The use of virtual reality as a potential restorative environment in school during recess

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Abstract. Previous research has found out that simulated, Virtual Reality (VR) -based forests can bring equal or even higher restorative effects than real forests. In this study, a Virtual Reality (VR) -based forest was created in order to compare whether VR-based forest can possess restorative effects in the context of primary school, and how the possible effects compare to restorative effects of a normal recess or to a situation when there is no recess at all. The effects were measured using Restorative Outcome Scale (ROS) and problem-solving tasks after the intervention. The results showed that VR-based forest had the highest restorative effect. There was a significant difference between VR-forest and no recess -groups, but no statistical difference between VR-forest and normal recess -groups. Future research avenues and implications of virtual forests are discussed.

Keywords: Virtual Reality · Virtual Forest · Restorative Outcome Scale Attention Restoration

1 Introduction

Learning involves multiple cognitive processes which require directed attention, such as absorbing, processing, remembering and retrieving information [9, 15]. Especially in schools, students are constantly directing their attention. Maintaining directed attention is required for maintaining concentration on a task, but is effortful and drains through constant use [19]. It recovers when involuntary attention is engaged [18]. A possibility to recover during a school day is important because hard workload and time pressures cause depleted attention and stressful short-term experiences [14]. Stress has even been proposed to be one of the underlying reasons for the mental health problem of students that is an increasing concern worldwide [5].

Previous research reviewed by Tzoulas et al. [36] has shown the restorative effects of nature environments. The recent evidence of using virtual reality (VR) in gaining these benefits is encouraging (e.g. [2, 11, 42]). A recent study [23] provided information some encouraging results about university students using VR to gain benefits such as improved restoration levels and subjective vitality and improved mood. However, the study had some major limitations, including

the lack of comparison groups and not measuring performance on concentration on a task. The current study was conducted to overcome these limitations by comparing three groups in a real-life situation (recess in a local primary school).

More specifically, the aim of this research was to study whether VR-based restorative environments can possess restorative effects and thus work as a recovering environment in primary school -context.

2 Literature

2.1 Attention

Jacobson [15] defines attention as the ability to focus on the stimuli which are relevant to the task at hand and as the ability to exclude stimuli which is not relevant to the task at hand [15]. Attention allows to absorb new information through various senses and select what information to pay attention to and what to ignore. For non-automated tasks, paying attention is crucial to remember, as the work memory has limits [15]. In learning, information is held in the work memory and then moved to the long-term memory [41]. Miller [28] summarises; without attention, there is no memory, and without memory, there is no learning.

2.2 Directed Attention and Directed Attention Fatigue

Directed attention is defined as a mechanism allowing the control and direct the focus of thought and perception [20]. According to Kaplan [19] , any prolonged mental effort, such as attention, leads to "directed attention fatigue", DAF, and lowers one's capability to focus and learn. Especially children, who have attention deficit disorders (e.g. ADD, ADHD) may suffer more from DAF, as they need more effort to keep up their directed attention. According to Kuo and Taylor [22], symptoms of ADHD and DAF are so similar, that the Attention Deficit Disorders Evaluation scale, which is used to measure ADHD, has also been used to measure DAF.

2.3 Attention Restoration Theory

Kaplan [19] suggests that sleep is insufficient for recovering from directed attention fatigue (DAF). In order to recover from DAF, one has to find another basis to maintaining the focus. This should make the use of directed attention temporary unnecessary [19]. One way to find an another basis to maintain one's focus is to involve in restorative experiences.

Following the attention restoration theory, ART [19], a restorative experience should include four components: fascination, being away, extent and compatibility. Fascination is essentially something that fascinates people. Fascination can arouse from content, for example an animal in a forest or from action, such as jogging in a forest. Being away refers more to the conceptual than to the physical transformation of place; a change in one's gaze away from old thoughts is

required in order to achieve the conceptual shift needed for restoration. Extent is a requirement for the environment; it must be rich and coherent enough to be considered as a whole other world. In addition, the environment needs to have sufficient scope in order to engage one's mind. Lastly, compatibility refers to the connection between one's purposes and the environment; the setting needs to fit what one is trying and wanting to do [19].

According to Kaplan [17], natural environments, such as parks and forests, work well as restorative environments. They involve characteristics required for restorative experience, such as fascination (e.g. in a form of flying butterflies) and being away (e.g. physical transformation from office to a forest). In addition, they require only involuntary, effortless attention [17]. Previous research has shown that natural environments have indeed helped recover from directed attention fatigue. Moreover, it has been found out that natural environments are generally more restorative than built environments [7, 6, 10, 12, 35]

2.4 Restoration during recess

Recess has been found out to improve classroom behaviour [13, 3, 16, 8, 1, 27]. The benefits of having a recess have been studied by using multiple approaches, including observing the behaviour in the classroom [16], teacher administration [3], observing children's' gaze (inattention) [30, 13], self-report measures of restorativeness, PRS [1], paper-based attention tests [1], cognitive performance (visual-spatial ability, recognition and reaction times, [27]) and sustained attention and creativity [3].

2.5 Simulated restorative environments

In addition to natural environments, simulated restorative environments have been found out to have recovering effects [38, 7]. However,virtual reality - based environments with head-mounted -displays (HMD) have not been tested widely on the field. HMD allows full immersion in the simulated world, offering a thorough experience of the simulated environments. Some studies about the restorativeness of a VR-based forest have been conducted [23, 26]. Both studies found out that the VR-based forest can possess restorative outcomes. Mattila et al. [26] also found out that the restoration level of VR-forest was higher or equal than a physical forest.

2.6 Research questions

This research research aims to fill the research gap on restorative VR environments, and its effects on problem solving ability outside VR: it is proposed that if students have restorated during recess, their problem-solving ability is higher. The possible restorative effects of VR in educational settings are considered and compared with two other treatment groups: a normal recess between the lessons and no recess between the lessons.

Based on the research gap and previous research, we formulate our research questions as follows:

1. Do the groups differ in restoration levels?
2. Do the groups differ in problem-solving ability?

3 Data and Methods

Following the four components of a restorative experience introduced by Kaplan [19], and previous research on the topic, a VR-based virtual forest was developed. The VR environment (Fig. 1) was built using Unreal Engine [37] and shown to the participants with HTC Vive Pro -headsets [39] The VR environment included several elements, which have been found out to have a restorative effect in previous studies: warm color temperature [34], blue sky [40], flying butterflies [25], bird singing [31], and ability to see the horizon and close nature objects ([19, 29, 33].

Fig. 1. Virtual Forest Environment.

Restorative effects were measured before and after the VR experience using Restoration Outcome Scale (ROS) [21], which have been used in previous studies regarding the restorativeness of both physical and virtual environments (e.g. [21, 35, 23, 26]). ROS scale includes six items measuring reflected relaxation, attention restoration and clearing one's thoughts [21]. Questions were answered using a Likert scale from 1 to 5.

Problem-solving ability was measured using a four page-problem solving test (Figure 2). Both the time to complete and the scores from tasks were used to measure the problem solving ability of the students. Results from the problem-solving task were also reviewed in order to know which way to spend the recess (VR-forest, normal recess, or no recess at all) had the highest restorative effect.

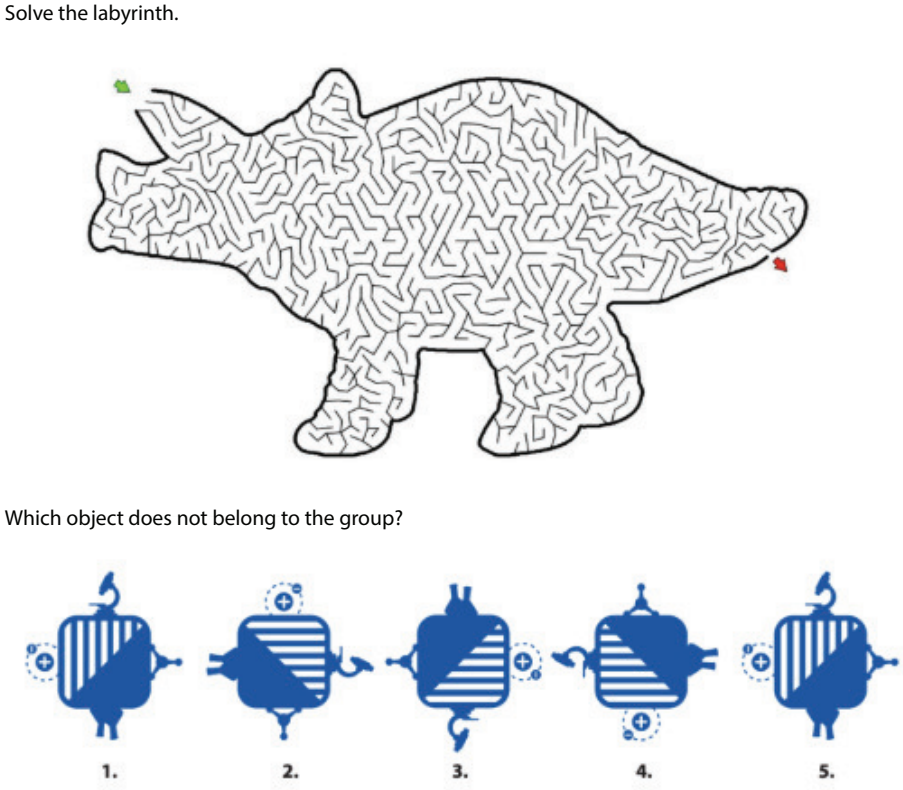

Fig. 2. Examples from the problem-solving tasks.

The research setting was as follows: at the end of a normal lesson held by the teacher of the class, all students were divided into three groups. All groups completed the first part of the ROS-questionnaire. After the questionnaire, the first group (N=19), had a VR-based restorative experience lasting five minutes. Second group (N=19) had a free break (15 minutes) and Group 3 (N=19) did not have any break. After the intervention, all three groups completed a problem-solving task and the second part of the ROS-questionnaire. Maximum time to complete the problem solving task was 20 minutes. After the problem-solving task and questionnaire, all three groups attended the second lesson normally. Participants (N=57) were all Finnish primary school students. Altogether, students from four different classes from the same primary school attended the study.

Restorativeness was measured by using a mean of all ROS items. The Cronbach's alpha of ROS was 0.94 and consistent with previous studies (e.g. [35]). Two-way repeated measures ANOVA was used to test if there were interactions between the groups and time points on restoration levels. In addition,

a non-parametric Kruskall-Wallis H-test was conducted to test whether there are differences between the groups. Analyses were completed utilizing the SPSS Statistics 25 –software. For problem task completion time and scores, a one-way ANOVA was conducted [24]. In addition, multiple linear regression was applied to investigate whether gender, group, post-test ROS score had interactions to the problem task completion time or problem task scores [24].

4 Results

4.1 ROS-questionnaire

The mean scores and standard deviations for the ROS questionnaire are presented in Table 1. The after-intervention means were highest for VR-recess followed by conventional recess, while no-recess control group showed the lowest ROS-scores.

Table 1. Scale statistics of ROS measure

Before recess (first time point)			After recess (second time point)		
	Mean	SD		Mean	SD
VR Recess	22.74	4.98		25.37	5.21
Normal Recess	21.95	5.75		22.53	6.58
No Recess	22.63	6.83		20.42	6.60

Two-way repeated measures ANOVA revealed that there was a significant interaction between time point and the treatment on the restoration levels (F(1,54) = 6.30, p ¡ .05, p 2 = .19). Kruskal-Wallis H test showed that there was no significant difference on restoration levels on the first time point 2(2) = .529, p = .768, with a mean rank restoration score of 29.16 for VR Recess -group, 26.97 for Normal Recess -group and 30.87 for No Recess -group. On the second time point, there was a significant difference between the groups, 2(2) = 7.000, p = 0.030, with a mean rank restoration score of 36.47 for VR Recess -group, 28.18 for Normal Recess -group and 22.34 for No Recess -group. Dunn's pairwise post-hoc tests were carried out for the three pairs of groups. Tests revealed a statistically significant difference evidence (p = 0.025, adjusted using the Bonferroni correction) between the VR Recess and No Recess -groups. The median restoration level for the VR group was 28.00 compared to 23.00 of the No Recess -group. There were no significant differences between the VR Recess and Normal Recess, or Normal Recess and No Recess -groups.

4.2 Problem task and concentration levels

There was no statistically significant difference between groups on one-way ANOVA on problem task completion time (F(2,54) = .181, p= .835) or on problem task scores (F(2,54) = .084, p = .919).

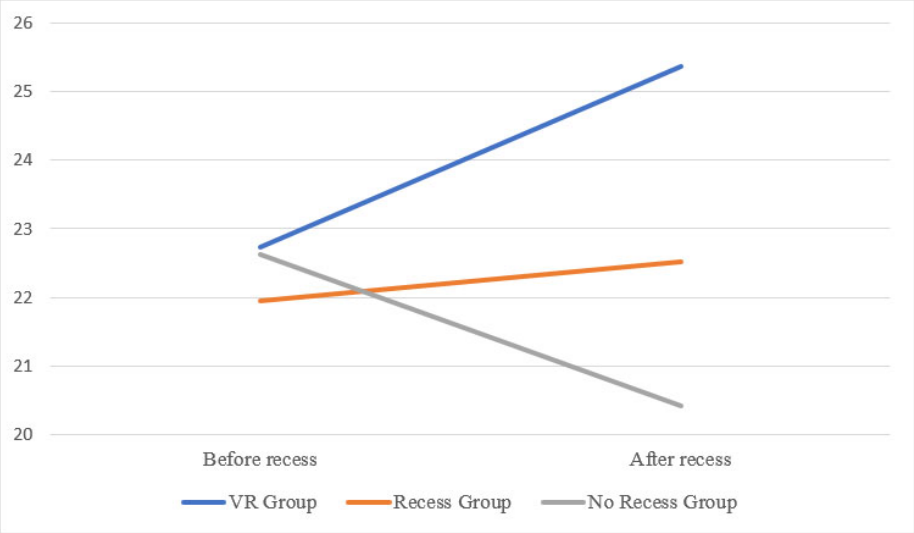

Fig. 3. Mean restoration levels before and after recess through all groups.

In addition, multiple linear regression was applied to investigate whether gender, group or ROS post-test score had an effect on the problem task completion time or scores. These variables did not predict neither problem task completion time $F(3,53) = .664$, $p = .578$, $R2 = .036$ nor problem task scores $F(3,53) = 0.62$, $p = .980$, $R2 = -.003$.

5 Discussion

The aim of this research was to know whether a VR-environment can possess restorative effects in the context of primary school, and how the possible effect compares to the restorative effect of a normal recess or to a situation when there is no recess at all.

From the results of the questionnaire it can be seen that VR-environment can indeed have restorative effects on primary school context. This result was in line with previous research on restorative VR environments [2, 11, 42, 23]. Interestingly, the group which had the VR intervention had the highest restoration levels. This is in line with the recent findings by Mattila et al. [26] who found out that a restorative VR environment can be perceived even more restorative environment than those urban forests that people usually have access to. There was a statistically significant difference to the group which had no recess at all. However, in this research, the difference between VR Recess and Normal Recess -groups was not found to be statistically significant. Regarding traditional recess, the study results were in line with the results of previous studies regarding the restorative effects of recess [13, 3, 16, 8, 1, 27].

There were challenges related to the data collection. The original idea was to have a normal lesson before the VR-intervention. This worked well, and we got good observation data about the concentration levels of the students. After the first lesson, students filled the first part of the questionnaire. Then, the students were divided into three groups. These steps worked well too. After the VR-intervention, however, it was hard to time everything so that the next lesson would start on time. Usually, the next lesson started approximately 10 minutes late, as the VR intervention group demanded more time. The other two groups (Normal Recess and No Recess), were already in the class waiting for the lesson to start. There is a possibility that this caused disturbance to the restoration levels of the other groups. In addition, the original idea was to have a normal lesson after the VR-intervention and second part of the questionnaire. In reality, students used approximately 9:09 minutes to do the problem tasks, so usually the next lesson was very short, and there was little time to observe how the concentration levels of the students from different groups differed. As we failed to get consistent data on how the concentration levels differed between the groups during the second lesson, we did not include those observations on this study.

There were no differences between the groups on problem-solving ability. It can be questioned if the tasks used in this study measured problem-solving ability well enough or if the students were tired enough so that the restorativeness of the recession would have a crucial effect on the test results. Future research is therefore invited to test new ways to study problem-solving after a recess. In addition, for future research it would be interesting to test whether better restoration during recess leads to better concentration or resilience on the lesson after the recess. Possible ways to measure this would be physiological sensors including heart rate sensors, heart rate variability sensors and electrodermal skin activity. Furthermore, it is important to validate the restorative effect to ensure that students do not just simply give high ratings to an interesting technology and intentionally creating more cognitive load (see: [4]).

Finally, the small sample size can affect the results and their significance. However, the results are encouraging and more research is needed to validate the effect of the VR environment. It is important to remember that as the technology is new and exciting, the technology itself can have positive effects, and not the environment. However, the results open both new and interesting research avenues and practical implication in e.g. letting the students with difficulties in keeping up directed attention to have a short VR break during a lecture.

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