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Investigating students' motivation and cultural heritage learning in a gamified versus non-gamified VR environment

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Abstract

This empirical study investigated how the use of a gamified versus a non-gamified Virtual Reality (VR) learning environment impacted student motivation and learning outcomes in the context of a virtual visit at a cultural heritage site. For this purpose, we adopted an experimental research design to analyse the experience of 46 undergraduate university students; 23 of them used a gamified version of the VR learning environment, while 23 of them used the same VR environment without the gamification elements. Data were collected using pre and post learning assessments, motivation questionnaires, as well as individual semi-structured interviews. The data analyses showed that students who experienced the gamified VR learning environment had greater learning gains and perceived competence, as compared to their counterparts who used the VR environment without the gamification elements. The findings of this research contribute to the principled design of VR environments to optimize students' knowledge acquisition and learning experience.

CCS Concepts

• ***Applied computing*** → ***Interactive learning environments;*** • ***Human-centered computing*** → ***Virtual reality;***

1. Introduction and theoretical background

In recent years, there has been a growing interest in the use of Virtual Reality (VR) environments to support learning across all levels of education due to their potential for creating immersive learning experiences. The affordances of VR, such as interactivity, immersion and embodiment can contribute to experiential and inquiry-based learning, and can increase students' active engagement and conceptual understanding [LLF*21]. However, studies report contradictory findings regarding the learning potential of VR environments [CBG22, HMEW21].

A possible explanation that has been discussed in the literature is that VR environments have the potential to evoke a sense of presence and perceived enjoyment, but at the same time can distract users from the learning process [MABM21]. In this context, gamification, namely the process of applying game elements and mechanics to non-game contexts to engage and motivate people to achieve certain goals or complete specific tasks [DDKN11], has been discussed as a possible parameter that can contribute to enhancing students' motivation and interest, making learning more attractive and there-fore, more effective [CEO14]. Gamification involves taking advantage of the psychological aspects of games, such as competition, rewards, achievements, and social interaction, and incorporating them into various areas of life, such as education. However, even though gamification has a long history in the field of education, various constraints have limited its use in VR environments [Kha21]. Furthermore, while some studies have demonstrated positive impact on motivation, engagement, and learning outcomes, other studies reported limited or short-term effects [HKS14, OODLR18]. The effectiveness of gamification appears to depend on factors such as the target audience, the design quality, the intrinsic motivation levels of participants and the context [HKS14]. Focusing on the latter, it seems that a given gamification element may be both extrinsically or intrinsically motivating for certain people at certain times in certain situations [Det14].

Motivation to learn refers to the internal and external factors that drive individuals to engage with and persist in learning activities. It plays a crucial role in determining the level of effort and commitment individuals invest in their learning endeavours. Understanding motivation in learning is important, as it can significantly impact the learning outcomes and overall success of students [Kra99, TSA*23]. Several theoretical frameworks have been proposed to explain the mechanisms behind motivation. Self-Determination Theory (SDT) is a theory of human motivation and personality development which focuses on the innate psychological needs that drive human behaviour and the conditions that support or hinder the fulfilment of these needs. The theory posits that individuals are motivated to satisfy three fundamental psychological needs: autonomy, competence, and relatedness [DR13, RD00a].

Based on these premises, this study aims to further investigate whether gamification elements can improve students' learning and

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motivation in VR environments. More specifically, VR learning environments can incorporate gamification elements such as points, levels, and badges. These game-like features may motivate learners through intrinsic and extrinsic rewards, fostering a sense of accomplishment and progress [CEO14]. In this context, the present empirical research aims to investigate whether and to what extent there were differences in the learning gains and students' motivation when using a gamified VR learning environment, as compared to a VR learning environment without gamification elements.

2. Methodology

This study adopted an experimental design, which included two groups of university students. Each student was randomly assigned to one of two conditions (Condition 1: Gamified VR environment, Condition 2: Non-gamified VR environment) to investigate students' motivation and learning gains per condition.

2.1. Participants and sampling

The sample consisted of 46 higher education students attending a Greek-speaking public university in Cyprus; students were recruited using convenience sampling and were grouped based on their availability. Students were randomly assigned to the gamification or non-gamification condition, forming two groups of 23 students each. None of the students had any prior experience in using VR. The study followed American Psychological Association (APA) ethical standards and General Data Protection Regulation (EU) 2016/679 (GDPR) guidelines. Its protocol was approved by the National Bioethics Committee (EEBK EP 2023.01.128).

2.2. Learning Intervention

As part of this study, a VR learning environment was developed for supporting higher education students' cultural heritage learning [NSK23]. The VR environment is immersive, as students participate in a series of gamified activities, designed to help them learn about the history and cultural heritage of the Angeloktisti Byzantine church in Cyprus, and in particular, a prominent ceiling mosaic that dates to the 6th century AD. The VR learning environment provides in its essence an imitation of the reality (i.e., the interior of the church) and therefore, also serves as a simulation.

The VR activity follows an inquiry-based learning scenario according to which students assume the role of historians who, with the guidance of an avatar-based agent, try to reach a conclusion about the dating of a church ceiling mosaic through the collection of evidence. The use of the avatar-based agent was grounded on that humanoid agents in VR learning environments have been proven to foster a sense of presence which in turn, may result in more impactful learning experiences. More specifically, studies are consistently showing better results in agent-led scenarios in comparison to static texts or even to abstract entities like glowing balls [PMM21].

To experience the VR world, each student used a head mounted VR display, and experienced the environment through a single-user mode. Once the student enters the VR environment, the avatar-based agent (see Figure 1), who is a dedicated learning companion to the student, approaches, and provides information on the learning mission and the tasks to be accomplished in audio format and captioned text.

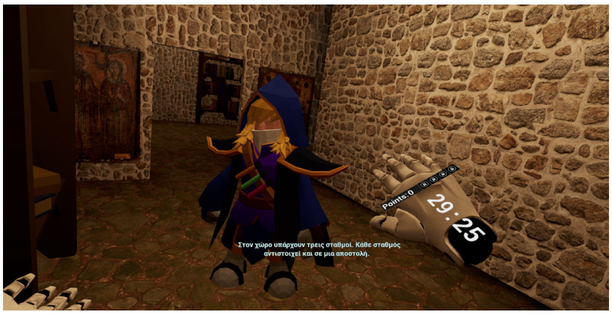

Figure 1: *The avatar-based agent in the VR learning environment.*

The learning mission requires the student to visit four areas (learning stations) in the church, collect evidence and complete a quiz at each learning station, before "unlocking", and proceeding to, the next learning station. Each learning station features different educational materials in various multimedia formats (e.g., videos, figures, and diagrams), providing information regarding the historical significance of the mosaic. In addition, the student can view high-resolution images of other mosaics of the same or different era on the walls of the church, strategically chosen to enable the student in applying the method of comparing-and-contrasting [AWF*12] to examine the mosaics according to their production (technique) and style (symbolism).

The gamified version of the VR learning environment includes several gamification elements designed to support students' motivation to learn. Specifically, it includes: (a) a scoring system, as students earn points by correctly completing a quiz (a multiple-choice question) at each learning station, (b) badges, as students receive a badge by completing tasks at each learning station, regardless of their performance on the quizzes, and (c) a time limit of 30 minutes to complete the inquiry; when the time limit expires the learning environment locks and students cannot further interact with it. Students are also awarded with a completion badge and points for each correct answer at each learning station. Nevertheless, students can progress to the next learning station regardless of providing a correct or wrong answer to the quiz. These gamification elements were all absent from the non-gamified VR condition.

The VR environment was designed to have a semi-realistic look, resembling the interior of the church (see Figure 2). For this purpose, the VR development team visited the church to capture and digitize its exterior and the key artifacts in display. The VR environment was developed using the "Unreal Engine" game engine and can be used with the Meta Quest 2 VR device; the latter is an all-in-one headset device, featuring a hand tracking system through two wireless controllers, which allowed the students to interact with the avatar-based agent, the learning materials, and to navigate within the VR environment.

Figure 2: *Screenshot from the VR Environment.*

2.3. Data collection and analysis

To collect data for this study we used the Intrinsic Motivation Inventory (IMI), developed and validated by [RD00b]. The IMI is a multidimensional questionnaire that aims to evaluate the subjective experience of participants involved in an activity and has been used in several studies related to intrinsic motivation. This instrument was selected because of its broad coverage of intrinsic motivation. It assesses the participants' inter-est/enjoyment, perceived competence, effort, val-ue/usefulness, experienced sense of pressure and tension, perceived choice, and relatedness while performing a given activity. As part of this study, five subscales (comprising of a total of 27 items) were adapted and translated to Greek, excluding the last two sub-scales (i.e., "perceived choices" and "relatedness"), as they were not related to the research scope of this study. Besides, as the authors of the IMI stated [RD00b], re-searchers using the IMI can decide which of the sub-scales want to use, based on what theoretical questions they are addressing. The items were designed using a seven-point Likert scale (1 - Strongly Disagree to 7 - Strongly Agree). As presented in Table 1, the internal consistency (Cronbach's alpha) of the five intrinsic motivation subscales was satisfactory, and the reliability test confirmed the already validated scale and also confirmed the reliability of the translated version of the questionnaire.

IMI subscales	Cronbach's a
Interest/enjoyment	0.88
Perceived competence	0.86
Effort/ importance	0.72
Experienced pressure and tension	0.76
Value/usefulness	0.87

Table 1: *Internal consistency of intrinsic motivation scales.*

Data were also collected through a pre-post questionnaire assessing conceptual understanding. The questionnaire was comprised by eight multiple-choice items to evaluate students' factual knowledge as well as four open-ended questions to evaluate students' conceptual understanding and reasoning. The highest score that students could get for factual knowledge was four marks and six marks for the open-ended questions, for a maximum overall score of 10 marks.

The data collected from the questionnaires were ana-lysed using statistical tests (T-test for paired samples, T-Test for independent samples). During the analysis we investigated whether there was a statistically significant difference between the average pre- and post-test learn-ing scores as well as in terms of students' self-reported intrinsic motivation. Data were also collected through individual interviews conducted upon the completion of the intervention; these data are currently being ana-lysed qualitatively.

3. Results

According to the analysis of the quantitative data, there were no statistically significant differences between the overall pre-test learning scores of the students in the gamified and non-gamified condition. Students' final learning performance (M=5.93, SD=1.00) in the gamified condition exceeded the overall initial performance of the students (M=3.21, SD=1.50) and this difference was statistically significant [t=-9.65, p<0.001]. Likewise, in the non-gamified condition, the final learning performance of the students (M=5.10, SD=1.33), exceeded the overall initial performance of the students (M=2.90, SD=1.37) and this difference was also statistically significant [t=-8.05, p<0.001]. However, the overall post-test learning scores of students in Condition 1 (Gamification) (M=5.93 SD=1.00) exceeded the overall post-test learning scores of students in Condition 2 (Non-Gamification) (M=5.10 SD=1.33) [t=2.40, p<0.05] and this difference was statistically significant.

In terms of students' intrinsic motivation, no statistically significant differences were identified between students' interest, effort, value/usefulness, as well as perceived pressure and tension. However, the analysis revealed a statistically significant difference between students' perceived competence. More specifically, the perceived competence of the students in Condition 1 (Gamification) (M=5.30, SD= 1.15) exceeded the perceived competence of students in Condition 2 (No Gamification) (M=4.49, SD=1.26) and this difference was statistically significant [t=2.28, p<0.05]. This indicates that students who participated in the gamified experience felt more competent than the students who participated in the non-gamified experience.

4. Conclusions, limitations, and next steps

Overall, the findings of this study demonstrate that the integration of the gamification elements in the VR learning environment contributed to students' increased learning gains and higher perceived competence. According to [RD00b], perceived competence is theorised to be a positive predictor of intrinsic motivation. Therefore, taken together these findings provide empirical evidence for the added value of gamification in VR environments. However, the findings of this study must be interpreted in light of some potential limitations. First of all, the sample of this study was relatively small and drawn from a population of convenience. Second, our findings are most relevant to the VR environment employed in this study. Finally, as part of this study, we discussed the impact of the gamification elements used in this study holistically rather than discussing the potential impact of each of the three gamification elements (i.e., points, badges, time limit) separately. However, it should be noted that in the present phase, the qualitative analysis of the interviews

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is ongoing to help us understand how each one of the gamification elements may have influenced the learning process and the participants' motivation.

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