VR is not alone on this front either. Multiple companies like SONY, Samsung, Google and HTC are creating their own versions of the hardware. Mobile applications are already getting developed to them, and we can expect many new developments these next couple of years. Google has already stepped in with the “Google Cardboard” towards educational use, but their technology is not as powerful, and they mostly use panorama images for this kind of work. The prototype is a step beyond that. Instead of only being able to see places in their current state users are taken in to the world as it were at its original state. With 3D software such as “Autodesk Maya” for example you are able to create almost anything in 3D space. Technology will therefore be used to recreate historical monuments for an educational purpose that will be usable both on a computer and a VR Platforms.

Since many schools around Sweden already have some sort of computerized learning technic it is important to not limit the user by creating it with a specific platform in mind. Some schools might use tablets while others use computers based on IOS systems and Windows systems.
2.3 Virtual Environments

The essential steps of creating 3D environments, whether it is a city, ruin or a hut in the open plains of Africa, is to understand the environment; why it looks the way it does and how it effect on the surroundings. This is what gives it its unique atmosphere and what can enhance the overall experience for users. D. Watkin describes in his book “The Roman Forum” (2009) the social lives of the Roman society and what different structures would have been used for and the crucial parts of reconstructing historical monuments. D. Watkin describes the Temple of Castor and Pullox explaining its history and use.

The Temple of Castor and Pollux, for example, one of the most ancient temples of the Forum, dating back to the fifth century BC, had a giant podium from which orators addressed the crowds, while inside the podium were vaults serving as safe-deposits for private citizens and as a public treasury. - The Roman Forum, David Watkin p.36.

This is just one example of the detailed descriptions he uses for the different locations and gives a greater understanding on how society could have looked like 2000 years ago. When creating some sort of civilization it rarely ends up as it was intended to. When it evolves it adapts towards the need at hand, roads, storehouses, markets etcetera. The currently named “Santa Maria Degli Angeli e dei Martiti” is currently used as a catholic church but was first created by the Romans as a bathhouse. Professor D. Kliener from Yale University brings this up from her online lectures (2009) focusing on the evolution on Roman architecture. She mentions the frameworks of which the Romans used during different eras. She describes how you can study the earlier architecture of the Romans and see patterns from Egypt and ancient Greece adapted in to the Roman constructs. But there are more factors to keep in mind: the material varies depending on location; carvings and sculptures can change depending on which Gods/religion were seen as most important - all this is important to keep in mind if you want to strive towards giving the user the most genuine experience possible. Banister Fletcher, formerly a professor of architecture in King’s College, London mentions in “A History of Architecture on the comparative method” (1905) the evolution of the Roman architecture and its expansion out through Europe. It contains information regarding structural differences depending on region and time and also illustrations showing details regarding structural plans on famous places, one being the Roman Forum. Both the Rome Reborn project and the Progetto Traiano project used this as a guideline when constructing their versions of Rome. Even if it is an old book many of the places mentioned were in better condition at the time than they are now, depending on seismic activity and how it has affected the area. For example the earthquake in February 1971 was picked up to be a 4.6 on the Richter scale (the main measurement for seismic active) by the USGS (United States geological survey’-s), and it was said to do extreme damage to the landscape across Lazio, Italy. This is why an older book is useful, there are a lot of structural design plans lost due to such events and combining old and new information gives a better understanding of the visual aspect of the Foro Romano. Elizabeth Bowens A Time in Rome (1959) makes some interesting claims in the first chapter of her book. She explains the many changes that took place in Rome between her visits and how imagination might trick one’s mind in to remembering a place in the wrong state.
What I recollected could not be found again: it had not existed. There came point when I wondered, where was my sanity? Memory must be patchy; what is more alarming is it face-savingness. - A Time in Rome, Elizabeth Bowen p5.

Even if she mainly refers to parts regarding new Rome, not Ancient Rome (753 B.C – 476 A.D), it is good to keep in mind that a living city constantly changes, and it can result in very different visualizations depending on the different experiences of users. B. Fletcher explains in “A History of Architecture on the comparative method” (1905, p113) how it was first after the “Building Act” under Augustus Caesar 27 B.C. Rome made considerable developments. If one were to compare Rome 300 B.C and Rome 300 A.D both of which still count as Ancient Rome, one would see immense differences in the architectural design and expansion.

This is why in the design of my prototype the structures were checked for accuracy so that they are from the same century and preferably under the same Emperor. Roman Emperors had a tendency to change minor architecture, sculpture, texts, podiums to fit their leadership/image better as mentioned by B. Fletchers (1905, p113). In “A History of Rome, to the establishment of the empire” (1855) by Henry George Liddell, he mentions the many impacts of war regarding the Roman evolution and its effect on the society. He also depicts the more practical uses for the Roman design, for example he discusses how heating and infrastructure would have worked with high-class citizens compared to low-class citizens.

B. Fletcher’s (1905), H.Liddell’s (1855) and D.Watki’s (2009) claims are very similar, and even if their books are focused on different subjects, their facts still branch in-to eachother on many topics. All served as support for my designs.
3 Problem

Technology has been advancing at a rapid speed, but it seems that the development for teaching purposes have been left behind. This is certainly different depending on what school and what subject one refers to, but in some cases the school system has not yet caught up with the new advancements in many ways. This is in my research, I evaluated if there is a possibility to advance learning with the help of virtual environments and also in which way it is beneficial for the students compared to older media.

Change is always difficult but it is essential if one wants to make progress in education. Even with some technology in the classroom, today’s students still study in a similar way they have done for hundreds of years. If we are to see progress, in students’ behavior and results schools and teachers must be encouraged to adapt. This is not an easy task and requires time to achieve, but with small implementations one could improve the experience for students by creating more interactive media. By interacting with the subject one is studying in a virtual environment students/users will not only get a clear image of a topic, in this case Forum Romanum, one can also get an understanding of how and why ancient civilizations look as they do. Text cannot fully capture all the information on a topic, and have limits to how they engage people in the experience of History. Movies may give a clear picture but they don’t give viewers the freedom to explore the experience in an immersive way. The best option could be actually visiting the place, but the next best thing would be to simulate it. Patrick Felicia author of “Handbook of Research on Improving Learning and Motivation through Educational Games” (2011) talk about the different benefits regarding interactive learning with computer technology. Even if P.Felicia main focus is physics, much of the information can be used to support my own claim that it has its place in schools and can be used for historical subjects too.

So, in my research my aim was to test, if there is any solid evidence supporting my claim regarding how virtual environments can improve learning regarding historical topics. This can be formulated as the question: What are the beneficial properties of using virtual environments as a teaching tool for history and how does it affect the user?

3.1 Method

The experiment involved two factors, a survey surrounding the subject with prewritten questions and also the creation of an actual prototype meant for testing whether there is any solid evidence supporting my claim that interacting with virtual environments can prove to be a useful tool for learning. The subjects themselves was not be focused on a specific target group of people, but was sorted out in the data collection later depending on their similar backgrounds and previous experiences. This type of questioning is called Structural interviews, the informant answers prewritten question in an open way, not restricting ones answers to a single statement or word. This is mentioned in by Östbye, H., knapskog, K., Helland, k., & Larsen, L. in “Metodbok för Medievetenskap” (2003, p102-103), and explains how structured interview is a way of obtaining information but still give the informant the option to answer in his own words and statements. Structured interviews are easier to analyze and collect as data, the answers’ are not up for interpretation the same way as compared to a non-formal interview with no questions guiding the conversation.
3.1.1 Survey
This step involved a collection of data surrounding both the user’s earlier experience and also thoughts concerning the implementation of such software in to schools or learning in general. This involved the following questions and descriptions.

Q1. Gender, Age, Student / Employed / Unemployed?

Q2. Out of the following options which one do you find is your most common source of information while studying?

Books (e-books) / Video source / Lectures / None of them

Q3. Do you have any earlier experience with virtual environments, for example games or simulators?

The collection of data showed differences involving age, gender, profession and if earlier experience was an important factor.

3.1.2 Prototype
The prototype represents a restored version of the Forum Romanum in a virtual environment using a game–engine. The constructions was recreated using 3D modeling software with guidance from David Watkins “The Roman Forum” (2009), Banister Fletchers “A History of Architecture on the Comparative method” (1905) and an overlay using Google Earth, which is a software used to map out cities and environments. Similar building such as the Maison Carrée, Nimes, France gave a greater understanding towards measurements and building technics. Earlier studies on the city of Pompeii also gave an insight on the historical attributes. The architectural findings of Pompeii are far more preserved and give a much more accurate picture of the details in the structures. Even if different materials were used, the structural design is still similar as mentioned by Fletcher (1905, p111-173).

The evaluation itself was split-up in to two pieces. The first half of the group started by getting a small explanation on the subject, details about Forum Romanum and its history. They were then presented with a text with more detailed information. The text explained the structural design and the history of Forum Romanum, how it looked and what it was used for. The test also contained a more in-depth explanation on each building and what uses it had in the society. The total length was around 2 pages. After that the subjects took a small test with questions related to what they just read. They then took part in phase 2 trying out the prototype.

The other half was set out to try the prototype on a computer to begin with. Here they were able to experience the site freely and walk around as they saw fit. Each place in the prototype had integrated text that the user was able to read while one walked around. The user was not restricted to a time period whilst using the prototype. Instead the total time of use was noted. This was to see if the prototype actually made people interested to learn more and explore. After they were done they took the same test as the other group to see if there was any clear indication supporting my claim. When they completed the test they were presented with the text from the first group to compare. Then a verbal discussion took place with prewritten
questions and I took notes on what their opinions were regarding the prototype. This involved the following questions and descriptions.

Q1. Before you took the test would you say you had any earlier knowledge about the Roman Empire or the Forum Romano, and how would you grade it in a 1 – 5 scale?

1. Almost no prior information regarding the Forum Romano or the Roman Empire.

3. A decent amount of knowledge about the Roman Empire, but very little regarding Forum Romano.

5. Knowledge about both the Roman Empire and the Foro Romano, and specific details surrounding the structures found inside the prototype.

Q2. Was there anything unclear to you during the experiment, if so what?

Q3. What did you find interesting and/or educating in the prototype?

Q4. What did you find interesting and/or educating in the text?

Q5. Was there any clear informative difference between the text version and Virtual Environment and which did you find more useful?

3.2 Method Discussion

The reason I divided the evaluation into two separate stages was because I wanted to be able to see the different opinions before and after they had tried the prototype and also the differences between reading about the subject and exploring it yourself. With that information I was able to see if there was any strong evidence supporting my claim and if pre-knowledge about such devices could influence the user’s experience. The questions in the first stage are structured to bring out differences towards the subjects and how that might affect their opinion towards the product. But this was only conclusive to a certain point. If I were to only interview one person that had earlier experience with VR I couldn’t conclude that all people who have previous knowledge about VR would have the same opinions. Therefore, it was important to have a balanced number between users who have had earlier experience, and those who did not. The same is true for the other criteria, such as gender and employment for example. If the subjects vary too much from each other, with no common ground the information will not reflect a larger group but instead the individuals own perspective. It is also worth mentioning that I chose to include the question about prior knowledge (part 2, Q1) in the second part. Sometimes it can be hard for people to answer what prior knowledge they possess concerning a subject before taking part of a discussion on it, and if I were to ask this question in part 1 they might not have recalled that they actually knew a thing or two about it but they didn’t realize it before the test took place. Visual or verbal cues might have triggered their memory later in the experiment that could have changed their opinions on their prior knowledge regarding the subject.
3.2.1 Qualitative Information

The first stage was to get a general sense on what the test subject’s earlier experience might be and if one could find patterns to try make certain generalizations. The first stage could be incorporated to fit quantitative information to get a broader sense of perspective, but with limited time, I chose to exclude that, and solely focus on a qualitative form of data collection. As I planned on having 10 test subjects, I knew that it wasn’t a big enough group to determine a broad generalization, but still offered some insight on the individuals and how their thoughts on the product might result in future development. After the subjects were done with the experiment the next segment was more directed towards deeper opinions on their experience during the test. This was also to see if the test was a success or not and if so, what part they found most useful and intriguing. I was able to see if the subjects considered some part of it less beneficial and/or if they have any opinions towards changing it.

3.2.2 Evaluating the data

After completing the test both groups’ scores, the prototype group (Group A) and the text group (Group B) was to be analyzed and assigned so that both group A and B would have a total score that represented how well each group performed individually. Each correct answer represented 1 point, with a maximum score of 9 for each individual test subject. To evaluate further both the total scored points between the groups was compared and also the individual average in each group. This showed if the prototype had the same amount of capabilities to educate students as a classical text based version had. Combined with the questioning section this also told us the differences between how the prototype works in practice and how its properties relate to the students’ capability to learn.

3.2.3 The creation of the prototype

Even if I have personally visited the site many times, reconstructing Ancient archeology results in me having to refer to others’ work. Many of the authors I have mentioned above, for example, B. Fletcher (1905), D. Kliener (2009) are my primary sources of information from where I recreated the Forum. The Rome Reborn (2013) project also provided useful information with their worldwide contribution from archeologists and historians. None of my created structures in the prototype are made from information gathered out from the field from me personally, but are solely from literary and visual sources concerning the subject. If the information in my sources would later be thought of as wrong or misleading my work will also lose its credibility. This is why I’ve chosen to note many similar projects instead of just one source of information to make my data more credible and not thought of as imaginative.
4 Implementation

This part explains the first try out of the prototype alpha V.1 and also the corresponding text version. How the pilot study contributed with new information on the subject and how one should approach the actual experiment itself. It mentions the many changes during the process of creating the prototype and important factors left out. The pilot study was only done on 2 different subjects, Subject A and Subject B. I decided not to ask the following question in the beginning of the experiment.

Q1. Gender, Age, Student / Employed / Unemployed?
Q2. Out of the following options which one do you find is your most common source of information while studying?
   - Books (e-books) / Video source / Lectures / None of them
Q3. Do you have any earlier experience with virtual environments, for example games or simulators?

These questions are made to sort out the different subject who took part in the experiment and was not relevant in this part of the study since the pilot study’s results wasn’t included in the final data sortation and therefore served no purpose in this step.

4.1 Pilot Study

In the pilot study 2 subjects were set out to do the first version of the experiment, this included one person playing the prototype and one only using a text document filled with the same information that is located inside the prototype. After that a test took place where both subjects answer questions about each major structure. This first test was only to see if the information inside the prototype and the text was clear enough and also if there were any major bugs or problems concerning the prototype. The subjects then answered the follow-up questions:

Q1. Would you say you have any earlier knowledge about the Roman Empire or the Forum Romano, and how would you grade in a 1 – 5 scale
   1. Almost no prior information concerning the Forum Romano or the Roman Empire.
   3. A decent amount of knowledge about the Roman Empire, but very little regarding Forum Romano.
   5. Knowledge about both the Roman Empire and the Foro Romano, and specific details surrounding the structures found inside the prototype.
Q2. Was there anything unclear to you during the experiment, if so what?
Q3. What did you find interesting and/or educating in the prototype?
Q4. What did you find interesting and/or educating in the text?
The subject that tried out the prototype, subject A, said that it was fun to learn in an interactive way. It was not what one normally is used to. Subject A felt it was strange at first and had some problems to use the device in the beginning but after under 1 min he understood the game mechanics and how everything worked. It is worth mentioning that I didn’t reveal any information about what everything was and how to do it. I wanted to see how the user interacted with it without verbal feedback and if that led them to go to certain areas of the map or structures that I originally might not have intended them to go. The pilot study for Subject A was a success; he didn’t encounter any bugs or any problems concerning the information given to him whilst in the prototype. Subject B, the person who tried the text, felt no problems while reading. Commenting it felt like reading facts about history whilst one was in school. Subject B didn’t find the content in the text interesting but also mentioned that he didn’t have any interest in history as a subject overall. Both Subject A and B graded their prior knowledge at 1 in the 1–5 scale.

The information regarding the forum Romano structures is not mentioned in this document, but all the information given to the test subjects are located inside the prototype alpha V.1. This is because the information given to the players is not the important part of the study; the only requirement is that it is understandable for the user. My opinion is that the information itself could just as easily have been made up information regarding Forum Romano. The experiment test the user’s ability to gather information whilst using the prototype and comparing that with people who only experienced a text version of the information, not how much they actually learned about the real forum Romano. The questions for the test itself are mentioned below:

- What was Basilica Julia used for?
- What was Basilica Aemilia used for?
- What is the purpose of Arch of Septimus Severus, and in honor to what was it built?
- What is the name of the Grand center column in the plaza and which emperor was it dedicated to?
- What or who was Temple of concord dedicated to?
  A. A god
  B. Emperor
  C. Victory
- The Temple of Castor and Pullox is named after what?
  A. Stars
  B. Soldiers
  C. Gods
- The Temple of Saturn is dedicated to what?
  A. Planet
  B. Battle
  C. God
- Temple of Divius Lulius is named after which Emperor?
- What was the main purpose of the Rostra?

The reasons I chose to mix question where you have prewritten answers and where you actually had to write the answer yourself is to make a difference in difficulty in the test. Both the pilot study test subjects had an easier time answering the questions with 3 prewritten answers. Both of the subjects had 4 out of the 9 correct, and whilst trying the
other version (text/prototype) they got a chance to answer the incorrect answers, this was to make sure that they felt that the text actually mentioned the answers needed for the questions which both of them agreed on that it did.

4.2 Progression

The creation of the alpha version of the program led to many changes from the original thought process around the project. Even if the prototype was never intended to be a hyper realistic representation of Forum Romano, a few problems accrued during the process. The Alpha V.1 of the program does not include textured surfaces due to time constraints, and therefore only represents the structural geometry of the Forum Romano.

![Representation of Prototype, alpha V.1](image)

Since the experiment is intended to test the beneficial properties of using virtual environments as a teaching tool for history it still serves its purpose as a representation of Forum Romano. Alpha V.1 also doesn’t include statues, the Progetto Traiano (2014) project do include this is their project, but I wasn’t able to find any convincing evidence supporting what the individual statues actually looked like. It seems that the Progetto Traiano project only implemented such decoration for an aesthetic purpose since many of the statues are duplicated, as can be seen in Figure 2. In B. Fletchers (1905, p 123) book he only mentions a general look of the statues and ornaments during the Roman time period, not an exact description of each one. This is why I have chosen not implement such details in the Alpha V.1, but might be included in future versions of the prototype.
Figur 2  Progetto Traiano project, BasilicaAemilia

The structures that are implemented in the prototype are taken from B. Fletchers (1905, p 121 - 125) blueprints over the Forum Romano and are the following.

- Basilica Julia
- Basilica Aemilia
- Arch of Septimus Severus
- Temple of Vespasian
- Column of Phocas
- Curia
- Rostra
- Temple of Concord
- Temple of Castor & Pullox
- Temple of Divus Julius
- Tempel of Saturn

Columns with no specific name description are also places out through the plaza.

From the start it was intended to be lower detailed structures surrounding the forum but after consideration and testing it almost doubled the computer requirements to run the program and was therefore erased. It would have given a more aesthetic feel to the environment and I assume a better experience for the user, but the test is supposed to compare if there is any benefits in learning via a virtual environment compared to a text based explanation including the same information. So I concluded that even if the scene losses some part of its aesthetics it still holds the same value of information the users are able to gain. This was shown while Subject A tried out the prototype he had no problem gaining information and after asking him afterwards if he felt that the lack of textures was disturbing, he answered: No, I actually didn't think about it, or maybe I did, at least I didn't think about it while playing. He felt that the important part was the structural design and representation itself.
5 Evaluation

The evaluation was conducted on two separate groups, Group A who got to test the prototype and Group B who got to try out the text version. This was so I could compare which group recalled the most information about the subject. The data collected can be sorted out into 3 major categories, the first part is meant to capture some general data about the applicants, such as gender, profession and age, but also their prior experiences with virtual environments (games, simulators, 3D tools) and what their most common studying tool is. In the second part the test subjects took part in the actual experiment, where they either got to do the prototype version or the text based version. All subjects had a maximum of ten minutes to study before they had to quit what they were doing and then take a test of 9 questions to see how well they had gathered information. Each question represents 1 point on how well they scored, with a maximum of 9 point per person. The last part of the study was the follow-up questions, these questions regarded their prior knowledge about the Foro Romano or the Roman Empire, also if they had any struggles during the test and lastly their opinions on what they just experienced.

5.1 The Study

Out of all the test subjects that were part of the prototype I chose to include 10 out of 16 in the results. This is because the 6 persons that got excluded had too much prior information about the Foro Romano and in the after comments they felt the test was too easy due to already knowing many of the answers, ranking themselves at 3 – 4 on the prior knowledge scale. The result of this was to cut out everybody that had rated their prior knowledge at 3 or above. Only people who had mostly no prior information or at least very little concerning the Forum Romano or the Roman Empire got included to be part of the final data. Both an average group score and a total group score was compared to see which method worked the best.
5.1.1 Introduction information
The test subjects that were chosen to be included in the experiment were between age 20 and 25 and all test subjects in the final results had an education above high school level and with no formal education in history on the subject of Forum Romano. As for part 1 the following questions were answered and here you can also see how the statistics looks.

Q1. Gender, Age, Student / Employed / Unemployed?
Q2. Out of the following options which one do you find is your most common source of information while studying?
Books (e-books) / Video source / Lectures / None of them
Q3. Do you have any earlier experience with virtual environments, for example games or simulators?

![Graph representing gender distribution](image1)

![Graph representing profession distribution](image2)

![Graph representing source of information](image3)

**Figur 3** Representation of the data collected from part 1.

As for the last question in part 1, all the test subjects had earlier experience with virtual environments and was familiar with what the term meant.
5.1.2 Results

As the experiment began Group A was chosen to test the alpha prototype V.1 with the individuals score ranging from 4 - 6 out of 9 being the maximum score and they had an average score of 4, 7 points and spent an average of 6 minutes preparing for the test.

Group B had similar results with their scores ranging from 4 - 5 and an average of 4, 4 points they spent an average of 7 minutes studying before taking the test. Some of the test subjects in both groups had an urge to go through the information more thoroughly than others, and reaching a time of 10 minutes and was then asked to end what they were doing to take the test.

In Figure 4 you can see how well both groups scored and also how each test subject performed.

![Graph of Total group score](image)

![Graph of Individual test subject score](image)

**Figure 4** Data collection, representing the amount of correct awensers for each group and the individual score per test subject.

In figure 4 you can see that both group performed very similar on the test and no group individual got all the answers correct, but the big difference was the questions concerning:

- What was Basilica Julia used for?
- What was Basilica Aemilia used for?

None of the test subjects in Group B got these questions right, either mixing the buildings up or not remembering them at all. This is where Group A excelled, each of the individuals had at least one of the questions right, and showed that it was easier to differentiate the buildings when they had a visual image of it in their mind. This was mentioned by two of the test subjects in group B after they had done the text based test and later tried out the prototype. They mentioned that they would have had an easier time remembering the differences if seen as in the prototype and also mentioned that they felt more excitement. This was an
overall conclusion out of all the test subjects and one subject from group A stated the following;

Normally I have a really hard time finding any interests in studying history this was a bit more entertaining and also gave me a new experience whilst I was doing the test. I wouldn’t say that it is something I would do freely but it was easier to keep my concentration compared to the text based version.

The full extent of the test group’s answers from the follow-up questions can be found in the section Appendix A- Test subject results.

5.2 Analysis

Since no clear pattern emerged from the results regarding gender, employment or their choice of learning media, one should rather discuss the differences from group to group.

Two of the test subjects in Group A had a tendency to give more accurate answers, describing a bit more information on the subject then the others in Group A and B. This might just depend on how they normally perceive information and is hard to tell if it depended on the prototype or not. Group A also had an easier time answering questions where you didn’t have prewritten options to choose from. This I believe is due to the visual feedback one gets whilst doing the prototype, compared to a text based version.

Concerning the matter of how prior knowledge might have affected their results each test subject got to rate their prior knowledge but it can still vary depending on the individual in a small way. A simple question of five choices can’t answer this with complete accuracy. The question itself only represents a generalization of what the test subject thinks their prior knowledge concerning subject is. This is why I chose to exclude the 6 persons who rated their knowledge at 3 or above, even if they might not have known the exact answer to the questions they might had earlier information helping them guess, especially the questions with prewritten answers. Here is an example of two of them:

- What or who was Temple of concord dedicated to?
  A. A god
  B. Emperor
  C. Victory
- The Temple of Castor and Pullox is named after what?
  A. Stars
  B. Soldiers
  C. Gods

Another factor that gave surprising results was time. The test subjects in both groups, who spent more time than the others, hitting the limit of 10 minutes, didn’t get more answers correct than people who spent less. 3 of the test subjects used up all their time and their scores ranged from 4 – 5, while people who spent little over 5 minutes got the same score or better. I would assume this is due to the individual ability to perceive information and will depend on which person who takes the test. If the test was longer and more complex the differences might have been clearer and also given more beneficial results regarding how
time spent in the prototype versus time spent reading plain text will result in better or worse test results.

The score and time of each individual test subject can be found in Appendix A – Test subject results.

Regarding the follow-up question and how the test subject felt their recent experience had been, varied with each individual, they all commented that they felt visual feedback is a valuable asset whilst studying, and that the prototype had the benefit of freely exploring the historical site. Some applicants also mentioned that even if they felt the prototype had its usefulness but it would probably be more likely to compliment normal history books not replace them. If the study would have had test subject who had no prior information on virtual environments this might have led to a different conclusion, they might have experienced greater issues whilst using the prototype then people who have had experiences with games and similar programs.

5.3 Conclusion

The study was set out to test what the beneficial properties of using virtual environments as a teaching tool for history was and how it affected the user. As for a conclusion on what my work has led to and what the data shows, I believe that the score difference between the groups is too similar to make any clear statement on whether the prototype is a better means of learning than plain text. Regarding the actual results of the history test it did show that visual assets did help the participants remember more specific details when answering the questions. As for the comments on how the subjects felt about each learning tool the prototype showed a big difference in how engaged the test subjects felt. Very few of the participants felt that they would read the text based version on their own time but some of them felt that they might have checked out the prototype even if they had no obligation to do so. This concludes that interactive learning does have its benefits and while the test results didn’t vary to a great extent it can still be said that it is a viable way of teaching history to students.
6 Concluding Remarks

6.1 Summary

What are the beneficial properties of using virtual environments as a teaching tool for history and how does it affect the user?

This is the question that has driven the whole work progress, everything including the development of the prototype to the research later conducted. Throughout the study many changes took place, both on how I personally look at the problem but also changes that improved the credibility of its results. The experiment tested how well people would perceive information while using virtual environments compared to a classical plain text based version. Results showed that people who used the prototype felt more enjoyment while playing it than reading a basic text document. Group A was set out to try the prototype and got a combined score of 24 points on the test and Group B who tested the text based version scored 22. The test included 9 questions regarding the history of the different buildings in Forum Romano.

The test also showed that the visual feedback in the prototype improved user’s ability to remember details more accurate. Though the prototype had many positive comments and good feedback, the test results regarding the actual history test was only conclusive in showing that a program like this has the capability to be used to study history. However the amount of information perceived is more dependent on the user and not the program itself.

6.2 Discussion

The prototype has shown that the explanation of Harris and Hayden (2013) on how interactive teaching has many benefits towards students’ learning capabilities and also how it increases the enthusiasm they show in school. This was shown in multiple cases and can be seen in the after comments concerning their opinions on how the participants experienced the prototype. This would have to be further studied to see if my adaptation of the concept actually fulfills these claims on a grander scale, including multiple test groups with greater age differences. My study only showed that the prototype group performed 9% better than the plain text version. Such a small difference with a test group of only 10 people could just as much have been due to the individuals themself being better or worse at perceiving information. Many other factors might also been a part of it, for example if any of the test subjects had concentration issues while taking the test this could have lead to them performing worse than they might have done in an ideal situation.

As for the credibility of the historical monuments in the prototype itself one could argue that depending on which source you use while recreating ancient buildings, some smaller details may vary. As mentioned in the Background chapter I mostly used Fletcher (1905) as I felt he gave the most accurate depiction on how the Roman civilization might have looked like. The Rome Reborn project also uses his depictions when reconstructing architecture from the Roman era, but they also have support from many other sources such as architects, historians and other people who can help them with analyzing new found data. As I do not have the resources to perform such a broad study, my work is completely based on the accuracy of similar work done before me.
6.3 Future Work

To develop this idea further many additions could be made, currently the program has no audible feedback whilst walking around in the prototype. Sound and narration would probably immerse the user even more. This would also make it ideal to use for people who have learning disabilities preventing difficulties that they normally would feel while reading plain text. Implementing virtual reality could also improve the immersion and a give the user a unique experience. As for the concept itself, rebuilding historical monuments in virtual environments for educational purposes, you could work with different historical periods. Not just Roman Empire, for example taking the users in to specific historical events like the American Civil War, World War II and other significant periods in time that have shaped humanity into what it is today. One could also continue on the path to add aspects such as animation and human models, this could give the ability to tell stories and not only depict the environment. This can show the many aspect of how civil status might have looked like and also the life of its habitants in real time. Adding all of these aspects may enhance the overall experience and also make it more enjoyable.
7 References


University, Y. (Producent), & D. Kleiner (director). (2009). *Introduction to Roman architecture* [Film].


Appendix A - Test subject results

Here is the summary of each test subject response and result during the testing phase.

Test subject 1:

Group A

Part-1

- Q1. Male, 21 years old, Student
- Q2. Normally uses books as his preferred type of learning tool.  
- Q3. Have had previous experience with virtual environment

Part-2

- Correct Answers: 6/9

Part-3

- Q1. Rated himself at 2 on the prior knowledge scale,
- Statement: I know about the Roman Empire but I really had no knowledge about Forum Romano.
- Q2. Statement: Not really, I felt it was pretty simple, might have been because my earlier experience with first person shooters.
- Q3 Statement: it was interesting to see it and be able to walk around freely, normally I guess I wouldn’t use it but if I had a reason I would defiantly try something like this out.
- Q.4 the text was pretty interesting, learnt a thing or two but I can't say I will remember everything. If I got the choice to use between only using one of the methods I would probably chose the prototype since in contains the same information just represented differently.
Test subject 2:

Group A

Part-1

- Q1. Male, 22 years old, Student
- Q2. Normally uses videos as his preferred type of learning tool.
- Q3. Have had previous experience with virtual environment

Part-2

- Correct Answers: 5/9

Part-3

- Q1. Rated herself at 2 on the prior knowledge scale,
  Statement: I have a little knowledge about it but I don’t know anything about the forum Romano.
- Q2. Statement: No, but I would imagine other people could have some problem with it since I am used to fps game and they might not be.
- Q.3 Statement: It was nice, I don’t think I would have used it if you dint asked me to be part in the experiment. But I can imagine it might be good way to learn things that I normally find boring.
- Q.4 I have huge amounts of problems reading longer texts and just by looking at the text version I felt like, nope. So yea I think the prototype is a good way to enhance concentration and entertainment.
Test subject 3:

Group A

Part-1

- Q1. Female, 21 years old, Student
- Q2. Normally uses books as her preferred type of learning tool.
- Q3. Have had previous experience with virtual environment

Part-2

- Correct Answers: 4/9

Part-3

- Q1. Rated herself at 2 on the prior knowledge scale, Statement: I know a little about the Roman Empire from school but not much.
- Q2. Statement: the controls were a bit hard in the beginning but didn’t take long before I understood how to get around.
- Q3. Statement: It was cool, and very well made. But I wished there was a bit more color, I think that would increase how the users see it.
- Q4 I have a bit of a hard time reading long texts so some details in the text based versions were hard to understand, it felt good to have some visual feedback instead of just plain text.
Test subject 4:

Group A

Part-1

• Q1. Male, 20 years old, unemployed
• Q2. Normally uses Videos as his preferred type of learning tool.
• Q3. Have had previous experience with virtual environment

Part-2

• Correct Answers: 4/9

Part-3

• Q1. Rated himself at 1 on the prior knowledge scale, I know what it is but I don’t know anything about it.
• Q2. Statement: it was nice, I am not the best at English but I think I understood all of it, so that’s good.
• Q.3 Statement: It was nice, I like the amount of detail, and sadly I don’t think I can run it at home.
• Q.4 well I barley read anything so no I wouldn’t read anything like this if I had a choice in the matter, so if I got the option to play a game and learn or read, I would chose the game.
Test subject 5:

Group A

Part-1

- Q1. Male, 24 years old, employed
- Q2. Normally uses Videos as his preferred type of learning tool.
- Q3. Have had previous experience with virtual environment

Part-2

- Correct Answers: 5/9

Part-3

- Q1. Rated himself at 1 on the prior knowledge scale, No I don’t think I know about it.
- Q2. Statement: Yea I liked it, was cool, don’t know really what to say, I don’t have any comments really.
- Q.3 Statement: I liked the scale of it, felt way more awesome actually seeing it like that.
- Q.4 I think I’ve read one book in my life, I don’t mind reading in English but like 90% of all the things I read is game related topics. Yea I would prefer having a game as a learning tool than a book.
Test subject 6:

Group B

Part 1

- Q1. Male, 24 years old, employed
- Q2. Normally uses Videos as his preferred type of learning tool.
- Q3. Have had previous experience with virtual environment

Part 2

- Correct Answers: 4/9

Part 3

- Q1. Rated himself at 2 on the prior knowledge scale, I know a little about it but I don’t know anything about the Foro Romano, just a little about the Roman Empire.
- Q2. Statement: I liked it, but I felt it had some latency problems but that might depend on my computer, but other than that I had no problems.
- Q.3 Statement: Yea it was interesting seeing it and being able to walk around on the place, some smaller details could be improved but they didn’t really matter.
- Q.4 well I don’t read so much but I have a bit of interest in history but yea I couldn’t say that I would choose to read a text like this if I had the option to use the other option.
Test subject 7:

Group B

Part-1

- Q1. Female, 21 years old, student
- Q2. Normally uses lectures as her preferred type of learning tool.
- Q3. Have had previous experience with virtual environment

Part-2

- Correct Answers: 4/9

Part-3

- Q1. Rated herself at 2 on the prior knowledge scale,
- No statement on this topic
- Q2. Statement: No don’t think so, I understood everything in the text.
- Q.3 Statement: yea it was really well made, and I liked all the details.
- Q.4 I think that If you have some visual feedback it would be easier to separate each building like it is in the prototype. But might use the a tool like the prototype but I would probably still study the same way I do know.
Test subject 8:

Group B

Part-1
- Q1. Female, 23 years old, student
- Q2. Normally uses videos as her preferred type of learning tool.
- Q3. Have had previous experience with virtual environment

Part-2
- Correct Answers: 5/9

Part-3
- Q1. Rated himself at 2 on the prior knowledge scale,
- Well I know a bit of the roman empire but not really anything about the Foro Romano
- Q2. Statement: No I didn't have any problems reading the text, was a bit hard to separate which building that had which name. But other than that no.
- Q.3 Statement: Yea it was nice, but it feels a bit unfinished, but I think it has good potential given a bit more time to work on it.
- Q.4 it was like a normal chapter from a history book, not much to say. Even if I would use the prototype on occasion I still would prefer my own way of studying, using text and lectures.
Test subject 9:

Group B

Part-1

- Q1. Male, 25 years old, unemployed
- Q2. Normally uses lectures as his preferred type of learning tool.
- Q3. Have had previous experience with virtual environment

Part-2

- Correct Answers: 5/9

Part-3

- Q1. Rated herself at 2 on the prior knowledge scale, No Statement
- Q2. Statement: No I didn’t have any problems reading the text
- Q3 Statement: was nice, im guessing you intend to put textures in a later stage, but other then that I liked it.
- Q4 Yea it was interesting , learned some new thing, I think you can mix both of them to reach an optimal learning experience.
Test subject 10:

Group B

Part-1

- Q1. Male, 22 years old, unemployed
- Q2. Normally uses lectures as his preferred type of learning tool.
- Q3. Have had previous experience with virtual environment

Part-2

- Correct Answers: 4/9

Part-3

- Q1. Rated herself at 2 on the prior knowledge scale, No Statement
- Q2. Statement: No I didn’t have any problems reading the text
- Q3 Statement: Yea I liked the details, felt like a cool way exploring Rome if you can’t be there.
- Q.4 Yea it was interesting, learned a lot of new thing