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# *Embodying nature in virtual reality generates different presence levels and learning outcomes*

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**Abstract**—Climate change is one of the greatest challenge people face in the 21<sup>st</sup> century. Teaching about it is difficult because its consequences are not directly tangible. Currently, immersive virtual reality (IVR) is expected as an effective educational technology emphasizing the personal relevance of climate change. The aim of this study is to test this expectation by examining the effects of the IVR experience The Shape of Us (TSOU) on sustainability-related attitudes and behavior change. The study applied an evaluative research approach with a pretest posttest design. Participants were 15 male and 16 female students (*mean age* = 14.94 years, *SD* = 0.51) from a secondary school in Switzerland. The results show that after experiencing TSOU sustainability-related attitudes and behavior intention were not significantly greater than before the experience. However, the IVR experience generated different presence levels among the students with implications for learning outcomes. Students with higher presence level reported significantly higher sustainability-related attitudes and behavior intention compared to the students with lower presence level. Implications of the findings for theories on immersive learning and the design of IVR applications intended for climate change education are discussed.

**Keywords**—*environmental education, climate change education, the shape of us, green scale, attitude change*

## I. INTRODUCTION

The destruction of our planet due to climate change is one of the greatest challenges of the 21<sup>st</sup> century. Therefore, there have been calls for the inclusion of environmental protection and sustainable development in education. The term *Education for Sustainable Development* (ESD) currently summarizes those initiatives aiming to change attitudes and behaviors towards sustainability and nature protection [1]. However, experiencing the consequences of climate change is difficult because they are abstract and usually not directly tangible [2].

To address this challenge, researchers explore the potential of immersive virtual reality (IVR) for ESD. IVR refers to the experience of entirely virtual worlds through head-mounted displays (HMDs) and the body's own movements [3]. IVR simulations differ from those displayed on screens in two aspects: IVR applications can generate presence (i.e., the feeling of being there) and agency (i.e., the feeling of controlling

actions) in users, resulting in a deep cognitive, affective-emotional, and bodily connection to the virtual world [4].

This presents an opportunity for ESD to make the effects of climate change tangible and emphasize the personal relevance of the topic [2]. Consequently, researchers assume that using IVR applications for ESD contributes to sustainability-related attitudinal and behavioral change. Although research in this field is at an early stage, some studies found support for this assumption. Markowitz et al. [5] conducted four studies using IVR field trips to teach about climate change. The results demonstrate that such learning experiences can contribute to attitudes change. Stenberdt and Makransky [6] developed an IVR application to instruct students about waste management. The results of the study show that the use of IVR led to increased pro-environmental intentions. Spangenberg et al. [7] used the IVR application “Tree” in which users literally become a tree and experience its growth as well as its devastation. After embodying the tree, the participants reported higher feelings of connectedness to nature than before.

In contrast to the results reported above, some studies found no effect of IVR simulations on sustainability-related changes in attitudes and behavior intentions. For example, in another study by Spangenberg et al. [8] using the tree simulation, no differences on nature relatedness before and after the IVR exposure were found. This is also true for experiment one in the multiple-study research project conducted in [5]. However, the authors of both studies point out that design features of the IVR experiences and their consequences for presence perception must be considered when interpreting the results. For example, in [8], a higher feeling of being immersed in the IVR experience was significantly associated with greater increase in nature relatedness.

Given the contrasting results to date and the urgency of using innovative and effective teaching methods in ESD, further research is needed to determine the effectiveness of IVR simulations on changes in attitudes and behaviors related to sustainability [6], [7]. The aim of this study is to contribute to this field of research. Additionally, it has been demonstrated that the experience of presence is particularly linked to sustainability-related learning objectives. However, experience of presence is dependent on design factors and characteristics of

the users [9]. Therefore, this study examines the following two research questions:

**Research question one:** Does an IVR experience about the consequences of climate change increases sustainability-related attitudes and behavior intentions?

**Research question two:** Does the perceived presence level affects sustainability-related attitudes and behavior intentions?

## II. METHOD

### A. The IVR experience

In this study, we used the IVR experience “The Shape of Us” (TSOU). TSOU was developed collaboratively by HeartWire and the Dutch game studio Monobanda. The experience is freely available in English and German. Within TSOU, users find themselves in a dystopian world characterized by dried-up rivers, destroyed landscapes, dead forests, and environmental pollution. A narrator, who represents Mother Nature, guides the users through the experience and chronicles the extent of the destruction of nature and animals caused by humankind [10].

Users interact with the virtual environment using body movements, such as touching the ground and crawling through a narrow tunnel. In the final part of the approximately 30-minute experience, the users themselves become part of nature – they embody nature and merge with it. TSOU was specifically developed for use in lessons on environmental education, sustainability, and political education. The high degree of embodiment realized within the experience should stimulate both cognitive and emotional processes with regard to the challenges associated with climate change [10].

### B. Sample and design

A total of 31 students (16 females, 15 males) with a mean age of 14.94 years ( $SD = 0.51$ ) of two classes of a secondary school in Switzerland participated in the study. To answer the research questions, an evaluative approach with pretest and posttest design was chosen [11].

### C. Instruments

To measure sustainability-related attitudes, we used a modified and reduced version of the *Affective-motivational beliefs towards sustainability scale* developed by [1]. The students answered six items on a Likert scale ranging from 1=do not agree to 5=fully agree in the pretest ( $\alpha = 0.90$ ) and the posttest ( $\alpha = 0.93$ ). To assess students behavioral intention in protecting the environment, we used the *GREEN scale* [12]. The GREEN scale is a questionnaire consisting of six items measuring green consumption values, which represent one’s purchases and consumption behaviors regarding the protection of the environment. The students answered the modified questionnaire on a Likert scale ranging from 1=do not agree to 5=fully agree in the pretest ( $\alpha = 0.92$ ) and the posttest ( $\alpha = 0.95$ ). To measure presence, we used the scale developed in [13]. The scale consists of two items answered on a Likert scale ranging from 1=do not agree to 5=fully agree. The students answered the presence items after the IVR experience only ( $\alpha = 0.90$ ).

### D. Procedure

TSOU is a highly bodily experience; hence, the study took not place in the regular classroom of the students. We prepared 10 Meta Quest 2 headsets for each class. One class experienced TSOU in the sports hall of the school and the other class in a community hall close to the school building. The students were first welcomed and informed about the study conditions. Participation was on a voluntarily basis, informed consent was given by both the students and their parents. Further, the teachers of the two classes and the headmaster of the school supported the study. At the beginning of the lesson, the students answered the pretest. Afterwards, students paired up to look out for each other during the experiment. Here, we followed the recommendations of Southgate and colleagues who state that experiencing IVR in pairs is safer than using the technology alone [14]. Each student experienced TSOU individually. When the experience was over, the students switched roles. After each student used the IVR experience, the posttest was completed. In total, the intervention lasted around 90 minutes.

## III. RESULTS

### A. Research question one

To investigate the impact of experiencing TSOU on sustainability-related attitudes and behavioral intentions, we used the paired sample t-test with pretest and posttest values for each variable. For attitudes no significant difference between the pretest ( $M = 3.30$ ) and the posttest ( $M = 3.27$ ) was found;  $t(30) = 0.09, p > 0.05$ . Students’ green consumption values in the posttest ( $M = 3.13$ ) are slightly higher than in the pretest ( $M = 3.04$ ). However, the difference was not statistically significant;  $t(30) = -0.39, p > 0.05$ .

### B. Research question two

To determine whether presence level impacts students’ sustainability-related attitudes and behavior intentions, we used the k-means algorithm (SPSS 28) with presence values to cluster the students in higher/lower presence groups. The algorithm assorted 25 students (16 females, 9 males) into the higher presence group ( $M = 4.22, SD = 0.74$ ) and six male students into a significantly lower presence group ( $M = 1.75, SD = 0.69$ );  $t(29) = 7.452, p < 0.001$ . We used the independent sample t-test with posttest results of the two measures as dependent variables and presence level as independent variable to investigate possible differences. Regarding attitudes towards sustainability, the t-test reveals a significant difference with a large effect size between the higher presence group ( $M = 3.57$ ) and the lower presence group ( $M = 2.03$ );  $t(29) = 3.54, p < 0.01, d = 1.61$ . Further, the results of the t-test show a significant difference in green consumption values between the higher presence group ( $M = 3.40$ ) and the lower presence group ( $M = 2.00$ );  $t(29) = 3.53, p < 0.01, d = 1.61$ .

## IV. DISCUSSION

The aim of this study was to contribute to the research regarding the effectiveness of IVR simulations to affect sustainability-related attitudes and behavior intentions. Further, we were interested in the role of presence when using IVR to teach about the consequences of climate change.

First, in research question one, we asked if the used IVR experience TSOU can increase sustainability-related attitudes and behavior intentions. The results show that experiencing TSOU did not contribute to an increase. This contrasts studies in which promising results were found when users experienced IVR simulations portraying the consequences of climate change [2], [5], [7]. However, the results are in line with other studies in which the experience of an IVR application had not affected attitudes and behavior intentions [8]. A possible explanation for the results is the one-time use of TSOU without further instructional activities.

Second, in research question two, we were interested in the impact of perceived presence level on the two learning outcomes. The results show that students with higher presence levels report higher sustainability-related attitudes and pro-environmental behavior intention compared to students with lower presence levels. This result is in line with theoretical models on immersive learning arguing that high levels of presence contribute to increased learning outcomes [4], [15].

The finding is also line with empirical contributions revealing a positive impact of presence on learning outcomes relevant in ESD [8].

Another interesting finding from the analysis to answer research question two is that only boys were grouped into the lower presence group. As mentioned in the introduction section, presence perception depends on characteristics of the users and IVR design features [9]. The used IVR experience TSOU is mainly developed as an interactive story. It is possible that this kind of IVR simulation appeals more to girls than boys. However, future research is necessary to prove this assumption.

## V. LIMITATIONS AND FUTURE RESEARCH

Several limitations must be considered when interpreting the results of this study. First, the sample size is small. In a future study, more students should be recruited and tested regarding the effects of TSOU on sustainability-related attitudes and behavior intentions. Further, other learning outcomes relevant in ESD should be assessed like nature connectedness [7], skepticism towards climate change [2], or other variables defined in the frame-model of sustainability competencies [1].

Another limitation is the unbalanced number of students clustered into the higher presence and lower presence groups. Here, more research is necessary to prove if experiencing TSOU generates different presence levels when used with other target groups (e.g., older students, adults, experienced IVR users). Also, the gender effect is worth of further investigation. The same applies to the assumption that integrating TSOU in a longer-lasting instructional design might improve attitudinal and behavioral learning outcomes.

## VI. CONCLUSION

In conclusion, the use of the IVR experience TSOU without further instructional design elements has not contributed to an increase in students' sustainability-related attitudes and behavior intention. The experience generated different levels of presence among the participating students. Students with higher

presence levels reported higher sustainability-related attitudes and behavior intention. Hence, we can conclude that IVR applications developed for use in ESD should integrate design features that promote presence to support students' learning about topics related to climate change.

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