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

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0 Background

Learning outcomes: New knowledge or abilities obtained from learning[1].

(Digital) Eye-strain: Also known as *Computer Vision Syndrome* (CVS), is defined as eye and vision problems that arise due to interaction with a computer display or a similar environment[2].

Hologram: An artificially made complete representation of a person. See part 2.5.

Telepresence robot: A self-movable device used for communication with video. See part 2.5.

Zoom: A videoconference software that is used a lot in distance learning.

Previous research focused on interest and motivation when teaching with a telepresence robot[3], but not on learning outcomes or negative effects such as eye-strain.

Previous researched has investigated CVS amid COVID-19 and concluded students are more at risk to suffer from CVS[4]. Their method based participants of their experiment on devices such as televisions, computers, smartphones, e-readers, tablets, and gaming systems.

The research is part of HoloLearn from the Centre for Education and Learning at LDE.

1 Research Question

(R) What effect does teaching with a telepresence robot have on the learning outcomes and risk of eye-strain of students?

(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.

(H2) Teaching with a telepresence robot **will decrease** students' risk of eye-strain compared to teaching with Zoom.

2 Methods

2.1 Participants

22 participants, mostly TU Delft students.

2.2 Apparatus

Zoom: A video with lecture slides and a thumbnail of the teacher.

Telepresence robot: A Double 2 from Double Robotics that streams the teachers face.

HoloDisplay: A hologram displaying the teacher.

VR: A virtual reality environment simulating a classroom along with students .

Each lecture is shown in F.1.

2.3 Materials & Measures

Learning outcomes: A 7-question multiple-choice pre-test and post-test. These two tests contain the exact same questions and options. The purpose of the pre-test is to gauge the knowledge of the participant on the lecture topic before the experiment.

Eye-strain: A 16-question questionnaire asking the participants on issues such as tearing and itching. The questionnaire is adapted from the paper of del Mar Seguí et al.[2]

2.4 Design

Independent measures study: Students will only follow one of the four lectures. Student's prior knowledge might complicate measuring the learning outcomes.

Independent variable: The representation of the teacher.

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

Confounding variables: Student's prior knowledge on the lecture topic.

Control group: Zoom lecture.

Treatment group: Telepresence robot lecture, hologram lecture.

2.5 Procedure

Participants are **randomly** allocated to one of four lectures prior to the experiment. Each lecture held between 5-6 students. The participants were briefed about the experiment and were not told that the pre-test and post-test were the same. After signing the informed consent forms, they filled in the pre-test before following their assigned lecture. The lecture takes 15 minutes. After the lecture, they first did the post-exam and then the eye-strain questionnaire. After the experiment, the participants were rewarded compensation in the form of a voucher.

3 Results

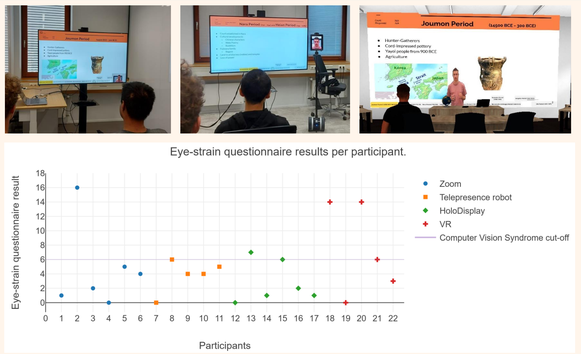
Z	R	H	V
3	3	5	1
5	3	3	3
3	3	4	5
5	4	4	4
3	3	1	4
4		3	
3.83	3.20	3.33	3.40

T.1: Test scores (out of 7) and mean of each lecture.

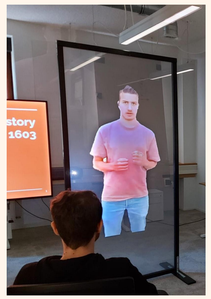
Learning outcomes:
T.1 shows the test results of each participant and the mean of each lecture abbreviated to (Z)oom, telepresence (R)obot, (H)oloDisplay, and (V)R. As the sample size is small, a right-tailed Wilcoxon rank sum test is used, which is a non-parametric test. **H0** is taken as H_0 and **H1** as H_α. The test showed that there is **no** significant evidence that telepresence robot teaching has better learning outcomes than Zoom ($T_1 = 24.5$, $T_2 = 41.5$, $m = 5$, $n = 6$, $\alpha = 0.05$). When compared to the HoloDisplay ($T_1 = 27$, $T_1 = 39$, m = 5, n = 6, $\alpha = 0.05$) and VR lecture ($T_1 = 24$, $T_1 = 31$, m = 5, n = 5, $\alpha = 0.05$), there is also no significant difference.

Eye-strain:
F.2 shows the questionnaire results of each participant. As the sample size is small and the data is nominal (either CSV or not), the Chi-squared test is used, which is a non-parametric test as well. **H2** is taken as H_0 and **H3** as H_α. The test showed that there is **no** significant evidence that telepresence robot teaching has decreased risk in eye-strain compared to Zoom ($X_2 = 0.0204$, $\alpha = 0.5$, $df = 1$). Comparing to the HoloDisplay ($X_2 = 0.245$, $\alpha = 0.5$, $df = 1$) and VR lecture ($X_2 = 1.67$, $\alpha = 0.5$, $df = 1$), there is also no significant evidence that the telepresence robot decreased risk to eye-strain.

Some students commented after the lecture that the telepresence robot, VR, and HoloDisplay lectures were sometimes distracting, especially the latter to due to flickering. Others also commented that they were more used to the Zoom lecture.



F.2: Eye-strain questionnaire results of each participant. Results equal or greater than 6 are considered to indicate Computer Vision Syndrome.



F.1: Zoom, telepresence robot, and VR lectures on the left respectively. HoloDisplay lecture on the bottom. Pictures taken during test-run.

4 Conclusion

Learning outcomes: The Wilcoxon rank sum test shows that telepresence robot teaching does not have increased learning outcomes than Zoom. Almost significant evidence that learning outcomes were worse than Zoom. Could be explained by students' comments that they were more used to Zoom lectures. When comparing to HoloDisplay and VR, there is also no difference.
Eye-strain: The Chi-squared test shows that telepresence robot teaching does not decreased risk of eye-strain than Zoom. Also no decreased risk of eye-strain when compared to HoloDisplay and VR. However, almost significant evidence that risk of eye-strain is decreased when compared to VR. In addition, results are inline with the research of Ganne et al[4]. reported higher scores on the questionnaire when screen distance decreases.

In a hybrid setting, teaching through the methods of videoconference software such as Zoom, telepresence robots, holograms, and VR at the same time poses no unfair advantages or disadvantages for the distance learning students when it comes to learning outcomes or risk of eye-strain. Future research should investigate if these distance learning methods have at least equal or higher learning outcomes and at least equal or lower risk of eye-strain when compared to the traditional lecture that is given onsite simultaneously.

5 Limitations

Small sample size: The sample size of 22 is less likely to produce accurate and representative results than higher sample sizes.
Duration of experiment: As lectures at school or university tend to be between 40-90 minutes, the 15 minute lecture might not accurately represent reality. This could limit the quality of the tests.
Pre-existing eye conditions: Participants that wear glasses, or had pre-existing eye conditions prior to the experiment could have impacted the accuracy of the questionnaire. Participants also could have suffered from seasonal allergies—such as hay fever—where they experience symptoms such as itching.

6 References

[1] Allan, J. (1996). Learning Outcomes in Higher Education. *Studies in Higher Education*, 21:1, 93-108.
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[4] 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.