Implications on Learning Outcomes and Eye-strain of using Telepresence Robots as a new Distance Learning Medium

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Abstract

Distance learning brings all sorts of advantages. The ability to follow lectures at home can save people transportation costs and time. Teaching through videoconferencing software such as Zoom is one of the methods to learn remotely. To explore new and better teaching methods, the possibility of using a telepresence robot is investigated. To determine its worth, an experiment is done to compare the learning outcomes of telepresence robot lectures to Zoom lectures. Differences in risk of eye-strain is also compared, as most distance learning methods are digital. An increase in risk of eye-strain may negatively impact the choice of adopting the learning method. Due to the small sample size, non-parametric tests were conducted. Concluding from the research, neither Zoom nor telepresence robot lectures had better learning outcomes compared to the other. The learning outcomes of both lectures were similar. Risks of eye-strain also did not differ between the two. Further analysis was done comparing the telepresence robot lecture with a hologram and a virtual reality lecture, as these were also part of the experiment. Similarly to zoom, there was no significant evidence that telepresence robot lectures had different learning outcomes or risks of eye-strain than holograms and virtual reality lectures.

1 Introduction

During the 2019 global pandemic, we have seen firsthand how sudden the world in the context of education can change. Governments can be forced to close down kindergartens, schools, and universities—which can be in effect for months—where no classes are being taught on location and students are not permitted to go to their place of learning. As one might expect, this raised justified concerns on the negative impacts it could have on schoolchildren's and student's developments and prospects.

While videoconference software—such as Zoom[1]—has been developed, it is important to examine how these new methods of learning affects the learning outcomes of the students. Videoconference lectures, however, brings obstacles such as difficulties for the teacher to interact with their students and vice versa, or for students to maintain at least as much attention as they would have in the traditional classroom setting where the teacher is physically present (Ferri et al., 2020). Even when teachers and students are allowed to get together again after the pandemic, it is still of interest to explore the possibilities of distance learning as it carries valuable advantages, such as saving commuting costs and time (Sadeghi, 2019).

Distance learning using self-movable robots that stream the teacher's head on them—which are usually called *telepresence robots*—has already been explored. Kwon et al. (2010) has experimented teaching English to children aged between ten and twelve for two months and concluded that their interest and motivation in English stayed the same. What they did not look into, however, was the children's learning outcomes, which are defined as the newly gained knowledge or abilities that one obtains from learning (Allan, 1996).

Furthermore, there may be negative effects that come with the usage of these telepresence robots. An example is eye-strain, which can be diagnosed as *Computer Vision Syndrome*. This syndrome is defined as eye and visions problems that arise due to interaction with a computer display or a similar environment (del Mar Seguí et al., 2015). Especially after years of online education and work, it is of utmost importance that potential new teaching methods do not further increase risks to Computer Vision Syndrome.

[1] https://zoom.us/

This paper discusses the effects on the learning outcomes and risk of eye-strain of students that results from online teaching that uses telepresence robots. This is achieved by conducting and analysing test results before and after a lecture given to students.

1.1 Research Question and Hypotheses

The lack of research on the learning outcomes when teaching with a telepresence robot led to the following research question: "What effect does teaching with a telepresence robot have on the learning outcomes and risk of eye-strain of students?". From this research question, four hypotheses can be formulated:

h0 Teaching with a telepresence robot will not have an effect on the learning outcomes compared to teaching with Zoom.

h1 Teaching with a telepresence robot will increase the learning outcomes compared to teaching with Zoom.

h2 Teaching with a telepresence robot will not have an effect on students' risk of eye-strain compared to teaching with Zoom.

h3 Teaching with a telepresence robot will decrease students' risk of eye-strain compared to teaching with Zoom.

2 Background

Distanced learning has been considered as early as the 1990's. Banas and Emory's research (1998) has evaluated online programs offered by American Universities and concluded that there were no meaningful differences between distance learning via these online programs, and traditionally "live" instructed programs on the students' learning outcomes (Banas & Emory, 1998, p.368).

In 2001, Cavanaugh (2001) did a quantitative meta-analysis looking at 19 independent studies on the effects of distance learning that make use of videoconferencing and telecommunications. They evaluated the learning outcomes of primary and secondary education students, instead of university students who were the focus of Banas and Emory. The study similarly concludes by stating that there was virtually no difference in academic performance between distance education and traditional classroom education. Such research prompted a new learning model in which both onsite and distance learning students can take part of the given lecture simultaneously. This model is called hybrid learning (Raes, Detienne, Windey, & Depaepe, 2020).

However, a recent study focusing on distance learning through videoconferencing argues that students following the course remotely through such online methods had worse learning outcomes compared to students following the course on-site (Roth et al., 2020). Furthermore, as online education increased due to the 2019 pandemic, students are also more at risk to suffer from Digital Eye-Strain (DES), or so-called Computer Vision Syndrome (Ganne et al., 2021).

There has been research on the usage of telepresence robots for distance learning, under the term robot-mediated communication (RMC) (see Gleason & Greenhow, 2017; Kwon et al., 2010). However, they do not specifically touch on the learning outcomes of students in a classroom setting. Any potential risks typical to videoconference teaching that telepresence teaching might bring—such as eye-strain—is also not discussed.

3 Methods

To assess the effects on students' learning outcomes and eye-strain when teaching with a telepresence robot, four lectures were held that is taught from different media. The first lecture is a Zoom lecture to simulate videoconferencing. The students can see the lecture slides with the thumbnail of the teacher on the same screen (see figure 1a). The second lecture is the HoloDisplay lecture, which creates a full-body hologram of the teacher standing next to the slides. The third lecture is the telepresence robot, and also stands next to the slides. The fourth and final lecture is the Virtual Reality (VR) lecture. The VR environment is a classroom, complemented with dummies seated in other seats to simulate other classmates (see figure 2). The contents of these lectures were the same.

The lecture was recorded with two Azure Kinect cameras. One recorded the teacher with the background removed using its infrared depth camera. This is used by the HoloDisplay and VR lectures. The other recorded the ordinary video of the teacher that is shown in the Zoom and telepresence robot lectures. It is important to note that these two recordings were done at the same time, with the two cameras stationed as close together as possible. This enforced all lectures to have no differences of the teacher's delivery of the lecture contents, such as the teacher's clarity of speech, or stuttering.

At the same time, a screen recording was made of the lecture slides. It was recorded simultaneously during the recording of the teacher such that it follows their narrative, transitioning to the right slides at the right moments.

The participants were allocated to one of the lectures at random. Because this is an independent measures study, they only followed one of the four lectures. Before the lecture started, they were asked to fill in a pre-test containing questions on the lecture contents. Its purpose is to gauge the participants' prior knowledge that they may have had on the lecture contents. After the lecture was concluded, they were asked to fill in a post-test. This test contains exactly the same questions as the pre-test. These two tests allowed for a better measure of the learning outcomes of the students. Along with the post-test, participants also filled in a questionnaire regarding computer vision syndrome. This questionnaire is taken from the paper of del Mar Seguí et al. (2015).

Exact copies of the questionnaire and the tests—along with its answers—can be found in the Appendix. The topic of this lecture is *Japanese History until 1603* and takes around 15 minutes.

3.1 Participants

A total of 22 students have participated. Every participant is and has not been part of the HoloLearn research group and have not worked with any of the apparatus such as the HoloDisplay. Most participants are third year Computer Science & Engineering students of Delft University of Technology. A small minority follow different majors at Delft University of Technology, with some even from other institutions. The majority of these participants were recruited through existing connections (e.g. friends and family).

3.2 Apparatus

The experiment made use of the videoconference software Zoom, the telepresence robot of Double Robotics[2], the HoloDisplay developed by HoloLearn[3] of the Centre of Education

[2]https://www.doublerobotics.com/

[3]https://www.educationandlearning.nl/projects/hololearn

and Learning at LDE[4], and the standalone VR headset Oculus Go[5].

3.2.1 Zoom

In the case of the Zoom lecture, the video stream of the teacher and the lecture's slides were displayed in front of the class. The setup of this lecture is shown in figure 1a. This setup is different, however, from the conventional way in which lectures are taught with Zoom, which is where all participants follow the lecture from their own individual monitor in front of them. This deviation was decided on purpose to minimize variations between the other three lectures, since those are taught in a classroom with classmates present in that same room.

3.2.2 Telepresence robot

In the case of the telepresence robot lecture, the *Double 2* of Double Robotics with an iPad Air was used. This robot stood next to the lecture slides. The setup of this lecture is shown in figure 1b.

3.2.3 HoloDisplay

In the case of the HoloDisplay lecture, a full-body hologram of the teacher was shown in front of the class. It stood next to the lecture slides. The setup of this lecture is shown in figure 1c.

3.2.4 VR

In the case of the VR lecture, five Oculus Go headsets were used. The participants were seated in a classroom behind a desk with the teacher and lecture slides in front of the class. The view of the participant inside the VR environment can be seen in figure 2.

3.3 Materials & Measures

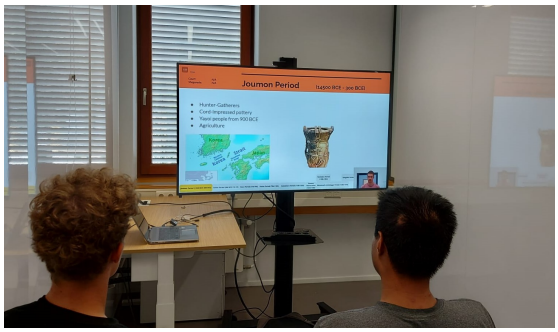
The pre-test and post-test consists of seven questions on the topic of the lecture (Japanese History until 1603). The pre-test is to evaluate if a participant had any prior knowledge on the topic and is compared to their post-test. Apart from these tests, the participants also filled in a 16-question questionnaire on issues related to eye-strain. As mentioned before, the questionnaire was taken from the paper of del Mar Seguí et al. (2015). The measures are the test scores and the answers to the questionnaire.

3.3.1 Learning outcomes

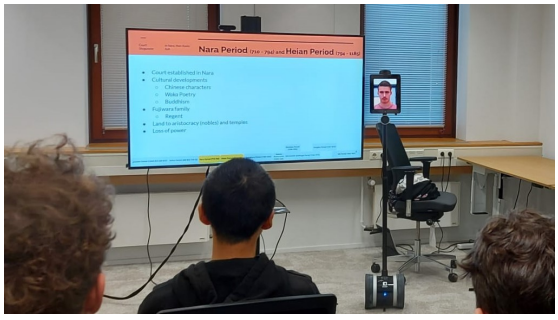
Each question of the tests has four options with exactly one option being correct. The two tests contain exactly the same questions and options. The participants were informed that it was not a problem to skip questions of the pre-test, but were encouraged to try answering all questions of the post-test. The pre-test and post-test—as well as the answer key—can be found in the Appendix.

[4]https://www.educationandlearning.nl/home
[5]https://www.oculus.com/experiences/go/

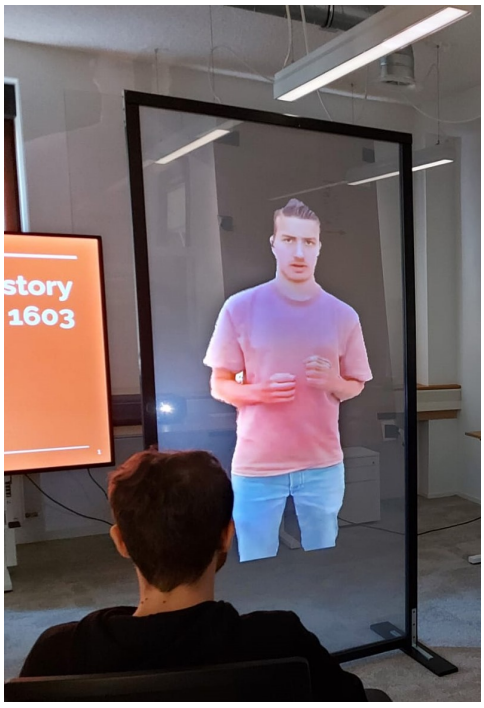
Figure 1
The setup of the Zoom, telepresence robot, and the HoloDisplay lectures during a test-run.



(a) *The Zoom lecture setup.*



(b) *The telepresence robot lecture setup.*



(c) *The HoloDisplay lecture setup.*

3.3.2 Eye-strain

The questionnaire contains 16 questions about issues such as tearing and itching. It is presented with two columns that are filled in by the participant: frequency and intensity. There are three options for frequency, which are "Never", "Occasionally", and "Often or always". On the questionnaire, there is further explanation that they are defined as "the symptom does not occur at all", "once during the lecture", and "more than once during the lecture" respectively. The second column has the options "Moderate" and "Intense". Participants were reminded that they should leave the intensity column blank when answering "Never" for frequency. The questionnaire can be found in the Appendix.

3.4 Design

Participants were randomly assigned to one of the four lecture rooms. As the students only followed one of these four lectures, it is an randomised independent measures study. In this experiment, the following variables and groups are defined:

Independent variable: The representation of the teacher.

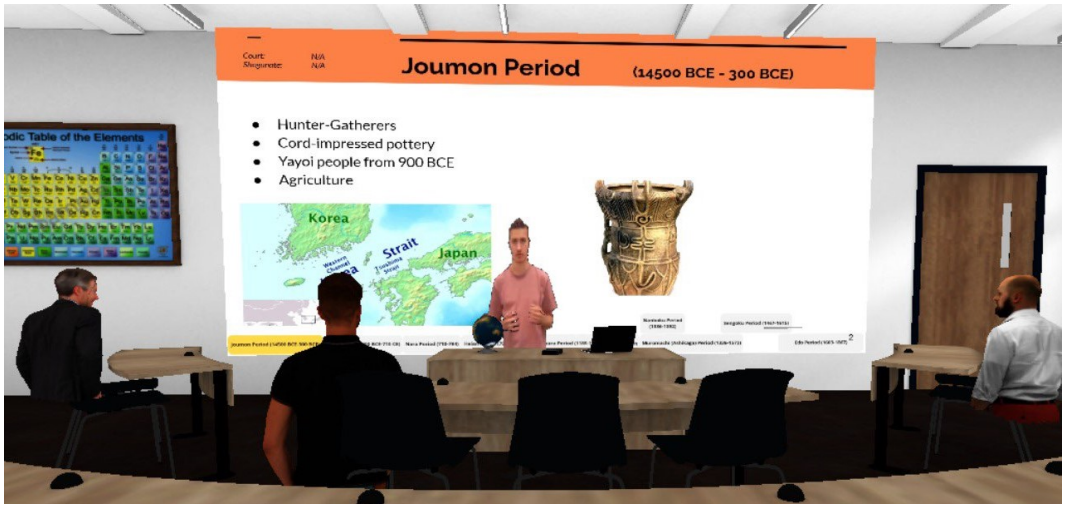
Dependent variables: The learning outcomes of the students, eye-strain of the students.

Confounding variable: Students' prior knowledge on the lecture topic.

Control group: The Zoom lecture.

Treatment group: The telepresence robot lecture and the HoloDisplay lecture.

Figure 2
Inside the VR environment of the VR lecture, which closely simulates an ordinary classroom.



3.5 Procedure

The experiment was split into two days due to insufficient room. On the first day, the Zoom and telepresence robot lectures were held. The HoloDisplay and VR lectures were held on the day after. All participants that have agreed to participate had been randomly assigned to one of the four lecture rooms prior to the experiment. They were also given an ID, made up of a combination of a number followed by a letter. These letters corresponds to the lecture the participants were assigned to follow, which are Zoom, telepresence Robot, HoloDisplay and VR. Participant 5V, for example, followed the VR lecture.

On the days the participants arrived, they were briefed on the aim of the research and the procedure of the experiment. They were then asked to sign an informed consent form. Next to the informed consent form, they were also asked to fill in a pre-test. Each pre-test has one of the participants ID written on the top of the page and are handed to the participants with the same ID. Finally, the participants also received a sticky note with their ID written on it in case they forget after following the lecture.

The participants were then escorted to the Zoom and telepresence robot lecture rooms—or HoloDisplay and VR lectures in the case of the second day—depending on their ID. They were also reminded to adjust their seating such that they can see the lecture materials clearly.

After the lecture had finished, the participants filled in the post-test and questionnaire, while being advised to do the former first. They were also instructed to write their ID on the top of the post-test and questionnaire. During the briefing, we explicitly did not mention that the post-test contained the same questions and options as the pre-test. The thought

behind this was that the learning outcomes could be different in the case where participants know what will be asked on the test. After the participant handed in their filled-in post-test and questionnaire, they were given monetary compensation for their time in the form of a voucher.

4 Results

Participant codes are suffixed with the letters Zoom, telepresence Robot, HoloDisplay or VR, as mentioned before in chapter 3.5. For example, participant 2R followed the telepresence robot lecture.

4.1 Learning outcomes

The results of the pre-tests and post-tests can be found in tables 1 and 2. One point is given for every correctly answered question. Nearly all participants skipped every question on the pre-test, except for the individuals 1R and 2H scoring one and two points respectively.

Table 1
Pre-test results.

Question	Zoom						Telepresence robot					HoloDisplay						VR				
	1Z	2Z	3Z	4Z	5Z	6Z	1R	2R	3R	5R	7R	1H	2H	3H	4H	5H	6H	1V	2V	3V	4V	5V
Q1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Q2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q5	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Q6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0

Table 2 shows the post-test results of the participants. Most people have 3 to 5 out of 7 questions correct. All participants answered all questions of the post-test, apart from 4H, 5H, 6H and 1V who have skipped at least one. These skipped questions of these four participants are counted as 0 points, as we assume they completely do not know the answer. These questions are shown as "NA" (not answered) in table 2.

Table 2
Post-test results.

Question	Zoom						Telepresence robot					HoloDisplay						VR				
	1Z	2Z	3Z	4Z	5Z	6Z	1R	2R	3R	5R	7R	1H	2H	3H	4H	5H	6H	1V	2V	3V	4V	5V
Q1	0	1	0	1	0	1	0	0	0	0	1	0	0	1	NA	NA	NA	1	0	0	0	1
Q2	1	1	1	1	0	0	1	0	1	0	0	1	1	0	NA	1	1	0	0	1	0	1
Q3	1	1	0	1	0	0	1	0	1	1	0	1	1	0	1	NA	NA	NA	0	1	0	0
Q4	0	1	1	1	1	0	0	1	0	1	0	1	1	0	1	NA	NA	NA	0	1	1	0
Q5	0	0	1	0	0	1	1	1	0	1	1	1	1	1	1	NA	NA	0	1	1	1	1
Q6	0	0	0	1	1	1	0	0	0	0	0	0	0	1	NA	NA	1	NA	1	0	1	0
Q7	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1	0	1	NA	1	1	1	1
Total	3	5	3	5	3	4	4	3	3	4	3	5	4	4	4	1	3	1	3	5	4	4

To assess the learning outcomes of the participants, their scores on the pre-test is subtracted from the post-test. For example, if a participant has questions {Q2, Q4, and Q5} correct on the pre-test and has all 7 questions correct on the post-test, then {Q2, Q4, and Q5} are not seen as newly attained knowledge. Only their other correct questions—{Q1, Q3, Q6 and

Q7}—are counted and thus their post-test scores are adjusted to 4. As only 1R and 2H had scored points on the pre-test, they are the only ones affected. Additionally, participant 2H has the unique case of having a question wrong on the post-test while originally answering it correctly on the pre-test (Q1). The 0 points that 2H scored on this question on the post-test stayed 0 on the adjusted table. The adjusted results are shown in table 3.

Table 3
Adjusted results.

Question	Zoom						Telepresence robot					HoloDisplay						VR				
	1Z	2Z	3Z	4Z	5Z	6Z	1R	2R	3R	5R	7R	1H	2H	3H	4H	5H	6H	1V	2V	3V	4V	5V
Q1	0	1	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1
Q2	1	1	1	1	0	0	1	0	1	0	0	1	1	0	0	1	1	0	0	1	0	1
Q3	1	1	0	1	0	0	1	0	1	1	0	1	1	0	1	0	0	0	0	1	0	0
Q4	0	1	1	1	1	0	0	1	0	1	0	1	1	0	1	0	0	0	0	1	1	0
Q5	0	0	1	0	0	1	0	1	0	1	1	1	0	1	1	0	0	0	1	1	1	1
Q6	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0
Q7	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1	0	1	0	1	1	1	1
Total	3	5	3	5	3	4	3	3	3	4	3	5	3	4	4	1	3	1	3	5	4	4

Of all four forms of teaching, teaching with a telepresence robot scored the lowest in terms of learning outcomes, with a normalized mean of 0.46 (see table 4). Zoom scored the highest with a normalized mean of 0.55.

Table 4
Mean and Standard Deviation.

	Zoom		Telepresence robot		HoloDisplay		VR	
	Raw	Normalized	Raw	Normalized	Raw	Normalized	Raw	Normalized
Mean	3.83	0.55	3.20	0.46	3.33	0.48	3.40	0.49
Standard Deviation	0.98	0.14	0.45	0.06	1.37	0.20	1.52	0.22

Note: Normalized mean is calculated by dividing all scores by 7 questions. Normalized standard deviation is calculated using those normalized scores.

To test the **h0** and **h1** hypotheses introduced in chapter 1.1, a non-parametric test is used as our sample data is extremely small and less likely to represent a normal distribution. Therefore, a right-tailed Wilcoxon Rank Sum Test is used with the following variables:

H_0 : Telepresence robot learning outcomes are equal to Zoom learning outcomes
H_α : Telepresence robot learning outcomes are larger than Zoom learning outcomes
α : 0.05

After constructing the rank sum table (see table 5a), we can see that there is no significant increase of learning outcomes when teaching with a telepresence robot compared to Zoom ($T_1 = 24.5, T_2 = 41.5, m = 5, n = 6, \alpha = 0.05$). T_1 would have to be greater or equal to the critical value of 40 to accept H_α, as W is [20, 40] with a right-tail significance of 5%, $m = 5$, and $n = 6$ (Glover & Mitchell, 2015, p.512). This means it is not enough to reject H_0, and H_α cannot be accepted.

When comparing teaching with a telepresence robot to teaching with a HoloDisplay or VR, we also see no significant increase (see tables 5b and 5c). The critical value W when comparing to the HoloDisplay ($T_1 = 27, T_2 = 39, m = 5, n = 6, \alpha = 0.05$) is also [20, 40], while the critical value W when comparing to VR ($T_1 = 24, T_2 = 31, m = 5, n = 5, \alpha = 0.05$) is [19, 36] (Glover & Mitchell, 2015, p.512). In both cases, T_1 is smaller than the upper bound of the corresponding W.

Some participants have commented after the lecture that the telepresence robot, VR, and HoloDisplay lectures were sometimes distracting, especially the latter two due to flickering. Others also pointed out that they were more used to the setup of the Zoom lecture, as they had been taught with similar videoconferencing software in the past couple of years.

Table 5
Wilcoxon Rank Sum Test Table.

Telepresence robot		Zoom	
Score	Rank	Score	Rank
3	4	3	4
3	4	5	10.5
3	4	3	4
4	8.5	5	10.5
3	4	3	4
		4	8.5
	$T_1 = 24.5$		$T_2 = 41.5$

(a) *Rankings of the Telepresence robot and Zoom.*

Telepresence robot		HoloDisplay	
Score	Rank	Score	Rank
3	4.5	5	11
3	4.5	3	4.5
3	4.5	4	9
4	9	4	9
3	4.5	1	1
		3	4.5
	$T_1 = 27$		$T_2 = 39$

(b) *Rankings of the Telepresence robot and the HoloDisplay.*

Telepresence robot		VR	
Score	Rank	Score	Rank
3	4	1	1
3	4	3	4
3	4	5	10
4	8	4	8
3	4	4	8
	$T_1 = 24$		$T_2 = 31$

(c) *Rankings of the Telepresence robot and VR.*

4.2 Eye-strain

The answers to the eye-strain questionnaire are shown in table 6. To determine if a participant suffers from eye-strain—which is diagnosed with Computer Vision Syndrome (CVS), their answers to the 16 issues are multiplied and summed up. This is calculated with the following equation:

$$\sum_{i=1}^{16} frequency_i \cdot intensity_i \tag{1}$$

while mapping the products to 0, 1, or 2 using the following:

$$frequency_i \cdot intensity_i = \begin{cases} 0 & \text{if } 0 \\ 1 & \text{if } 1 \text{ or } 2 \\ 2 & \text{if } 4 \end{cases} \tag{2}$$

For example, $2/2$ would mean a frequency of "Often or always" and an intensity of "Intense". Then, as $2/2$ would be $2 \cdot 2 = 4$, it will result in 2 after the mapping. If the result is greater or equal to 6, then the participant is considered to have CVS (see figure 3).

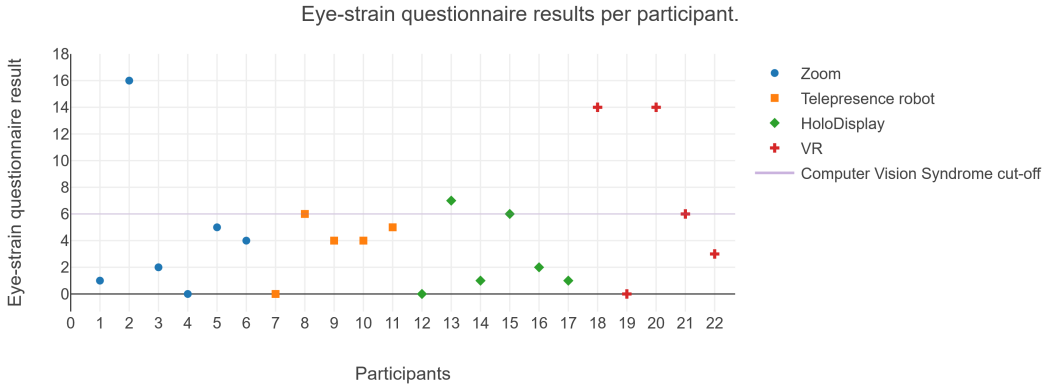
Table 6

Eye-strain

Question	Zoom lecture						Telepresence robot lecture					HoloDisplay lecture						VR lecture				
	1Z	2Z	3Z	4Z	5Z	6Z	1R	2R	3R	5R	7R	1H	2H	3H	4H	5H	6H	1V	2V	3V	4V	5V
Q1	0	1/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q2	0	2/1	0	0	0	0	0	0	1/1	0	0	0	0	0	0	0	0	0	0	1/1	1/1	0
Q3	0	1/1	0	0	0	0	0	0	0	0	0	0	0	0	1/1	0	0	0	0	0	0	1/1
Q4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2/2	0	0	0	0
Q5	0	2/1	1/1	0	1/1	0	0	0	0	1/1	0	0	1/1	0	1/1	1/1			0	1/1	0	0
Q6	0	1/1	0	0	0	0	0	0	0	0	0	0	0	0	1/1		0	0	0	0	0	0
Q7	0	2/1	0	0	0	0	0	0	0	1/1	0	0	0	0	0	0	0	0	0	2/1	0	1/1
Q8	0	2/2	2/1	0	1/1	1/1	0	1/1	1/1	0	1/1	0	1/2	1/1	0	0	1/1	0	0	1/1	0	0
Q9	0	1/1	0	0	1/1	1/1	0	0	1/1	1/1	0	0	0	0	0	1/1	0	0	0	2/1	1/1	0
Q10	0	2/2	0	0	1/1	0	0	1/1	0	0	1/1	0	1/1	0	0	0	0	2/2	0	2/1	2/2	0
Q11	0	2/1	0	0	0	0	0	1/1	0	0	0	0	1/1	0	0	0	0	2/2	0	1/1	0	0
Q12	0	2/1	0	0	0	0	0	0	0	0	1/1	0	0	0	0	0	0	2/2	0	2/1	0	1/1
Q13	0	2/1	0	0	0	1/1	0	2/2	1/1	0	0	0	1/1	0	2/1	0	0	0	0	2/2	0	0
Q14	0	2/1	0	0	0	0	0	1/1	0	0	0	0	0	0	0	0	0	2/2	0	1/1	0	0
Q15	0	1/1	0	0	1/1	1/1	0	0	0	0	1/1	0	1/1	0	1/2	0	0	2/2	0	2/1	1/2	0
Q16	1/1	0	0	0	0	0	0	0	0	1/1	1/1	0	1/1	0	1/1	0	0	2/2	0	2/2	1/1	0
Score	1	16	2	0	5	4	0	6	4	4	5	0	7	1	6	2	1	14	0	14	6	3

Figure 3

Results of the eye-strain questionnaire per participant. Participants on or above the purple line are considered to have Computer Vision Syndrome.



To test the **h2** and **h3** hypotheses introduced in chapter 1.1, a non-parametric test was used again as explained before. Moreover, the data is nominal as the participants are classified as having CVS or not having CVS. For this reason, the Chi-squared test is used.

H_0 : Telepresence robot teaching has no effect on the risk of eye-strain compared to Zoom teaching
H_α : Telepresence robot teaching decreases the risk of eye-strain compared to Zoom teaching
α : 0.05

As the Zoom lecture had one out of six participants considered to have CVS, and the telepresence robot lecture had one out of five, the Chi-squared test showed that the distributions are the same and H_0 not to be rejected (see table 7a). The X^2 is 0.0204 while the critical value with one degree of freedom and a significance of 5% is 3.84 (Glover & Mitchell, 2015, p.497). This means that there is not enough evidence that the two samples—being the Zoom and telepresence robot lectures—are different in terms of eye-strain. As a result, H_α cannot be accepted, regardless if the hypothesis were left or right-tailed (decrease or increase of risk of eye-strain).

When comparing the telepresence robot with the HoloDisplay, the Chi-squared test shows similarly that there is no difference between the two lectures ($X^2 = 0.245$, $\alpha = 0.5$, $df = 1$). However, the X^2 is larger than the comparison to the Zoom lecture.

The Chi-squared test between the telepresence robot and the VR has more favourable results, although not significant enough ($X^2 = 1.67$, $\alpha = 0.5$, $df = 1$). In this case, X^2 is 1.67 which is much closer than the other two lectures to the critical value of 3.84 mentioned before.

Table 7
Chi-squared test of the telepresence robot compared to the Zoom, HoloDisplay, and VR lectures.

	Observed		Expected		O - E		$(O - E)^2 / 2$		
	R	Z	R	Z	R	Z	R	Z	
No CVS	4	5	4.09	4.91	-0.09	0.09	0.0020	0.0017	
CVS	1	1	0.91	1.09	0.09	-0.09	0.0091	0.0076	
Total	5	6	5	6	0	0	0.0111	0.0093	**0.0204**

(a) *Telepresence (R)obot vs. (Z)oom.*

	Observed		Expected		O - E		$(O - E)^2 / 2$		
	R	H	R	H	R	H	R	H	
No CVS	4	4	3.64	4.36	0.36	-0.36	0.0364	0.0304	
CVS	1	2	1.36	1.64	-0.36	0.36	0.0971	0.0810	
Total	5	6	5	6	0	0	0.1336	0.1113	**0.245**

(b) *Telepresence (R)obot vs. (H)oloDisplay.*

	Observed		Expected		O - E		$(O - E)^2 / 2$		
	R	V	R	V	R	V	R	V	
No CVS	4	2	3.00	3.00	1.00	-1.00	0.3333	0.33333	
CVS	1	3	2.00	2.00	-1.00	1.00	0.5000	0.5000	
Total	5	5	5	5	0	0	0.8333	0.8333	**1.67**

(c) *Telepresence (R)obot vs. (V)R.*

Note: Expected values are calculated by multiplying the number of occurrences in the row and column of the entry and dividing them by the total number of occurrences of the whole table.

5 Responsible Research

The method can be accurately reproduced. It might be challenging to perfectly reproduce the method, as the HoloDisplay lecture makes use of an in-house technology developed by HoloLearn from the CEL at LDE to display the hologram. However, if a similar hologram can be produced, the method can be accurately reproduced. The script and slides of the lecture can also be found in the Appendix, which can be used to ensure that the lecture content can be the same when reproducing the experiment for even more accurate reproducibility.

Because the number of participants is extremely small ($n_{Zoom} = 6$, $n_{telepresencerobot} = 5$, $n_{HoloDisplay} = 6$, $n_{VR} = 5$), it may be the case that reproductions of the same method might result in different findings. Furthermore, a small sample size is also less likely to represent a whole group of people. Future research should aim for a larger number of participants to ensure a better fit to the general populace.

During the experiment, the participants were given IDs which are used to anonymize their data, such as their pre-test and post-test results. The results are thus not traceable

to the originator. Only the names of the participants are collected, which is needed for the informed consent forms. These forms will be destroyed after the research is finished. Approval has also been given by the HREC[6] (Human Research Ethics Commitee) of Delft University of Technology.

6 Conclusions

From the experiment and their results, teaching with a telepresence robot does not have an effect on the learning outcomes in comparison to teaching with Zoom. Also when compared to the HoloDisplay and VR lectures, telepresence robot teaching had the same learning outcomes. The rank total of the telepresence robot when compared to Zoom is actually not far from being lower than the lower critical value W, meaning that there is almost significant evidence that telepresence robot lectures have a decrease in learning outcomes than Zoom lectures. This is also reflected in the means of the scores. This could be explained by some of the students' comments that they were more used to Zoom lectures, as mentioned in chapter 4.1.

Teaching with a telepresence robot also does not have an effect on the risk of eye-strain in comparison to teaching with Zoom. This can also be said when compared to the HoloDisplay and VR lectures. Although the telepresence robot had no significant difference in risk for eye-strain, its comparison to the HoloDisplay lecture had a higher X^2 from the Chi-square test than its comparison to Zoom, favouring an decrease of risk of eye-strain. This might be caused by the projector that is used by the HoloDisplay. Due to the setup of the HoloDisplay, the projector has to shine its light from behind the glass, which results in the light shining at the participants. Furthermore, its comparison to the VR lecture had an even higher X^2. This does make sense as the majority of VR participants were considered to have CVS. In addition, this is in line with the research of Ganne et al. (2021), who reported that the scores to the CVS questionnaire increases when screen distance decreases. In both cases, however, their X^2 from the Chi-square test were still not significant enough to speak of a difference of risk of eye-strain across the learning methods.

For hybrid learning, it is possible to have lectures given through videoconferencing software such as Zoom, telepresence robots, holograms, and VR at the same time without significant unfair advantages or disadvantages for these distance learning students when it comes to learning outcomes or risk of eye-strain. Considering any or all of these methods in practice for students to follow in hybrid classrooms should be done with care, however, as almost a third of the participants experienced Computer Vision Syndrome during the 15 minute lecture.

Lastly, future research should look into how telepresence teaching—as well as holograms and VR—compares with onsite traditional classes in the hybrid classroom. The possibility of lower learning outcomes or worse eye-strain in comparison to onsite traditional classes should be investigated before hybrid classrooms are to be carried out to ensure fair treatment among students across all lecture methods.

7 Limitations

There are three main limitations. Firstly, the study had a small number of participants. As explained before, a smaller sample size makes it less likely for the results to be accurate and

[6]https://www.tudelft.nl/en/about-tu-delft/strategy/integrity-policy/human-research-ethics

representative.

Secondly, the duration of the experiment was fairly short. As lectures at school or universities typically take between 40 to 90 minutes, the 15 minute lecture of our experiment might not accurately represent reality. In turn, this limited the quality of the tests that examined the learning outcomes. A longer experiment enables a longer lecture, which may provide better options for the contents of the tests. A longer experiment would also make it possible for the test to be more elaborate, such as the option for open questions which does not show the choices unlike multiple-choice questions.

Finally, participants' existing eye conditions were not taken into account at the analysis, such as wearing glasses but also any significant differences in average screen times between the participants. These could impact the questionnaire results as they might experience the issues on the questionnaire differently from people without glasses or other average screen times. The experiment was also conducted during a time in which people with seasonal allergies—like hay fever—experience more allergy symptoms, such as itching. Both of these points could make the eye-strain questionnaire less accurate.

References

Allan, J. (1996). Learning outcomes in higher education. *Studies in higher education*, *21*(1), 93–108.

Banas, E. J., & Emory, W. F. (1998). History and issues of distance learning. *Public Administration Quarterly*, 365–383.

Cavanaugh, C. S. (2001). The effectiveness of interactive distance education technologies in k-12 learning: A meta-analysis. *International Journal of Educational Telecommunications*, *7*(1), 73–88.

del Mar Seguí, M., Cabrero-García, J., Crespo, A., Verdú, J., & Ronda, E. (2015). A reliable and valid questionnaire was developed to measure computer vision syndrome at the workplace. *Journal of clinical epidemiology*, *68*(6), 662–673.

Ferri, F., Grifoni, P., & Guzzo, T. (2020). Online learning and emergency remote teaching: Opportunities and challenges in emergency situations. *Societies*, *10*(4), 86.

Ganne, P., Najeeb, S., Chaitanya, G., Sharma, A., & Krishnappa, N. C. (2021). Digital eye strain epidemic amid covid-19 pandemic–a cross-sectional survey. *Ophthalmic epidemiology*, *28*(4), 285–292.

Gleason, B., & Greenhow, C. (2017). Hybrid education: The potential of teaching and learning with robot-mediated communication. *Online learning journal*, *21*(4).

Glover, T., & Mitchell, K. (2015). *An introduction to biostatistics: Third edition*. Waveland Press. Retrieved from `https://books.google.nl/books?id=v2B3CgAAQBAJ`

Kwon, O.-H., Koo, S.-Y., Kim, Y.-G., & Kwon, D.-S. (2010). Telepresence robot system for english tutoring. *2010 IEEE Workshop on Advanced Robotics and its Social Impacts*, 152–155.

Raes, A., Detienne, L., Windey, I., & Depaepe, F. (2020). A systematic literature review on synchronous hybrid learning: gaps identified. *Learning Environments Research*, *23*(3), 269–290.

Roth, J. J., Pierce, M., & Brewer, S. (2020). Performance and satisfaction of resident and distance students in videoconference courses. *Journal of Criminal Justice Education*, *31*(2), 296–310. doi: https://doi.org/10.1080/10511253.2020.1726423

Sadeghi, M. (2019). A shift from classroom to distance learning: Advantages and limitations. *International Journal of Research in English Education*, *4*(1), 80–88.

Appendix

PRE-TEST

In the interest of the research, you may skip questions if you do not know the answer.

1. Which period denotes the first Shogunate?
   - Sengoku Period
   - Kamakura Period
   - Muromachi Period
   - Kofun Period

2. How did Taira no Kiyomori gain power in the court?
   - Staged a coup d'état, ousting the Emperor
   - Fighting and winning in a lot of battles and gaining favour from the court
   - He came from a family of high nobility and status
   - Having his daughter marry the Emperor

3. Which one of the following battles took place at sea?
   - Battle of Yashima
   - Battle of Ichi-no-tani
   - Battle of Sekigahara
   - Battle of Dan-no-ura

4. After losing the battle against Ashikaga Takauji, Go-Daigo sets up the…
   - Northern Court
   - Western Court
   - Southern Court
   - Eastern Court

5. Oda Nobunaga lived in the…
   - Heian Period
   - Sengoku Period
   - Joumon Period
   - Nara Period

6. What is **not** correct about Minamoto no Yoshitsune?
   - Fled from battle during the Genpei War
   - He is the half-brother of Minamoto no Yoritomo
   - He is chased down due to suspicion and forced to commit suicide when surrounded
   - According to rumour, escaped to Mongolia and re-surfaced as Genghis Khan

7. How many times did Japan invade Korea during Toyotomi Hideyoshi's rule?
   - 1 time
   - 2 times
   - 3 times
   - 4 times

POST-TEST

In the interest of the research, please answer every question.

1. Which period denotes the first Shogunate?
   - Sengoku Period
   - Kamakura Period
   - Muromachi Period
   - Kofun Period

2. How did Taira no Kiyomori gain power in the court?
   - Staged a coup d'état, ousting the Emperor
   - Fighting and winning in a lot of battles and gaining favour from the court
   - He came from a family of high nobility and status
   - Having his daughter marry the Emperor

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   - Northern Court
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   - According to rumour, escaped to Mongolia and re-surfaced as Genghis Khan

7. How many times did Japan invade Korea during Toyotomi Hideyoshi's rule?
   - 1 time
   - 2 times
   - 3 times
   - 4 times

TEST ANSWER KEY

1. Which period denotes the first Shogunate?
   - Sengoku Period
   - Kamakura Period
   - Muromachi Period
   - Kofun Period

2. How did Taira no Kiyomori gain power in the court?
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   How many times did Japan invade Korea during Toyotomi Hideyoshi's rule?
   - 1 time
   - 2 times
   - 3 times
   - 4 times

5. Eye-strain

Please indicate whether you have experienced any of the following symptoms during the lecture. For each symptom, mark with an **X**.

First, the **frequency**, that is, how often the symptom occurs, considering that:

Never = the symptom does not occur at all

Occasionally = once during the lecture

Often or always = more than once during the lecture.

Second, the **intensity** of the symptom. Remember: if you indicated NEVER for frequency, you should not mark anything for intensity.

	Frequency			Intensity	
Issue	Never	Occasionally	Often or always	Moderate	Intense
Burning					
Itching					
Feeling of a foreign body[1]					
Tearing					
Excessive blinking					
Eye redness					
Eye pain					
Heavy eyelids					
Dryness					
Blurred vision					
Double vision					

[1] A sensation as if a foreign object were scratching the eye.

Difficulty focusing for near vision					
Increased sensitivity to light					
Coloured halos[2] around objects					
Feeling that sight is worsening					
Headache					

[2] Circles.

Japanese History until 1603

Welcome to the lecture of Japanese History until 1603. In this lecture, I will explain Japanese history in a nutshell from as early as 14500 BCE all the way to 1603.

Joumon Period

The Joumon Period spans from around 14500 BCE to 300 BCE. These people were the first inhabitants of Japan and were hunter-gatherers. They also did pottery with cord-impressions. Later, a new group of people moved to Japan from Korea called the Yayoi from 900 BCE. These people mostly started to populate from the south of Japan, moving upwards while also driving the Joumon people to move north as well. The Yayoi people brought the introduction of Bronze Age technology, such as bronze bells but also iron. They also were the first ones in Japan to start agrarian settlements, unlike the Joumon people. Due to such settlements, a hierarchy came about with social class differences.

Kofun Period

What followed next is the Kofun period. The name Kofun comes from the keyhole shaped tombs designated for rulers, which was a practice during this period. This period is split into two phases: One phase from 300 BCE to 500 CE where Japan consisted of local chiefdoms, and another phase that spans from 500 to around 710 where Japan started to develop a centralized state under the so-called Yamato rulers. That is also the reason why the second phase is regarded as the more important phase of the two. Furthermore, it was during this time that Buddhism was introduced to Japan by one of the Korean kings.

Nara Period and Heian Period

Following the Kofun Period, is the Nara Period from 710 to 794. The reason it is called Nara is because the Empress established her court in Nara. You can see the court as sort of the government and capital of Japan. However, later I will explain that Japan will actually have a second kind of capital. The period following Nara is the Heian Period which spans from 794 to 1185. Heian is the old name for Kyoto, which is very close to Nara.

Developments during these two periods were mostly cultural developments. For example, it was during the Nara Period that Chinese characters were introduced to Japan. From these characters, a new syllable system was even created. Next to that, poetry has started to get a foothold in the court, especially *waka*, which is Japanese poetry of 5 lines in 5-7-5-7-7 syllabic units. Buddhism was also flourishing in Japan. Next to these, there were also some internal developments. The most important thing to note is the Fujiwara family. This family gained a lot of power in the court by having their daughters marry the Emperors. This way, they got the title

of “*Regent*” which is like a chief advisory position to the Emperor. Actually, especially during the Heian Period, the Fujiwara were the effective rulers of Japan, and not the Emperor.

The last development you need to know about these two periods is that the court gave away plots of land to the aristocracy and temples so that they can turn the wild land into agricultural land. However, as they gave away more and more plots of land, the court lost more and more power and control, and power shifted from the court to the noble families and temples. Basically decentralization of Japan. Eventually, this led to the court having practically no control anymore which leads us to the following period.

Kamakura Period

The Kamakura Period is the first period with a Shogunate, spanning from 1185 to 1333. As the court lost its power, so did they lose its army. The court now relied on hiring private elite warriors for its army. This led to the formation of military families. The two most important families are the Minamoto and the Taira.

In 1156, due to a succession dispute at the court of who should be the next Emperor, fighting erupted in the capital with the aid of these hired warriors. This was called the Hougen Rebellion. The side of Go-Shirakawa had won the dispute while hiring both the Minamoto and the Taira, and was thus set to become the new emperor.

However, the Minamoto believed they received too little rewards for their help in this rebellion compared to the Taira. The new Emperor also favored the Taira more than the Minamoto. This infuriated them, and resulted in the Heiji Rebellion of 1159 where they attacked and set fire to the court. The Minamoto actually lost this battle, which resulted in the Taira to become even more influential. A particular man from this family, called Taira no Kiyomori, became the first chief-minister as a result, which was a very powerful title.

Next slide transition
Years have passed, and at a certain point in 1180, Kiyomori no Taira became too much for the court to handle, as he started to become more and more dangerous to the court by trying to have his grandson become the next Emperor. The court asked the Minamoto for help, and they of course gladly accepted. The following battle that would ensue is called the Genpei War.

This Genpei War lasted for five years, ending in 1185. The Battle is highlighted with three important battles at the end of the war. Battle of Ichi-no-tani, Battle of Yashima, and Battle of Dan-no-ura. In the Minamoto family, there are two key people during this time which are: Yoshitsune and Yoritomo. The most influential person in these battles is Minamoto no Yoshitsune, who is the half-brother of Yoritomo. Yoritomo was known as the current leader at that time of the Minamoto family. Yoshitsune played a big role in these battles and is mostly the reason that they were won by the Minamoto. The final battle of the Genpei War, which was the Battle of Dan-no-ura, took place at sea. The Taira fought to the death, with people, including even the grandson of Kiyomori no Taira, to jump in the sea and drown.

After the Minamoto victory of the Genpei War, they set up a Shogunate at the city of Kamakura, which is near Tokyo. The Shogunate is basically a military capital. Now there are two capitals in Japan: The court, which is in Kyoto, is now more of a symbolic and ceremonial capital where the Emperor lives. The Shogunate, which is near Tokyo, is a new sort of capital where Minamoto no Yoritomo, the first Shogun, is the effective ruler of Japan. Not much later, Yoritomo had ordered the assassination of his half-brother, Yoshitsune, due to suspicion. After a long chase, he was surrounded and was forced to commit suicide. There is a fun rumor, saying that he actually escaped to Mongolia and re-surfaced as Genghis Khan.

The only other noteworthy thing that happened during this period is the two Mongol invasions. These were in 1274 and 1281. They were however ineffective, mostly due to the typhoons as they attacked during the typhoon seasons.

The period was pretty peaceful up until around 1333, which brings us to the next period.

Kenmu Restoration

A certain Emperor named Go-Daigo decided to try to overthrow the Shogunate in 1324. He, however, failed and was banished in 1331. After he escaped 2 years later, he and other Go-Daigo loyalists succeeded in overthrowing the Kamakura Shogunate in 1333.

During the next 2 years, Go-Daigo had full control. This brief period was called the Kenmu Restoration. When it looked like Go-Daigo would be defeated again, he asked Ashikaga Takauji for help. However, when Ashikaga Takauji defeated Go-Daigo's enemies, Takauji turned his back to Go-Daigo to establish a new Shogunate. Ofcourse, Go-Daigo didn't want this because for him to have full control, there can be no Shogunate. Again, a battle ensued. This battle in 1336 was called the Battle at Minatogawa and was fought between the side of Ashikaga Takauji and the side of Go-Daigo. The result was a victory for Takauji, and he established a new Shogunate in Kyoto. He also designated someone else as the new Emperor. This is the start of the Muromachi Period.

Muromachi Period

Interestingly, this new Shogunate called the Muromachi Shogunate was placed in the same city as the court. You can also call this Shogunate the Ashikaga Shogunate instead, which I prefer more. As Ashikaga Takauji placed his new Shogunate in Kyoto and became Shogun, Go-Daigo fled to Yoshino and set up his new court there. From 1336 to 1392, apart from a Shogunate, Japan now actually had two courts. This period was called the Southern and Northern Court period. A pretty easy name. Finally, after a 60 year period of constant war, Go-Daigo surrendered and the Southern Court dissolved in 1392.

Compared to the previous Shogunate, which was the Kamakura, the Ashikaga Shogunate actually had very little land. As a result, they gradually became less powerful while the provinces of Japan grew and became more powerful. These provinces were called domains, with the leader of such a domain being called "*Daimyo*". Near the end of the Ashikaga period, there were constant wars between these domains as there were conflicts over the succession of the Ashikaga Shogun. This resulted in the Ounin War between 1467 and 1477.

There was actually no clear victory, as the war ended due to everyone being exhausted. This Ounin War marked the beginning of the warring states, called the Sengoku Period spanning 1467 to 1615. The Sengoku Period is characterized by the Ashikaga Shogunate losing power and the central authority breaking down, eventually being dissolved in 1573.

Sengoku Period

It was during this period that Japan got more contact with the outside world, especially Europe. The Portuguese landed in the southern tip of Japan and introduced western science, technologies, and Christianity.

During this period there are three key people that are important to note. Oda Nobunaga, Toyotomi Hideyoshi, and Tokugawa ieyasu (iejeejasoe). Oda Nobunaga, who was a *Daimyo*, got the idea of conquering other domains. His goal was to unify the numerous domains in Japan at the time, having all of Japan under his control. He was very successful, as he had good strategy but also access to fire weapons from the Portuguese. Midway during his conquest, however, he was assassinated by one of his men. He was then succeeded by Toyotomi Hideyoshi who finished his conquest of unifying the whole of Japan.

During his rule, he tried to invade Korea twice. Once in 1592 and another time in 1598. During the first invasion, they captured the Korean capital of Seoul within a month, but they had to retreat because the Chinese drove them back. The second invasion was less successful. Whatsmore, during the second invasion, Toyotomi Hideyoshi suddenly died. To decide who succeeded him, there was a huge battle between two people in 1600. It was the Eastern Army of Tokugawa Ieyasu, and the Western Army of Ishida Mitsunari. In the end, Tokugawa Ieyasu won the battle, but mostly because a lot of the Western Army defected to the Eastern Army. This battle was called the Battle of Sekigahara.

As the relations between Korea and Japan were sour due to the Invasions, Tokugawa Ieyasu made peace with Korea in 1604 as he wasn't interested in conflict with them. Tokugawa Ieyasu then marked the third shogunate period in 1603 by establishing his Shogunate in Edo, which is modern-day Tokyo, and becoming Shogun.

This marks the beginning of the Edo Period and the end of our lecture. Thank you so much for your attention.

Japanese History until 1603

1

Court: *N/A*
Shogunate: *N/A*

Joumon Period (14500 BCE - 300 BCE)

- Hunter-Gatherers
- Cord-impressed pottery
- Yayoi people from 900 BCE
- Agriculture

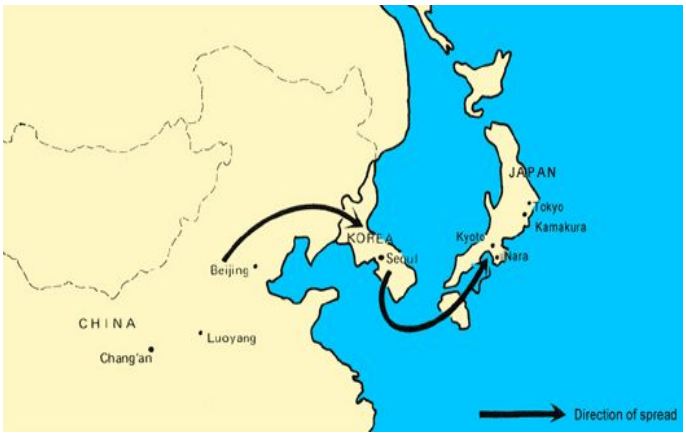
Joumon Period (14500 BCE-300 BCE) | Kofun Period (300 BCE-710 CE) | Nara Period (710-794) | Heian Period (794-1185) | Kamakura Period (1185-1333) | Kenmu Restoration (1333-1336) | Nanboku Period (1336-1392) | Muromachi (Ashikaga) Period (1336-1573) | Sengoku Period (1467-1615) | Edo Period (1603-1867)

2

Court: *N/A*
Shogunate: *N/A*

Kofun Period (300 BCE - 710 CE)

- Keyhole shaped tombs
- 1st phase (300 BCE-500 CE): local chiefdoms
- 2nd phase (500-710): centralized state
- Buddhism imported from Korea



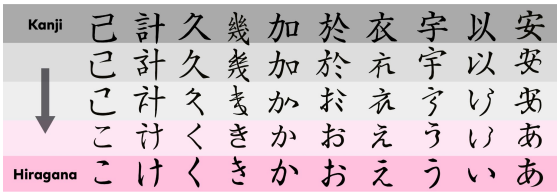
Joumon Period (14500 BCE-300 BCE) | Kofun Period (300 BCE-710 CE) | Nara Period (710-794) | Heian Period (794-1185) | Kamakura Period (1185-1333) | Kenmu Restoration (1333-1336) | Nanboku Period (1336-1392) | Muromachi (Ashikaga) Period (1336-1573) | Sengoku Period (1467-1615) | Edo Period (1603-1867)

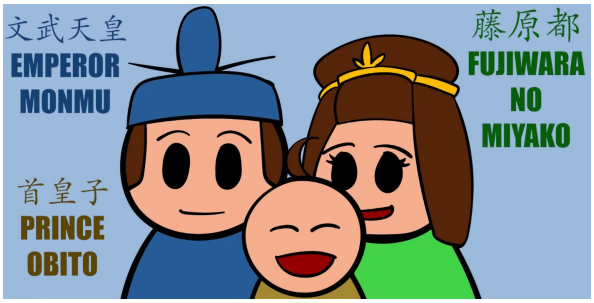
3

Court: *in Nara, then Kyoto*
Shogunate: *N/A*

Nara Period (710 - 794) and Heian Period (794 - 1185)

- Court established in Nara
- Cultural developments
  - Chinese characters
  - *Waka* Poetry
  - Buddhism
- Fujiwara family
  - Regent
- Land to aristocracy (nobles) and temples
- Loss of power





Nanboku Period (1336-1392) | Sengoku Period (1467-1615)

Joumon Period (14500 BCE-300 BCE) | Kofun Period (300 BCE-710 CE) | Nara Period (710-794) | Heian Period (794-1185) | Kamakura Period (1185-1333) | Kenmu Restoration (1333-1336) | Muromachi (Ashikaga) Period (1336-1573) | Edo Period (1603-1867)

4

Court: *in Kyoto*
Shogunate: *in Kamakura*

Kamakura Period (1185 - 1333)

Minamoto emblem

Taira emblem

- Military families
  - Minamoto
  - Taira
- Succession dispute
- Hougen Rebellion (1156)
- Minamoto “short end of the stick”
- Heiji Rebellion (1159)
  - Taira win
- Taira no Kiyomori
  - Chief-minister

Heiji Rebellion (1159) : Sanjo Palace on fire.

Joumon Period (14500 BCE-300 BCE) | Kofun Period (300 BCE-710 CE) | Nara Period (710-794) | Heian Period (794-1185) | Kamakura Period (1185-1333) | Kenmu Restoration (1333-1336) | Nanboku Period (1336-1392) | Muromachi (Ashikaga) Period (1336-1573) | Sengoku Period (1467-1615) | Edo Period (1603-1867)

5

Court: *in Kyoto*
Shogunate: *in Kamakura*

Kamakura Period (1185 - 1333)

- Taira no Kiyomori becomes problem
- Court asks Minamoto for help
- Genpei War (1180-1185)
  - Battle of Ichi-no-tani
  - Battle of Yashima
  - Battle of Dan-no-ura
  - Minamoto win

Minamoto no Yoshitsune

Minamoto no Yoritomo

Joumon Period (14500 BCE-300 BCE) | Kofun Period (300 BCE-710 CE) | Nara Period (710-794) | Heian Period (794-1185) | Kamakura Period (1185-1333) | Kenmu Restoration (1333-1336) | Nanboku Period (1336-1392) | Muromachi (Ashikaga) Period (1336-1573) | Sengoku Period (1467-1615) | Edo Period (1603-1867)

6

Court: *in Kyoto*
Shogunate: *in Kamakura*

Kamakura Period (1185 - 1333)

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- Court asks Minamoto for help
- Genpei War (1180-1185)
  - Battle of Ichi-no-tani
  - Battle of Yashima
  - Battle of Dan-no-ura
  - Minamoto win

Battle of Dan-no-ura (1185).

Joumon Period (14500 BCE-300 BCE) | Kofun Period (300 BCE-710 CE) | Nara Period (710-794) | Heian Period (794-1185) | Kamakura Period (1185-1333) | Kenmu Restoration (1333-1336) | Nanboku Period (1336-1392) | Muromachi (Ashikaga) Period (1336-1573) | Sengoku Period (1467-1615) | Edo Period (1603-1867)

7

Court: *in Kyoto*
Shogunate: *in Kamakura*

Kamakura Period (1185 - 1333)

- Taira no Kiyomori becomes problem
- Court asks Minamoto for help
- Genpei War (1180-1185)
  - Battle of Ichi-no-tani
  - Battle of Yashima
  - Battle of Dan-no-ura
  - Minamoto win
- First Shogunate in Kamakura
- Two Mongol invasions
  - 1st: 1274
  - 2nd: 1281

Joumon Period (14500 BCE-300 BCE) | Kofun Period (300 BCE-710 CE) | Nara Period (710-794) | Heian Period (794-1185) | Kamakura Period (1185-1333) | Kenmu Restoration (1333-1336) | Nanboku Period (1336-1392) | Muromachi (Ashikaga) Period (1336-1573) | Sengoku Period (1467-1615) | Edo Period (1603-1867)

8

Court: *in Kyoto*
Shogunate: *N/A*

Kenmu Restoration (1333 - 1336)

- Emperor Go-Daigo
  - Banished
  - Escaped 2 years later
- Kamakura Shogunate overthrown
- Full control
- Ashikaga Takauji
  - Helps Go-Daigo
  - Betrays Go-Daigo
- New Shogunate established
  - Muromachi Shogunate in Kyoto

Battle of Minatogawa (1336).

Nanboku Period (1336-1392) | Sengoku Period (1467-1615)

Joumon Period (14500 BCE-300 BCE) | Kofun Period (300 BCE-710 CE) | Nara Period (710-794) | Heian Period (794-1185) | Kamakura Period (1185-1333) | Kenmu Restoration (1333-1336) | Muromachi (Ashikaga) Period (1336-1573) | Edo Period (1603-1867)

9

Court: *in Kyoto (and Yoshino)*
Shogunate: *in Kyoto*

Muromachi Period (1336 - 1574)

- Muromachi Shogunate (a.k.a. Ashikaga Shogunate)
  - Same city as court
- Go-Daigo flies to Yoshino
- One shogunate, two courts
- Southern and Northern Court Period (1336-1392)
- Go-Daigo surrenders
  - Southern Court dissolved in 1392
- Shogunate loses power
- Domains and their "*Daimyo*"
- Ounin War (1467-1477)
  - Marks start of Sengoku Period

Nanboku Period (1336-1392)
Sengoku Period (1467-1615)
Joumon Period (14500 BCE-300 BCE)
Kofun Period (300 BCE-710 CE)
Nara Period (710-794)
Heian Period (794-1185)
Kamakura Period (1185-1333)
Kenmu Restoration (1333-1336)
Muromachi (Ashikaga) Period (1336-1573)
Edo Period (1603-1867)

10

Court: *in Kyoto (and Yoshino)*
Shogunate: *in Kyoto*

Muromachi Period (1336 - 1574)

- Muromachi Shogunate (a.k.a. Ashikaga Shogunate)
  - Same city as court
- Go-Daigo flies to Yoshino
- One shogunate, two courts
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- Go-Daigo surrenders
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- Shogunate loses power
- Domains and their "*Daimyo*"
- Ounin War (1467-1477)
  - Marks start of Sengoku Period

The domains of Japan in 1467.

Nanboku Period (1336-1392) | Sengoku Period (1467-1615)

Joumon Period (14500 BCE-300 BCE) | Kofun Period (300 BCE-710 CE) | Nara Period (710-794) | Heian Period (794-1185) | Kamakura Period (1185-1333) | Kenmu Restoration (1333-1336) | Muromachi (Ashikaga) Period (1336-1573) | Edo Period (1603-1867)

Court: *in Kyoto*
Shogunate: *in Kyoto, later in Edo*

Sengoku Period (1467 - 1615)

- Also called Warring states period
- Portuguese as first European contact with Japan
  - Western science/technologies
  - Christianity
- Three key people:
  - Oda Nobunaga
  - Toyotomi Hideyoshi
  - Tokugawa Ieyasu

Oda Nobunaga

Toyotomi Hideyoshi

Tokugawa Ieyasu

Court: *in Kyoto*
Shogunate: *in Kyoto, later in Edo*

Sengoku Period (1467 - 1615)

- Invading Korea twice
  - 1st: 1592
  - 2st: 1598
- Battle of Sekigahara
  - Eastern Army (Tokugawa Ieyasu) vs.
  - Western Army (Ishida Mitsunari)

Nanboku Period (1336-1392)

Sengoku Period (1467-1615)

Joumon Period (14500 BCE-300 BCE) | Kofun Period (300 BCE-710 CE) | Nara Period (710-794) | Heian Period (794-1185) | Kamakura Period (1185-1333) | Kenmu Restoration (1333-1336) | Muromachi (Ashikaga) Period (1336-1573) | Edo Period (1603-1867)

Court: *in Kyoto*
Shogunate: *in Kyoto, later in Edo*

Sengoku Period (1467 - 1615)

- Invading Korea twice
  - 1st: 1592
  - 2st: 1598
- Battle of Sekigahara
  - Eastern Army (Tokugawa Ieyasu) vs.
  - Western Army (Ishida Mitsunari)
  - Eastern Army win
- Edo Shogunate in 1603

Battle of Sekigahara (1600).

Nanboku Period (1336-1392) | Sengoku Period (1467-1615)

Joumon Period (14500 BCE-300 BCE) | Kofun Period (300 BCE-710 CE) | Nara Period (710-794) | Heian Period (794-1185) | Kamakura Period (1185-1333) | Kenmu Restoration (1333-1336) | Muromachi (Ashikaga) Period (1336-1573) | Edo Period (1603-1867)