The use of gamification and virtual reality in higher education: A literature review

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Abstract

This paper summarizes findings from a systematic literature review about how gamified virtual reality (VR) is used in the context of higher education. We analyzed 12 unique studies to understand their context, how they applied gamification, and the lessons learned. Our results reveal a research gap especially outside STEM subjects. Additionally, we found the main number of studies do not follow gamification standards, making it tough to compare and reproduce their results. Also, we noticed a shift from the conventional "*points-badges-leaderboard*" approach that was popular in earlier research, to a more diverse use of game elements in gamified VR applications for higher education. This paper provides a clear overview of the current state of gamified VR in higher education, providing practical insights for researchers and practitioners.

Keywords

Gamification, game elements, virtual reality, higher education, literature review, slr

1. Introduction

Integrating gamification into education or utilizing virtual reality (VR) for educational purposes are not recent innovations. The application of gamification principles in educational settings is an established practice [1][2] and the use of VR for educational settings has been prevalent since the introduction of consumer VR products at the latest [3][4].

Gamification entails the application of game elements and principles in non-game contexts to, *e.g.*, motivate and engage learners [5]. Game elements are defined as "*elements that are characteristic to games — elements that are found in most (but not necessarily all) games*" [5]. In education, VR immerses users in simulated environments, offering unique and interactive learning experiences [3]. This approach yields great advantages for learning, including enhanced enjoyment and communication, as well as improved collaboration [6].

Nevertheless, the simultaneous utilization of both concepts for learning in higher education holds promise but appears to be less common. Conducting a literature review is valuable for pinpointing both existing pitfalls and potential solutions in the development of new VR applications that integrate gamification for educational purposes.

In this paper, we provide an overview of current research concerning the integration of gamification and VR in higher educational contexts, investigate the game elements which are utilized in gamified higher education VR applications, and identify research gaps in the implementation of gamification and VR in higher education. By synthesizing current research, we aim to present an understanding of the state-of-the-art practices and their implications in higher educational settings.

2. Related work

Several literature reviews surrounding the topics *gamification*, *e-learning*, or *VR* were conducted in recent years: For example, [7] analyzed research on the topic of eLearning in a higher education context. They found, that most current studies use a quantitative research approach and that the focus of e-learning research has shifted over the years from "*integration of e-learning into higher education is demanding issue*" in 2011 to "*development of customized e-learning environments according to learners' needs*" in 2019.

The maturity of Virtual Reality (VR) has made it a reliable option for educational approaches that are now being increasingly utilized. Hence, [3] reviewed 38 studies using VR in higher education. Their results criticize the focus on usability instead of learning outcome, emphasizing that VR is predominantly in an experimental stage, and has not been effectively incorporated in the daily teaching routine. They did not analyze the details of gamification or game-based learning in the studies but focused more on the applied

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learning theories and research methodologies in general.

However, the use of gamification for educational purposes is still a popular research topic. For example, the literature review of [8] about gamification for learning purposes in general found 128 research papers regarding the topic. They analyzed, *e.g.*, affordances, psychological, and behavioral outcomes of empirical studies. 5 of 128 studies used some kind of virtual world as a gamification element. However, it is not specified, whether these virtual worlds are part of VR or just any kind of virtual environment. In another review, [1] analyzed studies about gamification frameworks in different learning environments. They had a closer look on the study contexts and the game design elements that were used to enhance learning. [2] reviewed studies about gamification more specifically in *Massive Open Online Courses* and found that gamification can be a possible solution to the problem of a high no-show and a low retention rate. To sum up, to the best of our knowledge there is no review about the use of gamification and VR in higher education contexts that provides an overview of the current situation.

3. Methodology

We followed an established process for systematic literature reviews [9] to answer the following research questions:

- **RQ1** In which use cases are gamification and VR for higher education applied?
- **RQ2** What kind of gamification is used in combination with VR for higher education?
- **RQ3** What are the learnings and recommendations from the use of gamification and VR for higher education?

To answer these research questions, we analyzed peer reviewed research papers that provide example applications of a combination of gamification and virtual reality in a higher education context. We identified relevant papers by applying the following search-string:

> *"Gamif*" AND ("Virtual Reality" OR "VR" OR "Virtuality" OR "Mixed Reality") AND ("higher education" OR "university" OR "college" OR "students")*

The search string has been adjusted to the search engines of the databases IEEE Xplore, ACM, SpringerLink and Science Direct. For IEEE Xplore, ACM and Springer link, we applied the search as a full text search, for Science Direct we used the option to restrict the search to title, keywords and abstract. We only considered publications from 2016 to 2022, to ensure current relevance. Figure 1 shows the selection process of relevant papers from the search results.

We used the SLR tool from Hinderks et al. [10] to manage the search results and to support the selection process. The SLR Tool offers the functionality to apply an extended search to all papers within a project. Scientific databases have a variety of differing search and filter algorithms. With the extended search, we applied the same search string for title, keywords and abstract of all identified papers (N_{P0} = 4246) and ended up with N_{P1} = 20 papers for the manual scanning process. We applied the following inclusion and exclusion criteria at the screening process:

- **In1** The paper describes a practical application of gamification and virtual reality in a higher education learning context
- **In2** In2 Paper containing a literature review that aligns with inclusion criteria 1 is retained for the snowballing process.
- **Ex1** The paper does not specify the target group as higher education
- **Ex2** The paper does not actually apply gamification or serious games concepts
- **Ex3** The paper does not actually use VR
- **Ex4** The paper does not describe the use of the gamification strategy in detail
- **Ex5** The paper is not about a practical project
- **Ex6** The paper focuses on exergaming/sports or therapy/rehabilitation/behavior change

We identified N_{P4} = 6 relevant papers for snowballing. Snowballing in a SLR involves recursively exploring references of identified papers to discover additional relevant studies. We applied backward snowballing (references used in the already identified papers) and forward snowballing (papers, that reference the already identified papers). This process led us to n = 7 additional papers. Finally, we considered N_{P5} = 13 papers for the analysis.

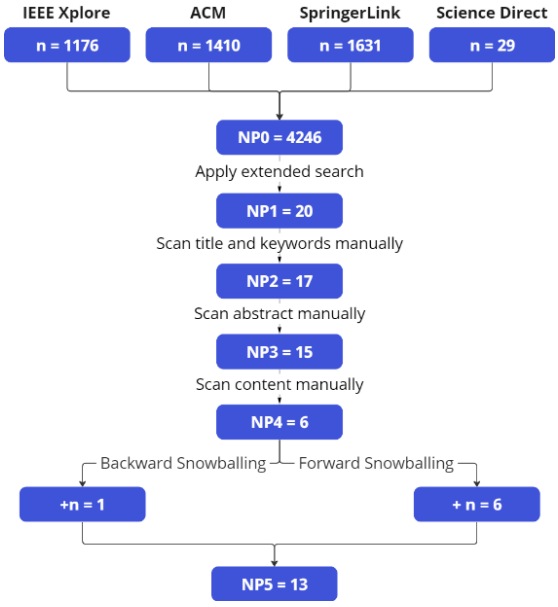

Figure 1: The selection process to identify the literature for the analysis

A recent study showed that gamification project reports are not standardized [11]. For example, the used game elements are often ambiguously defined among various studies. Which means, two papers may name a game element similarly but have different meanings (*e.g.*, one might use points as a form of currency, while another uses them in a reward system) or two papers may name a game element differently but mean the same (*e.g.*, points or score for the

Table 1
All papers included for analysis

Paper ID	Title	Subject area	Use case goal	Use case scope	Source
S1	Serious Game for Medical Imaging in Fully Immersive Virtual Reality	medical education	general teaching, increase student engagement, increase student retention	Serious game	[13]
S2	Immersive Virtual Reality Training of Bioreactor Operations	chemical engineering	provide equal access to expensive equipment, practical learning	Virtual lab environment	[14]
S3	Merging 360°-videos and Game-Based Virtual Environments for Phlebotomy Training: Teachers and Students View	biomedical	support training	Full laboratory exploration and training	[15]
S4	VR for Education in Information and Tehnology: application for Bubble Sort	computer science	Increase Learnability (Gamification)	Single task application	[16]
S5	Virtual reality instructional modules for introductory programming courses	computer science	Support Learning	VR instructional modules	[17]
S6	Thinkercise: An educational VR game for Python programming	computer science	Increase Motivation, Increase Learning, do physical exercise	Exergame/Serious game	[18]
S7	VR Medical Gamification for Training and Education	medical education	increase interactivity	Mobile Android platform application	[19]
S8	Formative evaluation of immersive virtual reality expedition mini-games to facilitate computational thinking	computer science	understanding users' learning processes, facilitating students' computational thinking skills	VR exploration application + mini games	[20]
S9	Educational Game-Theme Based Instructional Module for Teaching Introductory Programming	computer science	teach linked list and binary trees	Learning module	[21]
	Game Theme Based Instructional Module to Teach Binary Trees Data Structure	computer science	teaching binary trees	Non-immersive VR learning module	[22]
S10	Usability and Learning Effectiveness of Game-Themed Instructional (GTI) Module for Teaching Stacks and Queues	computer science	teaching stacks and ques	Learning module	[23]
S11	Investigating the effect of imikode virtual reality game in enhancing object oriented programming concepts among university students in Nigeria	computer science	understanding of the subject (OOP), improving programming skills	Serious game	[24]
S12	iProgVR: Design of a Virtual Reality Environment to Improve Introductory Programming Learning	computer science	incite intrinsic motivation	Framework	[25]

performance measurement). To address this issue, we decided to use the *gamification codebook* [12] as an analysis tool to ensure a uniform analysis of the applied game elements. The gamification codebook contains a list of game elements with a descriptive definition of each element and is supposed to help gamification practitioners to choose the best game elements for their project [12]. By using it as an analysis tool, we apply one wording and description to all papers. We had to add some game elements, that are not included in the gamification codebook neither by name nor definition.

4. Results

The N = 13 papers describe n = 12 individual studies (see Table 1). One study includes two papers [21][22]. Although exclusion criteria Ex6 excludes papers with focus on exergaming from the study, we kept the exergame of S6 because the proposed outcome of playing the game is learning and not fitness or doing sport. The studies were analyzed with focus on the research questions and the results are presented in the following sections. We refer to each analyzed study by the ID assigned in Table 1, column "*Paper ID*".

4.1. Use case attributes

To answer **RQ1 - In which use cases are gamification and VR for higher education applied?**, we analyzed the studies application area, the goal of the studies and the scope of the studies (see Table 1). Most of the studies (n = 9) are in the area of *computer sciences* (see Table 1, column "*Subject area*"). The rest of the studies are also for STEM relevant courses: S1 and S7 are set in *medical education*, S2 in *chemical engineering*, and S3 in *biomedical*. The objectives of the studies exhibit a wider variety and heterogeneity (see Table 1, column "*Use case goal*"). Although most of them (n = 10) aim to increase or support learning, teaching, or understanding of the individual topics (S1, S2, S3, S4, S5, S6, S8, S9, S10, and S11), increasing motivation, engagement and interactivity is also relevant for n = 4 studies (S1, S6, S7, S12). S2 additionally aims to provide equal access to expensive equipment with the use of VR, thereby supporting practical learning. In contrast, the scope of the studies is very diverse (see Table 1, column "*Use case scope*"): In S4 a single task application is developed and S9 and S10 are describing learning modules. S5 presents virtual reality instructional modules, while S2, S3 and S8 provide some form of laboratory exploration scenarios. Besides that, S1, S6 and S11 utilize full serious games, one of which is an exergame (S6). Lastly, S12 proposes a framework consisting of three individual modules.

4.2. Gamification strategies

To answer **RQ2 - What kind of gamification is used in combination with VR for higher education?** we examined the use of gamification at two different levels. Initially, we identified the overall gamification strategy employed in each study. Meaning, if the study followed a certain gamification design framework, used gamification tools, or followed an approach that was not specifically designed for gamification and if so: Did they specify how they choose their game elements? The second level examines unique game elements, that are applied in the analyzed studies.

Our results show that no standards for reporting gamification are used. n = 4 studies gave no definition of the used process (S2, S7, S8, S12). S4 named their strategy "*play and learn*" but gave no definition as to what this strategy includes. n = 2 studies used previously developed games (S3, S11), one of which did not give details in the analyzed paper (S3). The details to the game elements had to be extracted from another paper [26]. The rest of the studies named some kind of underlying process or concept (n = 3 used some form of *constructivism* (S5, S9, S10), S6 used *game-based-learning* and S1 *ASSURE instructional design*), but no study elaborated further on why they specifically choose the game elements, they ended up using.

The reporting of the used game elements is mostly not very detailed: Only one of the analyzed studies gave a distinct list of the used game elements with definitions (S2). n = 3 studies described the used game elements in more detail in the text (S1, S5, S10) and n = 3 studies at least described parts of the used gamification (S8, S9, S12). Hence, we needed to identify most of the used game elements by analyzing descriptive texts and images of the applications. It is possible, that the lists are incomplete, because there were not enough information to identify all game elements used. For instance, if a text did not mention any sound effects, we were unable to account for them in our analysis, regardless of their potential presence in some application.

All in all, N = 40 individual game elements were used in den studies (see appendix 1). From these, n = 17 game elements were used in only one study. In contrast to other research, the most used game elements are not *points, badges* and *leaderboards [11]*[2][8][11], but *game environments* and *Visuals/Graphics* (n = 11 each), and *interactivity* (n = 9). Followed by *learning* and *voluntary approach* (n = 8 each) and the use of a *tutorial* (n = 7).

Not all game elements that were explicitly described are defined in the gamification codebook. However, since many game elements are not described at all, we want to emphasize these elements as important enough for the researchers to be mentioned. Overall, we identified 8 game elements that we could not match to a game element from the gamification codebook:

- Narrator/Guide
- Quiz
- Interface/Character Control
- Mini-Games
- Game Mechanics
- Virtual World
- Virtual Instructor
- Non-Playable Character

Furthermore, one study emphasized the *personalization* of the *feedback* game element, which was described in the gamification codebook, but without the individualization.

4.3. Results of the studies

To answer **RQ3 - What are the learnings and recommendations from the use of gamification and VR for higher education?** we had a look at the limitations and recommendations of the analyzed studies. Based on these, we can recommend best practices that proved to be useful, as well as things to avoid, because they may have caused bigger or smaller problems.

Several of the analyzed studies listed at least one limitation of their project. For example, S7 was not tested yet. Hence, the results of S7 are to be taken with caution. Other limitations of the studies lead to more clear recommendations for future studies. Thereby, creating valuable learning for other researchers. S2 and S3 both acknowledge the difference in technical affinity and experience for potential users. While S2 only had test-users with prior VR experience, S3 sees a challenge with the technical affinity of users in general. Hence, we found that potential gamified higher education VR applications should be tested with tech-inexperienced users to ensure the usability not only for a subgroup among the students. This would become especially important for applications outside the field of computer sciences. After all, one could

argue, that a certain technical experience could be a requirement for students in technical courses. S4 warns of health issues like motion sickness. They recommend using their app no longer than 10 minutes. The time-constraint could affect sustainable learning and is not feasible for all application scenarios. However, it serves as an important reminder that accessibility and safety must be considered. Furthermore, S8 and S9 show a rather small number of participants (n = 6 and n = 14). To generalize findings of user studies and avoid bias, a larger number of test-users is needed. Especially, since we should consider various skill-levels and characteristics of potential users.

The analyzed studies offer more insights by recommending future steps for their own research or more generalized learnings:

In general, S2 sees their application only as a supplement and not as a replacement for in-person training. The potential of gamified VR applications for higher education still offers research potential. Furthermore, S2 also recommends additional familiarization training for VR applications. S12 recommends including comparison studies when evaluating VR applications with non-VR versions.

More detailed recommendations are provided for specific aspects of gamified VR applications in higher education. S4 and S10 both recommend the use of levels, S3, S8 and S10 underline the importance of high-quality graphics and animations. S3 also advise for a neutral guide who is not the lecturer, the use of cooperative features and friendly competition, as well as tactile feedback and input mechanisms. All in all, they suggest utilization of interactive items. S10 and S11 recommend making use of time constraints, by adding time limits or real time feedback. S11 also suggests doing an AI integration in future research.

5. Discussion

In the following section, we discuss the results of our research in relation to our research questions and present implications for future research.

5.1. Implications from use case attributes

The results of RQ2 show little variation in applied research areas. All analyzed studies were done in STEM or STEM-related subjects. This leaves interesting potentials for other application areas, such as visiting historic sites for archaeology or history students, immersive scenarios for pedagogical or social studies, or interactive experiences for liberal arts students. Another literature review that focused on VR applications for higher education also identified a high amount of STEM or STEM-related subjects (over 60% of the analyzed studies) [3]w. However, they also identified a few studies in other application areas (5% *nursing* and *art* each). This is in line with our research and underlines a research gap for future studies in more research areas.

In contrast to the consistent application areas, the diverse application scopes we identified could pose a challenge in comparing the employed gamification approaches. However, since we do not aim to evaluate the single studies but are more interested in their individual approaches, we do not expect a relevant impact on our results.

5.2. Implications from applied gamification

Recent research has demonstrated that numerous standards for gamification development and reporting exist in form of various gamification frameworks or processes [27]. Researchers are encouraged to utilize these standards to ensure comparability of studies and unambiguous understandings of results [11]. However, the findings from RQ2 indicate that these standards were not employed in our sample. This absence was noted both in the development of gamification strategies and in the reporting of game elements.

Many of our analyzed studies did not give a distinct list or description of applied game elements. Hence, it is not only possible, but likely, that our results about the use of individual game elements is not comprehensive. For example, only one study reports the use of music and two report the use of sound effects. However, although sound is of less importance in VR application than for non-VR ones, it is still an important and commonly used feature [28]. We presume the possibility, that more studies used sound but may not felt the necessity to mention it. Maybe they found it too obvious, or they did not describe any game elements at all and the used game elements were identified by analyzing images, which can obviously not convey sound. Similar challenges are possible for the other game elements as well. The use of standards for game element reporting and definition would have increased the reliability and integrity of this and similar analyses.

The most used game elements we identified (*Game Environment* and *Graphics/Visuals*) could be due to the VR setting. When developing a VR application, simply being immersed in the VR setting often inherently creates a game-like environment. Furthermore, the VR is mostly built based on game-like graphics, except for, *e.g.*, 360°-video environments. Hence, these signature game elements are also somehow signature elements of VR and not necessarily due to the gamification of the applications. *Interactivity*, which is the second most identified game element, is also close at hand when developing a VR application, but VR also allows for the user to take a more spectating role. However, the advantages of practical learning are widely known, so utilizing interactivity to support practical learning in VR comes naturally. Since the analyzed studies all revolve around education applications, the high percentage of applications that support the game element of *learning* is not surprising. Nevertheless, it is noteworthy that a high number of applications build upon the *voluntary approach* concept, because higher education offers an easy opportunity to make the use of an application mandatory, which was mostly omitted. However, it is possible, that the voluntary approach is due to the evaluation of new concepts and more mandatory applications may be developed in the

future. The change over the next periods of time remain to be seen.

The next most used game element was the integration of some kind of *tutorial*. In higher education contexts, it is important that everyone is able to use the learning materials. Hence, to have a tutorial is important for the inclusion of all students that are not used to VR applications, yet. Furthermore, in complex scenarios it can be necessary to prevent frustration due to basic control issues. Thereby, the students can focus on the learning content instead of struggling with the controls. We recommend the integration of an (optional) tutorial for future gamified higher education VR applications to ensure the access and usability for all students.

All in all, our results show that there is no "how-to" structure for gamified VR applications for higher education. This is in line with other research, that shows heterogeneous gamification scenarios and many variations of game element usages [1]. Thereby, we show a development in gamification research, away from the criticized simplified and almost exclusive use of *points, badges and leaderboards* which was sometimes dismissively called *pointsification* [29]. The increased variation of the used game elements give more justice to the vast world of games and may develop even further in the future.

5.3. Learnings and recommendations

For RQ3, we explored the limitations, learnings, and recommendations of the analyzed papers authors. Thereby, our results offer insights into difficult-to-measure qualitative experiences of each study.

The limitations of the analyzed studies are, in some cases, quite severe, thereby raising concerns about the overall quality of the research. Standardized approaches for development and reporting could create comparability and trust of the results, as well as avoiding errors from external factors [11].

All in all, the recommendations and learnings of the analyzed studies show high potentials and various possibilities for future research. On one hand, there is still a need for generalized research like the comparison between VR and non-VR or the potential of VR as a replacement for in-person training. On the other hand, there are some very detailed findings for single game elements and their applicability.

5.4. Conclusion & future work

In this study, we conducted a systematic literature review on a total of 12 studies that implemented gamified VR applications for higher education. Our findings provide an overview of current research, revealing numerous opportunities for future investigation. We successfully identified several research gaps, that merit further exploration: For instance, the application area of gamified VR in higher education closely revolves around STEM and STEM-related topics, although gamification and VR also offer numerous chances for every other subject area as well. Furthermore, we identified a list of the most used game elements in gamified VR applications for higher education. This compilation not only serves as inspiration for future projects but also demonstrates that gamification is evolving beyond the criticized and limited *pointsification* approach.

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A. Appendix 1 – Game elements distribution

Table 2
The identified game elements in the analyzed studies

Game Element	*N*	Included in Study
Game Environments	11	S1, S2, S4, S5, S6, S7, S8, S9, S10, S11, S12
Visuals/Graphics	11	S1, S2, S3, S4, S5, S6, S8, S9, S10, S11, S12
Interactivity	9	S1, S2, S4, S5, S6, S7, S8, S9, S11
Learning	8	S2, S4, S5, S6, S7, S8, S9, S11
Voluntary Approach	8	S1, S2, S4, S5, S6, S8, S9, S11
Tutorial	7	S1, S4, S5, S6, S8, S9, S10
(Personalized) Feedback	5	S1, S2, S5, S8, S11
Points	5	S3, S5, S6, S8, S10
Visual Cues	5	S1, S2, S7, S10, S12
Challenge	3	S2, S6, S8
Free Exploration	3	S2, S8, S9
Goals	3	S4, S5, S8
Level	3	S2, S6, S9
Rewards	3	S8, S9, S12
Score	3	S1, S4, S6
Time Challenge	3	S1, S4, S6
Achievement	2	S1, S2
Any Progress	2	S6, S8
Disincentives/Negative Rewards	2	S3, S8
Rules	2	S6, S8
Sound Effects	2	S5, S12
Theme	2	S5, S11
Virtual Instructor	2	S9, S10
Attractive/Aesthetic design	1	S6
Avatar	1	S5
Competition	1	S1
Feedback System	1	S6
Framing	1	S8
Game Mechanics	1	S8
Leaderboard	1	S1
Mini Games	1	S8
Music Effects	1	S6
Narrative	1	S12
Narrator/Guide	1	S1
Non-Playable Character	1	S11
Onboarding	1	S2
Quiz	1	S1
Scoreboard	1	S9
Virtual World	1	S8
Interface/Character Control	1	S7