EcoVR – A virtual reality for learning eco-friendly food choice

Martin Dobricki[1*], Michael Rihs[1,2], Sina Shahmoradi[1]

[1] Education & Digital Technologies Lab, Institute for Research, Development and Evaluation, Bern University for Teacher Education, Bern, Switzerland

[2] Cognitive Psychology, Perception and Research Methods Lab, Institute for Psychology, University of Bern, Bern, Switzerland

*** Correspondence:**
Corresponding Author
martin.dobricki@phbern.ch

Keywords: learning, food choice, sustainability, human-environment relation, virtual reality.

Abstract

Eco-friendly food choice requires that human individuals relate themselves and their natural environment to each other. They may establish this human-environment relation by experiencing their food choices being accompanied by negative or positive changes of the eco-system. Hence, educating human individuals by enabling them to such human-environment experiences may foster their eco-friendly food choice. Yet, this would require inducing climate-related environmental changes on purpose that immediately follow one's choice of food. We have, therefore, developed a VR consisting in a life-sized virtual environment in which grabbing food is accompanied by climate-related environmental changes or their reversal depending on the food's carbon footprint. Moreover, we have started to investigate the educational utility of this *EcoVR* by asking experienced lower secondary school teachers to rate it in controlled experiments. Our findings suggest that the teachers regard EcoVR to be useful for teaching climate-friendly food consumption. Moreover, they regard this educational usefulness of EcoVR to be higher than that of its PC version. Hence, in lower secondary education EcoVR may have the potential to serve pupils for learning climate-friendly food choice. Moreover, it may serve as a digital bridge or «metaverse» between the learning of relevant skills at school and the application of these skills in real life.

1 Introduction

The ecosystems of earth are important for human well-being (Millennium-Ecosystem-Assessment, 2005). Climate-related changes of these ecosystems may therefore be regarded as a threat. Such climate-related environmental changes are driven by greenhouse gas emissions (Yue and Gao, 2018). Almost 30 % of these emissions are caused by the production of food (Poore and Nemecek, 2018). Hence, eating more food with a low carbon footprint and less food with a high carbon footprint has the potential to reduce greenhouse gas emissions significantly. Such eco-friendly food consumption requires that human individuals relate themselves and their natural environment to each other (Davis et al., 2009). They may establish this human-environment relation (Kaufmann-Hayoz, 2006) by experiencing their food choices being accompanied by negative or positive environmental changes. Hence, educating human individuals by enabling them to such human-environment experiences may foster their eco-friendly food choice. Yet, this would require inducing climate-related environmental changes on purpose that immediately follow one's choice of food. Being impossible in physical reality this can be accomplished in virtual reality (Markowitz and Bailenson, 2021). In fact, climate-related environmental changes can be programmed in virtual reality (VR) in a way that they occur or disappear as the immediate consequence of one's own behavior (Dobricki et al., 2021). Accordingly, we have developed a VR consisting in a life-sized virtual environment in which grabbing food is accompanied by climate-related environmental changes or their reversal depending on the food's carbon footprint. A promising opportunity for using this VR to teach eco-friendly food choice early to a large part of society may be in lower secondary education (Keller and Brucker-Kley, 2021). Here we have, therefore, started to investigate the utility of EcoVR for this educational level. For this purpose, we have asked experienced secondary school teachers to assess the educational utility of EcoVR in controlled experiments.

2 Material and methods

2.1 Participants

Ten teachers (3 males, mean age = 44.9 yrs, SD = 9.2 yrs) with normal or corrected-to-normal vision participated. This sample size was suggested by a priori power analysis (Brysbaert, 2019) specified as follows: $f = 0.3$, alpha error = 0.05, power = 0.8, corr. = 0.8. All participants had been teaching in lower secondary school for at least 7 years. All participants gave their written informed consent and could have withdrawn from the study at any time.

2.2 Stimuli and apparatus

The participants were presented with a 3D virtual environment from a first-person perspective (see here). This was accomplished by using the graphics engine Unity3D on a Lenovo Legion 7 computer with an AMD Ryzen 9 processor and an NVIDIA GeForce RTX 3080 graphics card. The virtual environment consisted of an island on a lake with a wooden house on one side of it and a market stand on its other side, and two other small islands with a market stand on each of them. One could move around on the different islands using a controller in the right hand and place food items into a basket or for removing them from this basket using a controller in the left hand. At each market stand one food item with a high carbon footprint and one with low carbon footprint were available. When placing a high carbon footprint food item into the basket, the sky becomes immediately cloudy, it starts to rain heavily, and the level of the lake rises such that everything is flooded. When replacing the high carbon footprint item with a low carbon footprint item, these climate-related environmental changes are immediately reversed. These were the two food items at the market stand on the three islands: Minced beef and potato (first island), cheese and tomato (second island), chocolate and apple (third island). The virtual environment was presented either with the desktop display of the computer or with a stereoscopic motion-tracked Reverb G2 head-mounted display (HMD) from Hewlett-Packard. Wearing this HMD participants were able to move around and place food items into the basket with the two controllers belonging to the HMD. Being presented with the virtual environment on the desktop screen they could do this using two Joy-Con controllers from Nintendo.

2.3 Problem-based learning task

On each of the three islands the following problem solving task (van Merriënboer, 2013) had to be accomplished. First, the high carbon footprint food item had to be placed into the basket. This triggered the rise of the sea level, which prevented that one could get to any of the other island. Second, this problem had to be solved by replacing the high carbon footprint food item with the low carbon footprint item, which caused the sea level to drop. The instruction of this task was as follows: Please imagine that your grandparents are in the wooden house and want to cook there. They want to cook a stew and prepare a dessert. However, they do not have everything they need for this. Therefore, they send you to get the following three products on the islands in front of you: minced beef and cheese for the stew and chocolate for dessert. Please get these products on the small islands in front of you and come back here. Under no circumstances should you return with an empty basket. The task is only completed when you have placed three food items on the table in front of the wooden house.

2.4 Experimental design

The study was pre-registered (https://osf.io/2hv5j). We used a within-subjects crossover design with two experimental conditions. Hence, all participants were exposed to both experimental conditions. The order of the conditions was determined by the crossover design. In one condition, the 3D virtual environment spatially included its observer, as it was viewed within the head-mounted display. This was the EcoVR condition. In the other condition, the 3D virtual environment spatially excluded its observer, as it was viewed on the desktop display. We named it the EcoPC condition.

2.5 Procedure

The procedure was the same in both experimental conditions: First, the use of the virtual environment was explained and briefly practiced. Subsequently, the teachers were informed about the learning task described above and asked to accomplish the task at the various market stalls using the controllers. This experience phase was followed by an evaluation phase. In this phase, the teachers were asked to assess EcoVR and EcoPC using the three psychometric questionnaire scales described in the next section.

2.6 Measures

The teachers were asked to assess EcoVR and EcoPC using three psychometric questionnaire scales (response format: 100 mm visual analog scale, minimum: not at all; maximum: very much). The first two of these scales corresponded to those of the technology acceptance model (TAM) from Davis (1989) and were each assessed using 6 items. One of these two scales was used to assess the perceived usefulness of EcoVR and EcoPC for teaching climate-friendly food consumption. The other scale was used to assess the ease of use of EcoVR and EcoPC. The third scale was used to evaluate spatial presence, i.e., the feeling of being present in the virtual environment. This scale was assessed using 8 items taken from the MEC Spatial Presence Questionnaire (Rössler, 2011).

2.7 Data analysis

The participants' individual scores on the TAM scales named perceived usefulness and ease of use, and on the spatial presence scale, were determined by calculating their mean rating of the questionnaire items used to assess each of these psychometric scales. Subsequently, these scale scores were compared across the two experimental conditions by one-way repeated-measures analyses of variance (ANOVAs) and by calculating the effect size η_p^2. As for descriptive statistics, we calculated the median (*Md*) and interquartile range [IQR] for all ratings. The statistical analyses were performed with the statistical software SPSS. The visualization of the statistical results was generated with the ggplot2 package within the statistical software R.

3 Results

The statistical analysis of the teachers' ratings in the two experimental conditions yielded the following results: As can be seen in Figure 1 the teachers rated the usefulness of EcoVR for teaching, *Md* = 69.5, IQR [55.3, 81.2], significantly higher, F (1, 9) = 6.78, p = 0.029, η_p^2 = 0.430, than the usefulness of the PC version, *Md* = 54.0, IQR [27.6, 71.9]. They also rated the ease of use of EcoVR, *Md* = 73.5, IQR [61.3, 91.3], significantly higher, F (1, 9) = 9.24, p = 0.014, η_p^2 = 0.507, than the ease of use of the PC version, *Md* = 47.3, IQR [17.8, 61.6]. In addition, the teachers' feeling of being present in the virtual environment, i.e., their sense of spatial presence (Figure 1) in EcoVR, *Md* = 83.1, IQR [70.0, 95.3], was significantly stronger, F (1, 9) = 61.68, $p < 0.001$, η_p^2 = 0.873, than in the PC version, *Md* = 29.1, IQR [12.0, 34.9].

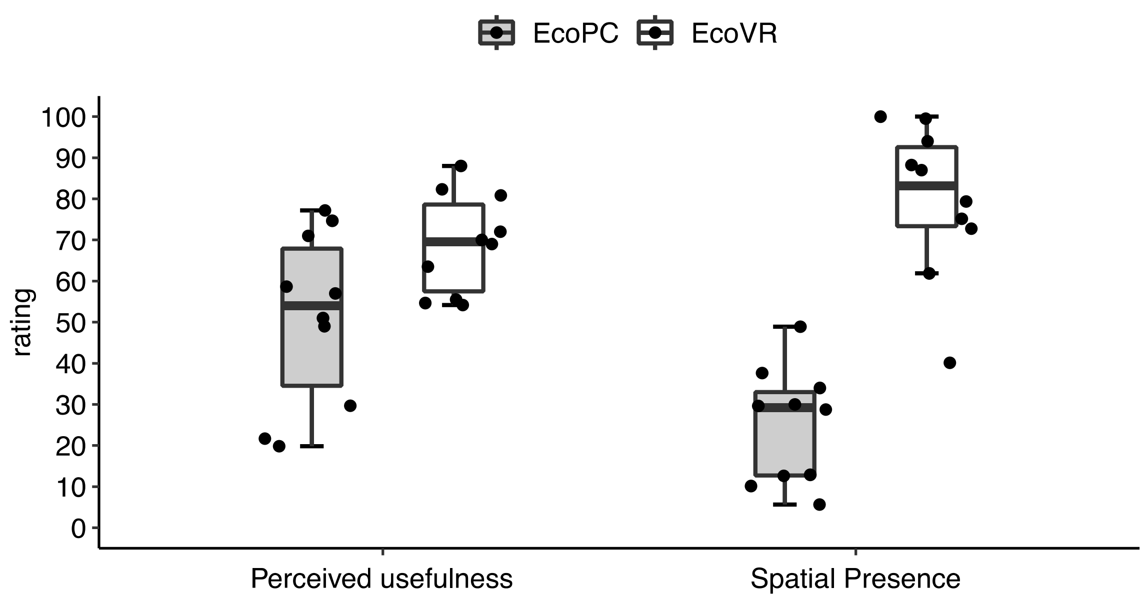

Figure 1. Comparison of EcoVR and EcoPC. Box-whisker plots of the ratings of EcoVR and the PC version in terms of their perceived usefulness for teaching and in terms of sensed spatial presence. Bold horizontal lines show the median of the ratings; boxes show the lower and upper quartiles; whiskers show the furthest data points within 1.5 times the distance to the lower and upper quartiles. Dots depict the individual ratings of the 10 teachers.

4 Discussion

The ratings of EcoVR by experienced teachers working in lower secondary education suggest that they regard EcoVR to be useful for teaching climate-friendly food consumption. Moreover, their ratings suggest that they regard the educational usefulness of EcoVR to be higher than that of its PC version.

EcoVR is programmed in a way that climate-related changes of the ecosystem such as heavy rainfall, immediately arise or disappear depending on the choice of food and its carbon footprint (Poore and Nemecek, 2018). Hence, the core feature of EcoVR is to enable learners to directly experience their food choices and such climate-related environmental changes relative to each other. Experiencing this human-environment relation (Davis et al., 2009) may serve to learn the information processing skills required for engaging into climate-friendly food consumption.

There are two important questions regarding the educational utility of EcoVR that soon need to be addressed in future studies. First, it must be investigated if EcoVR really can serve to foster the learning of eco-friendly food consumption. Second, it has to be investigated if pupils are able to transfer their learning in EcoVR to their everyday life. Most likely, this transfer may be facilitated by a learning task that has to be accomplished by pupils at home and then reported and reflected in school. Hence, when using EcoVR in the school context, the learning in EcoVR may be understood as part of a process that takes pupils from school to home and back to school again. In such a school-life cycle, EcoVR may serve as a digital bridge (Schwendimann et al., 2015) or «metaverse» between the learning of relevant skills at school and the application of these skills in real life.

5 Funding

This study was supported by BeLEARN (www.belearn.swiss).

6 Acknowledgments

The authors would like to thank to Jasin Sahraoui for helping with the design, development and programming of EcoVR and EcoPC.

7 References

Brysbaert, M. (2019). How many participants do we have to include in properly powered experiments? A tutorial of power analysis with reference tables. *Journal of Cognition* 2**,** 1-38.

Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly* 13**,** 319-340.

Davis, J.L., Green, J.D., and Reed, A. (2009). Interdependence with the environment: Commitment, interconnectedness, and environmental behavior. *Journal of Environmental Psychology* 29**,** 173-180.

Dobricki, M., Kim, K.G., Coppi, A.E., Dillenbourg, P., and Cattaneo, A. (2021). Perceived educational usefulness of a virtual-reality work situation depends on the spatial human-environment relation. *Research in Learning Technology* 29**,** 2453.

Kaufmann-Hayoz, R. (2006). Human action in context: A model framework for interdisciplinary studies in view of sustainable development. *Umweltpsychologie* 10**,** 154–177.

Keller, T., and Brucker-Kley, E. (2021). "Experiences with virtual reality at secondary schools : is there an impact on learning success?," in *Balancing the tension between digital technologies and learning sciences,* eds. D. Ifenthaler, D.G. Sampson & P. Isaías. (Cham: Springer), 77-94.

Markowitz, D.M., and Bailenson, J.N. (2021). Virtual reality and the psychology of climate change. *Current Opinion in Psychology* 42**,** 60-65.

Millennium-Ecosystem-Assessment (2005). *Ecosystems and human well-being: synthesis.* Washington, DC: Island Press.

Poore, J., and Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science* 360**,** 987-992.

Rössler, P. (2011). *Skalenhandbuch Kommunikationswissenschaft.* Wiesbaden: Springer VS.

Schwendimann, B.A., Cattaneo, A., Zufferey Dehler, J., Gurtner, J.-L., Bétrancourt, M., and Dillenbourg, P. (2015). The 'Erfahrraum': a pedagogical model for designing educational technologies in dual vocational systems. *Journal of Vocational Education & Training* 67**,** 367-396.

Van Merriënboer, J.J.G. (2013). Perspectives on problem solving and instruction. *Computers & Education* 64**,** 153-160.

Yue, X.-L., and Gao, Q.-X. (2018). Contributions of natural systems and human activity to greenhouse gas emissions. *Advances in Climate Change Research* 9**,** 243-252.

8 Data Availability Statement

The datasets for this study can be found here: https://osf.io/6tsze/