Effects of a holographic teacher projection on the engagement with the learning materials

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Abstract

This study examines the effects of holograms when used for online learning. The research question is: "How does a holographic teacher projection affect engagement of the students with the learning material?". The engagement of students was compared in different lectures. The base lecture was a zoom lecture. The holographic lectures were a VR lecture, a HoloDisplay lecture and a robot lecture. A big experiment was done where different people attended one of those 4 lectures. After the participants were done watching the lectures they had to fill in questionnaires. The data of these questionnaires was then used to compare the lectures. A conlclusion was that Zoom lectures definitely take more attention than holographic lectures. Another conclusion was that the HoloDisplay and the Robot lecture are more engaging than a normal zoom lecture, this conclusion was backed up with statistical tests. There was no evidence that either the HoloDisplay or the Robot lecture was more engaging than the other one. Both of them need to be looked into further and be developed further. These ways of teaching can definitely be the future of online learning.

1 Introduction

During the Corona pandemic, ways of teaching and learning changed fast. Schools shut down and online classes became customary. After a while, people were more used to online classes than traditional lectures. However, a majority of students had less energy during these classes and a lot of students had a lack of motivation during this period of their study [4]. Students were not the only ones affected, teachers indicated that because of the lack of interaction with students their teaching was affected in a negative way.

Work has to be done to make online classes more engaging and thus more fun for teachers and students. One way to do this is through holograms. Holograms can enhance students' real-time visual experiences and thus give students a better understanding of the material [2]. Holograms also improve the perception of co-presence, which makes the class more similar to a traditional lecture and thus more fun [5]. Lastly, holograms present realistic and convincing views, this also makes communication among users attractive and efficient [1]. The HoloLearn project in TU Delft has built a prototype for online 3D classrooms [8]. However, more research has to be done on the effects of these 3D classrooms.

In this paper the focus of the research will be on the engagement in these classes. The research question is: "How does a holographic teacher projection affect engagement of the students with the learning material?". Engagement is defined as: "Active involvement of the student for learning activities." [9]. Different types of lectures will be given and through questionnaires the engagement in these lectures will be measured.

After gathering the data from these questionnaires, analysis will be done. The different lectures will be compared on the different types of questions in the questionnaire. After that several statistical tests will be applied to the data to test the hypothesis: "Holographic lectures are more engaging than zoom lectures". The difference in engagement between these holographic projection will also be tested. It could be the case that one of the holographical lectures is more engaging than another one. If this is the case more research should be done in these kind of lectures.

The outline of this paper is as follows: the following section is about the methodology used for the research done. This includes the way the experiment will be done and how the data will be gathered. After the methodology the results of data analysis will be discussed. What can be learned from the experiment, are 3D classrooms actually more engaging? A

short section about responsible research will be following and the paper will end with some discussion of the experiment, conclusions and future work on the topic.

2 Methodology

To research how engaging holographic lectures really are, an experiment was done with multiple people. The idea of the experiment was a bit similar to the research of Paredes et al. [7]. The experiment was as follows: the same lecture would be given in different settings and data would be collected from these lectures through questionnaires. By using this data it would be possible to come up with conclusions about the difference in lectures, for this study, the difference in engagement in these lectures.

2.1 Participants

After planning a date it was time to start gathering participants. 5 participants per group were needed and we wanted them to be mostly Computer Science students. It was a requirement for them to speak fluent English, since their English should not be a factor in the research. We did not get any contact information from the participants, we just invited them to a specific location on a specific time. Before the lectures the participants were randomly assigned to a group. The participants got a post-it with a code. They had to keep this code with them and write it on the questionnaires they filled in. This way we could check which questionnaires belonged to which lecture group. After watching their lecture and filling in all the questionnaires the participants received a 10 euro bol.com voucher. This was promised to them if they would help us with our research.

2.2 Apparatus

For our experiment a lot of materials were needed. 4 different lectures were given and all of them needed different apparatus. For the zoom lecture a big screen was necessary. The participants were sitting in front of this screen and just needed to watch this screen with sound on. This lecture was the least interesting material wise. See figure 1.

The second lecture that was given was a HoloDisplay lecture. The slides of this lecture also had to be on a big screen. However, the teacher was in actual size on the HoloDisplay screen. See figure 2.

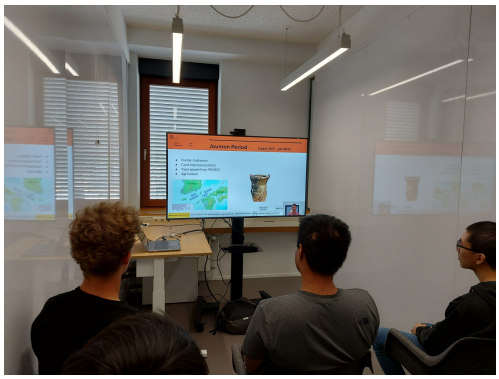

Figure 1: Zoom Lecture

Figure 2: HoloDisplay Lecture

The third lecture was a robot lecture. This lecture was similar to the HoloDisplay lecture. However here the teacher was not in actual size on a big screen, but head-only on a robot. This was a robot that could drive around and had an Ipad as it's head. So for this lecture again a big screen was needed and a room with chairs. See figure 3.

The last lecture was a VR Lecture. This lecture was inside an actual VR environment and recorded with a Kinect camera.The participants who were doing this lecture put on an Oculus Go VR headset (fig 4) and could see themselves sitting in a virtual classroom. The slides were on a big screen inside the classroom and the teacher was talking in the classroom. See figure 5.

Figure 3: Robot Lecture

Figure 4: VR Oculus go headsets

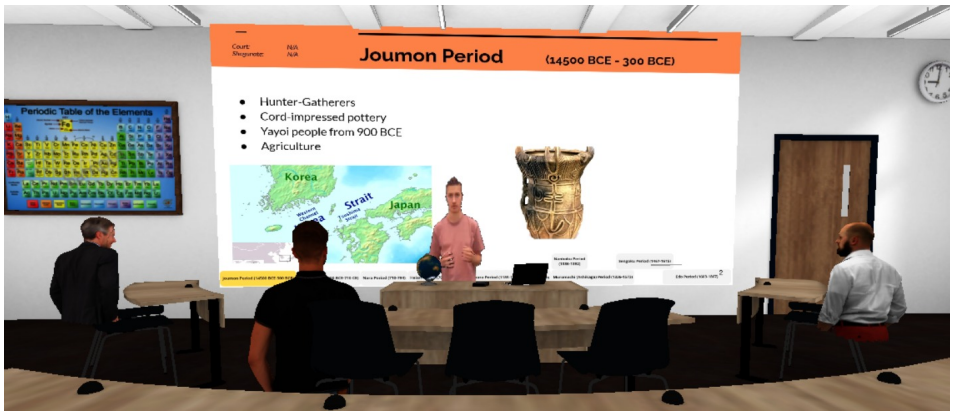

Figure 5: VR classroom

2.3 Measurement

To measure engagement in the lectures a questionnaire had to be used. The questionnaire from a study of O'Brien et al. [6] was used. Most questions were usable, a few had to be removed which were not applicable to our experiment. The questionnaire has questions like "the lecture felt taxing" and "the time spent during the lecture just slipped away". The questionnaire had 22 questions in total and took approximately 2 minutes to fill in. The participants had to rate the questions on a scale from 1-5, strongly disagree to strongly agree. The questionnaire can be found in Appendix A.

2.4 Procedure

After all the participants arrived in place they first got a post-it with their code, as explained in the participants section. Thereafter they had to sign an informed consent form. This has to be done to make the research responsible and ethical. After signing the form they made a pre-exam to test their knowledge of the subject: Japanese history before 1603. After everybody filled this in the actual lectures were given. The lecture about Japanese history took approximately 15 minutes. The participants could just sit in a chair and watch the lecture they had to follow. After the lecture a post-exam was given to the participants to see if they actually learnt something and gained more knowledge about the subject. This exam was exactly the same as the pre-exam to see how much the participants improved. We did not tell them beforehand that these exams would be the same since then they could focus on those questions only. After the post-exam the participants had to fill in all of our questionnaires. This was our way to get data from the experiment. This whole experiment was divided over 2 days, since we did not have enough rooms to do everything at once. The first day we did the Zoom and the Robot lecture, the second day the VR and the HoloDisplay lecture were done.

3 Results

With the data acquired it could now be checked if the holographic lectures were actually more engaging. The engagement questionnaire consisted of 4 different types of questions: Focused attention, Perceived Usability, Aesthetic Appeal and Reward Factor. In figure 6 the means of these different types can be found when tested on the different lectures.

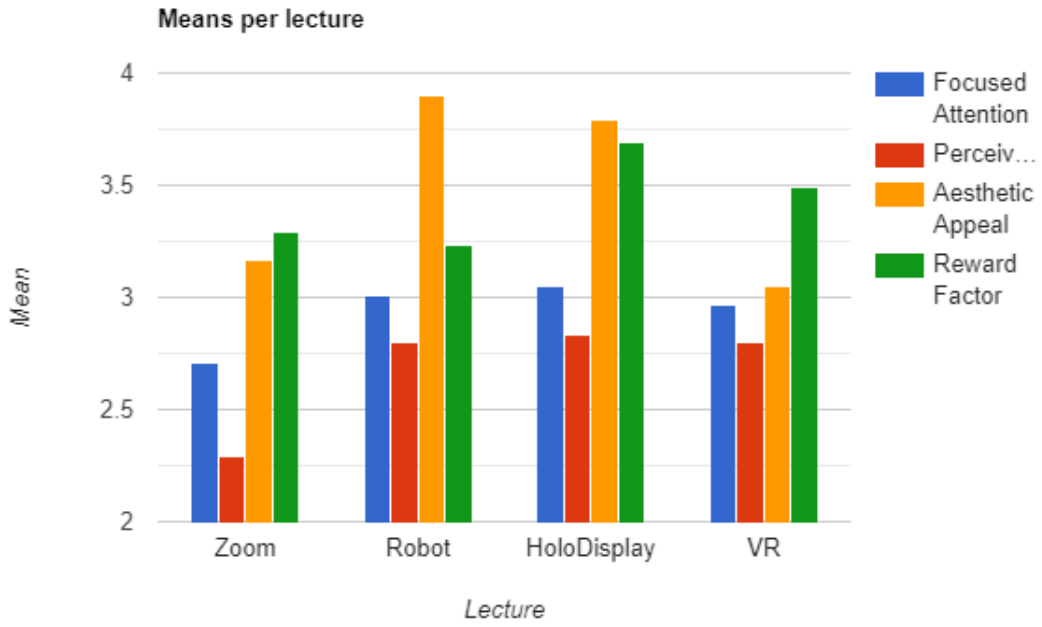

Figure 6: Bar graph with means per lecture

One immediate fact that stands out from the figure is the low perceived usability of the zoom lecture. Perceived usability had questions like: "The experience was demanding". This shows that the zoom lecture really was harder to follow and more tiring to do than the other lectures. This is interesting since this could be another good reason to use holographic lectures over Zoom lectures.

Another interesting observation is that the Aesthetic Appeal for the Robot and the HoloDisplay lecture is a lot higher than for the Zoom and VR lecture. Aesthetic Appeal is about the attractiveness of the lectures. I did expect the holographical lectures to score higher than the zoom lecture. However I did not expect the VR lecture to score low. The VR lecture should be very aesthetically appealing since it really feels like you are in a classroom. I think the reason for this is that the screen was sometimes flickering and the environment as a whole just was not perfectly done yet.

Several tests were applied to the data to check if the main hypothesis is correct: "Holographic teacher projection lectures are more engaging than normal zoom lectures". An important thing to note is that all the tests that have been done are non-parametric. There was not enough data to do parametric tests. The tests were done using the means between

students from the zoom lectures and students from another session, for example the VR session.

The first test that was done was the sign test. When comparing the means of the Zoom lecture to the Robot lecture the p-value was 0.0148. Since a p-value below 0.05 indicates a statistically significant difference, the robot lecture had a better engagement rate according to this test. When doing the sign test on the HoloDisplay lecture the p-value was 0.000019. This is really low and this shows a very significant difference in these two lectures. The HoloDisplay thus had a way better engagement rate. The last comparison was to the VR lecture. This lecture also got a p-value of 0.0148 and thus also has a better engagement rate than the Zoom lecture according to this test. Since the sign test is a simple test we can not draw any big conclusions from this yet. However it is a good sign that the holographic lectures are doing better than the Zoom lecture.

The next test that was done was the Mann-Whitney test. This test checks if two independent samples are from the same population. This is exactly what we need to know for this experiment. Since if this is the case there is no difference between the Zoom lecture and the other lectures in engagement. The p-value for the robot lecture was 0.029. This indicates that there is a significant difference between these lectures and thus that the robot lecture is more engaging. The p-value for the HoloDisplay lecture was 0.013, this again indicates a significant statistical difference in engagement. However, for the VR lecture the p-value was 0.197. Since this is higher than 0.05 this indicates no statistical difference. According to the Mann-Whitney test, the VR lecture is not more engaging than a normal Zoom lecture.

Since both tests indicated that holographic lectures do pretty well compared to the zoom lecture. It is interesting to look at the difference between the holographic lectures. This was also done using the Mann-Whitney test. The p-value when doing a Mann-Whitney test with the robot vs the HoloDisplay lecture was 0.516. This result is not significant at all so we can not say there is a difference in engagement between these two lectures. Same goes for the VR lecture against the robot, the p-value was 0.184. This value is also higher than 0.05 and thus there is no significant difference in engagement. The last comparison was between the HoloDisplay Lecture and the VR Lecture. The p-value of this comparison was 0.087. This is a lot closer to 0.05 and thus there is a bigger difference in engagement between these lectures. However, the value is not below 0.05 and thus we can not really say that the HoloDisplay is doing statistically significantly better than the VR lecture when looking at engagement.

4 Responsible Research

To do the research responsibly some things needed to be done before the experiment and while we were doing our experiment. Before the experiment we had to do a request to the ethics committee of TU Delft. For this we needed to fill in an HREC form. This is a form for the Human Research Ethics Committee of the TU Delft. This form asks questions concerning user data and how the participants will be protected and anonymized. They also ask what is being done against Covid for example.

The second document was a DMP form, a Data Management Plan. This plan was all about what we were going to do with our data after the experiment. How we would store it and what we would do with it after we have written our papers for example. After filling in both the HREC and the DMP form they were send to the ethics committee and they reviewed them. We got a response that the form was approved so we were allowed to do our experiment and we could be sure that we did it in a safe manner.

Before all of our participants started the experiment we needed their consent for the experiment. For this a letter was written with instructions. The participants needed to read and sign this before actually taking place in the experiment. The informed consent form can be found in Appendix B.

Reproducing this experiment is very doable. The only thing that is hard to reproduce is the HoloDisplay screen since this is something TU Delft specific. The rest of the material, like a new lecture with a new pre and post-exam is not be hard to make. Inviting the participants and getting the right questionnaires is also not too difficult and if you have those things the experiment can be done for the most part.

5 Conclusions and Future Work

This study attempted to measure engagement in holographical lectures. The main research question of this paper was: "How does a holographic teacher projection affect engagement of the students with the learning material?". In the results section it came to light that all the holographic teacher projection lectures had a better engagement rate than the normal zoom lecture. However, for the VR lecture this difference was not significant enough to be certain that it actually is more engaging. For the HoloDisplay and the Robot lecture this was the case. This shows that these holographic lectures could really be the future of online learning.

In the results section it can also be seen that there is no statistical difference in engagement rates between the HoloDisplay and the Robot lecture. However, this could definitely be because there were not a lot of participants in this research. More research needs to be done on this topic, starting with an experiment with more participants.

Another interesting observation is the engagement rate of the VR lecture. Beforehand I thought that this lecture would be the most engaging. This is new for the participants and the environment was well made and fun to be in. The reason for the lower engagement rate could be some flaws in the design. The screen would sometimes flicker and the VR headsets became really hot and slow after a while. It is not sure that this is the case for the lower engagement rate and it would be interesting to do more research on this topic.

An interesting similar experiment would be one where the teacher is live on the HoloDisplay Screen and live on the Robot. A live teacher is more real and can be asked questions, so the lecture is more interactive. In this setting it would be easier to measure engagement since you could easier tell if people are actually participating in the lecture. This would be a good experiment to do next since more research is needed to learn everything about holographic lectures.

Measuring engagement is also not this straight forward. There are a lot of different ways to measure engagement and engagement should be measured in multiple ways [3]. Every way has it's flaws and it's strengths so more and different kind of experiments definitely need to be done on this topic.

This study supports the hypothesis that holographic lectures are more engaging than zoom lectures. However, the experiment was on a small scale and certain things could still be improved, like the VR environment. The study was an interesting first step into the effects of the holographic lectures and is a good starting point for more studies in this topic. The idea of holographic lectures are new and exciting and definitely need to be looked into more.

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A Questionnaire

Item No.	Item	Strongly Disagree	Some What disagree	Neutral	Some What Agree	Strongly Agree
Focused Attention (FA)						
	I lost myself in this experience					
	I was so involved in this experience that I lost track of time					
	I blocked out things around me during the lecture					
	The time spent during the lecture just slipped away					
	I was absorbed in this experience					
	During this experience I let myself go					
	During the lecture, I lost track of the world around me					
Perceived Usability (PU)						
	I felt frustrated during the lecture					
	I felt annoyed during the lecture					
	The lecture felt taxing					
	The experience was demanding					
Aesthetic Appeal (AE)						
	The lecture was attractive					
	The lecture was aesthetically pleasing					
	The lecture appealed to my visual senses					
	I liked the graphics/visuals during the lecture					
Reward Factor (RW)						
	Attending the lecture was worthwhile					
	My experience was rewarding					
	I would recommend the lecture to other students					
	The content of the lecture incited my curiosity					
	I was really drawn into this experience					
	I felt involved in this experience					
	This experience was fun					

Figure 7: Engagement questionnaire

B Informed consent form

Dear Participant,

Thank you for agreeing to participate in this study of our BSc Thesis for HoloLearn research group. This study is being conducted by Otte van Dam, Roman Sirokov, Chong Zhao, Stephen Huang, and Thom van der Velden Mem from the TU Delft.

Purpose: The purpose of this study is to research the ways how distance teaching & learning can be improved using Holograms technology. It will take you approximately *45* minutes to complete. The collected data will be anonymous and used only for the analysis that will be conducted in the context of this study.

Data management: To the best of our ability your answers in this study will remain confidential. We will minimise any risks by anonymising the collected data, storing it securely under the university's secure infrastructure, and limiting access to the data only to people who are directly involved in the research. Nevertheless, the processed results may be included into the paper publications, while remaining anonymised.

Procedure: During the experiment, you will be offered to take a 15 minute lecture about the topic of Japanese history before year 1603. After signing this consent form, you will be given a pre-exam to assess your current knowledge about the topic. Then, you will be allocated to one of the groups where you will be able to listen to the lecture about the topic. Afterwards, you will be given a survey that will ask you the questions about your experience during the lecture. And in the end, you will be given a post-exam that will assess your knowledge again. Note that the goal of the study is not to evaluate your knowledge about the topic, but rather the process of learning. The topic was intentionally chosen to be less known for most of participants.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. However, you will not be able to remove your data after its submission, due to its complete anonymisation.

Responsible Teacher: [redacted]
Supervisor: [redacted]

By signing this document I consent to voluntarily participate in the study and acknowledge that I have fully understood and accept what it entails. I also accept that I was given enough opportunity to ask any questions I may have before taking part in the experiment.

_____
Name and date

_____
Signature

Figure 8: Informed consent form