A Mid-Range Theory for Designing Sustainable Safe Spaces of Immersive Learning Environments: A Design-Science Based Gamification Approach

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Abstract. Gamification provides a prominent technique that can be used to provide Immersive Learning Environments (ILEs) for domains, where it is dangerous or expensive to learn in real environments. Especially industrial organizations (e.g., manufacturing, mining, construction) are a promising domain for implementing ILEs that combine gamification concepts with a pedagogical design to facilitate safety training under secure circumstances. Although there are design research studies that exemplify the utility of gamification of learning activities, or how to improve organizational safety training through gamification, there is a need to address how sustainable safe spaces can be designed for enhanced safety training in ILEs. Safe spaces are key elements of a successful safety training experience in ILEs as they provide safe and secure training environments, which in the physical world are typically considered too dangerous with high risk of injuring the training participants. This study reports findings from an ongoing DSR project that stresses the design of ILEs for sustainable safety training. Within the project, an artifact for immersive fire safety training in virtual reality has been designed, developed, and evaluated together with employees of a train operator company. The research responds to the need of producing design knowledge that moves beyond the highly contextualized designs principles that are particular for IVR applications. We use gamification concepts as a kernel theory for developing a mid-range theory of designing immersive virtual safety training environments.

Keywords: Immersive Learning Environments · Virtual Reality · Safe Spaces · Design Science, · Gamification · Sustainability · Mid-Range Theory

1 Introduction

The immersive human interface brought forth by innovation and technological development, resulted from the intricate connection of Virtual reality (VR) technology [1]. VR has, over time, continued to evolve into Immersive Virtual Reality (IVR) technology [2]. Typically, the IVR technology is constructed into Head Mounted Devices (HMD) that

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users equip to transport their senses to a reality beyond the physical one [3]. As such, the IVR experience becomes an absorbing experience based on immersion, an increased sense of embodied presence, and high level of interactivity [4]. Consequently, the application of IVR technology has had significant implications in facilitating Immersive Learning Environments (ILEs) for organizations and schools, which has led to scholars to explore the design of ILEs [5, 6].

Traditionally ILEs consist of a mix of different approaches to facilitate learning in an immersive way [7]. The feeling of 'immersion' is an experiential mode of becoming absorbed by the virtual reality through an increased sense of 'being-there', also known as embodied presence [8]. The experiential attributes that ILEs consist of vary heavily with respect to learning objectives, learning scenarios, pedagogical design (e.g., learning methods), and design features [9]. The design features of ILEs are thus constituted through properties that convey a narrative for learning, whether it is through simulation, visualization, and/or more typically, through a gamified approach that makes the immersive learning highly interactive for the participants [10]. Previous research advocates that the gamification provides a prominent collection of techniques that can be applied to incorporate game elements into ILEs (e.g., [11]. Especially industrial organizations (e.g., manufacturing, mining, construction) have showcased to be a prominent domain for implementing ILEs that combine gamification concepts with a pedagogical design to facilitate safety training [12, 13].

Recent research within the field of IS (e.g., [3, 14–16]) calls for prescriptive design knowledge that informs the design process of ILEs through game elements [17]. In the paradigm of Design Science Research (DSR) in IS [18, 19], scholars follow an inherent tradition of producing design knowledge that balances rigorous scientific output (e.g., design principles, design theories) with viable artifacts [20]. And although there are DSR studies that exemplify the utility of gamification of learning activities in general (e.g., [21, 22]), and studies about how to improve organizational safety training through a gamification approach (e.g., [23]), there exists a current need to address how 'safe spaces' can be designed for ILEs that facilitate safety training [24]. Safe spaces are considered to be key elements of a successful safety training experience in ILEs because they provide secure virtual training features that, in the physical world, would typically be considered as dangerous with high risk of injuring the training participants.

In light of the given background above, this study reports findings from an ongoing DSR project that stresses the design of ILEs for sustainable safety training. Within the project, an instantiated artifact for immersive fire safety training in virtual reality has been designed, developed, and evaluated together with employees of a Swedish train operator company. The design of the IVR artifact provides a basis for exploring the possibilities for extracting design knowledge that can be transferred from the current design context to a context that share similar challenges and characteristics. Such kind of aspiration lies in the heart of the constitution of a DSR project [18, 20, 25]. Hence, this study incorporates current learning outcomes from the project and attempts to extract design knowledge that advances the research towards addressing the following research question:

- *How can sustainable safe spaces be designed for gamified Immersive Learning Environments to facilitate safety training?*

The research question responds to the need of producing design knowledge that moves beyond the highly contextualized designs principles that are particular for IVR applications. In order to address the research question, this study employs a design science approach that employs a synthesized body of knowledge on gamification concepts into a kernel theory for developing a mid-range theory [26]. As such, the contribution of this study is a mid-range theory for designing sustainable safe spaces of ILEs, and the implications of the mid-range theory are targeted to: (1) advance DSR and gamification for training in VR (e.g., [21, 22]); (2) advancing an ongoing DSR project by developing design goals for sustainable safe spaces as constitutive parts of the mid-range theory; and (3) discussing the added value of safe spaces for the discourse of sustainability in the IS field [27–29], with a specific interest for research that urges to inform how innovative technologies can be designed to help resolving environmental, social, and economic issues over [30, 31].

The rest of this paper is organized as follows. First, a section of related research on ILES, IVR and safety training, along with sustainability in the IS field, is outlined. Second, the design science-based gamification approach along with the empirical setting of the ongoing DSR project is presented. Third, the preliminary findings of this study are presented. Fourth and finally, a section on concluding remarks and an outlook for future research is presented.

2 Related Research

2.1 Research on Immersive Learning Environments and Safety Training

Safety training (also referred to as 'safety education') is a special form of learning experience that integrates the development of procedural skills (e.g., how to accomplish something) through hands-on exercises that are heavily task-dependent and can expose the training participants to potential risks [32]. Moreover, practical safety training exercises can also require expensive, fragile, or rare equipment, which could be difficult to secure for real-life training experiences [33]. A particular field that is affected by such issues is that of industrial training, where operators must be prepared to work with potentially hazardous systems (e.g., robotic manipulators, electrical machinery) [34], or dangerous situations that might affect other people such as fire safety training (e.g., [35]). However, thanks to the rapid development of IVR technology, organizations can today create high-detailed simulations of real-life training scenarios that, given also the widespread availability of low-cost devices, can be easily exploited to safely facilitate safety training in ILEs [36, 37].

ILEs are based on IVR technology, and they are gaining traction as innovative bundles of technology for facilitating safety training experiences in the virtual reality [15]. One of the major reasons why ILEs are prominent for safety training is their high practicality, low risk, and low cost, as well as their capacity to ensure both safety and efficiency during learning processes [38]. ILEs are mainly based on pedagogical design features and experiential modes of learning through simulation, visualization, and/or gamified learning scenarios [39]. As such, ILEs employed for safety training purposes allow workers to actively participate in scenarios that represent the actual conditions of real-life scenarios, enhancing and strengthening safety awareness and allowing them to experience the learning activities, under secure circumstances [40]. Application areas include emergency preparation [41], fire prevention [42], and first aid [43], and preparation for managing workplace accidents [15, 44, 45]. However, with increasing possibilities of organizing and facilitating safety training in ILEs, come ideas about how such learning experiences become meaningful for the individual employees' life-long learning process [46], and what their implications are for organizations' strategies of increased sustainability through safe spaces that eliminate unsafe practices and increase the safe performance of dangerous training tasks [47].

2.2 Research on Sustainability and Safe Spaces

Sustainability issues are one of our times' main concerns and include a complex set of interconnected environmental, social, and economic problems. The sustainable development goals (SDGs) set by the United Nations (UN) for 2030 involve the three dimensions (environmental, social, and economic), requiring, at the same time a massive reduction of resources' use and their accessibility to the whole global population. This radical transformation determines a need to educate citizens, organizations, and professionals, increase their awareness, and ultimately support a behavior change towards sustainable choices. To this purpose, IVR technology, that constitute the technological foundation for ILEs, has been identified as a prominent for tackling all three dimensions of sustainability in the context of safety training by increasing employees' industrial skills with a particular emphasis on enhanced safety awareness [15]. Organizing and conducting safety training in ILEs is considered to be a sustainable approach because of the safe spaces that focus the environmental dimension by reducing heavy pollution and environmental issues [24] and supporting the socio-economic dimensions of sustainability by reducing costs for training initiatives and increasing behavioral skills and safety awareness of participants under secure circumstances [48].

Currently, there are no universal definitions of what a safe space is. However, as a concept, safe spaces have typically been employed in IVR to promote education and learning experiences that feel safe for participants that want to experiment with their personal identities [49]. This includes safe spaces for provoking new ideas for learning that might be controversial [50], and/or to provide low skilled novice workers with a safe environment to learn through experience and perform actions that might be costly or embarrassing to do in the physical space [51]. Safe spaces provide thus a secure virtual space that allow and encourage end-users of ILEs to navigate freely, experiment with behaviors and actions, and iterate around learning objectives through a safe trial-and-error process. Moreover, safe spaces focus trigger warnings that raise negative reactions among training participants. Such trigger warnings could for instance be related to certain sounds, imagery, or behaviors that create an uncomfortable atmosphere in the physical space. As such, safe spaces are feasible for organizations that want to experiment with training scenarios through low-cost initiatives and secure circumstances that are efficient for developing meaningful learning experiences that do not lead to traumatic experiences or physical injuries [37, 38, 52]. This includes designing a safe space in virtual reality that facilitate learning activities for development of situational awareness through procedural skills (how to accomplish something), descriptive skills (how to define/describe something), and behavioral skills (how one can behave in a given situation).

And while many frameworks and models have been developed to support design for sustainable behavior and decision improvements among organizations in general [40–43, 53, 54]**,** to this day, there is a lack of design knowledge that guide and support the design of sustainable safe spaces in ILEs that facilitate safety training across a variety of safety training contexts [14, 44, 54]. With 'sustainable', we are referring to the need of mapping design elements with safety training objectives that resolve sustainable issues that traditional safety training initiatives consist of [55]. Such issues include high consumption of natural resources, limited flexibility to various fields and areas of training, lack of adaptability for experimentation and repetition of training scenarios, and high risk for injury in safety operations. Although it is evident that ILEs provide safe spaces a remedy towards resolving such issues [56], there is still a need for producing design knowledge that explicate the mapping of design elements that increase the internal and external motivation of learning experiences. One way of pursuing to address such gap, is through gamification in DSR.

2.3 Research on Gamification and Design

Gamification applies knowledge from gaming theory and flow theory [56–58] to nongaming contexts. As such, gamification is "*[…] the application of lessons from the gaming domain in order to change stakeholder behaviors and outcomes in non-game situations*" [59]. Although gamification emerged from the flow literature as it is applied to gaming, scholars have not reached a consensus regarding gamification's definition [58]. Similarly, in IS research, scholars such as Liu et al. [62, p. 3] concluded that:

> "*The common themes that emerge from the various definitions over the past decade are: gamified systems must have a specific user engagement and instrumental goals, and the way to achieve these is by the selection of game design elements."*

Another key gamification concept is that a game-like user experience activates the end-users' individual motives and make the learning experience meaningful for them [61, 62]. However, Bui et al.'s [63] review of gamification disclosed that most gamification studies do not explain the design elements of the gamified artifact, such as how these artifacts foster gamification for meaningful learning experiences, and that there is a:

> *"[…] large gap in research of potential relevance to organizations… more research is needed on employees interacting with group systems resulting in collaboration dynamics and longer-term behavioral outcomes."* [63].

Moreover, gamification is difficult to design for a variety of reasons, most prominent of which is that: (1) the inspirational source of gamification design [64]; games, are complex, multifaceted, and thus, difficult to generally design and let alone transfer to other environments [65, 66]; (2) the goal of gamification is to affect behavior and not only to entertain – as it is primarily the intention of games [67]. Hence, the design of gamified ILEs should not be equaled with developing games in general. Otherwise, transferring game elements to the meaningful learning experience in safe spaces, may lead to the design of ILEs that provide a level of entertainment, but might not lead to a behavioral change as is intended from gamification; (3) the serious learning context in which gamification is applied provides requirements, which may limit the design space drastically compared to games [68]; and (4) in order to affect behavioral change through gamified learning experiences, gamification involves motivational development of design knowledge which entails the understanding of how to incorporate synthesized game elements into the immersive learning experience [69].

However, so far, only a few sources exist that provide methodological insights and practical guidance into how to gamify IT artifacts (e.g., [70–72]), gamification of immersive learning experiences in VR (e.g., [38, 73, 75]), or how to systematically incorporate gamification into the design process of a DSR project (e.g., [21–23, 76]). As a response, we propose that gamified safety training represents a natural opportunity to apply a design-science based gamification approach that advances the development of a mid-range theory for designing sustainable safe spaces of ILEs.

3 The Design Science-Based Gamification Approach

In order to support our design science-based gamification approach, we adhered to a methodology that closely follows the framework advocated by [26], which emphasizes mid-range theories as: theories that lie between the minor but necessary working hypotheses that evolve in abundance during day-to-day research and all-inclusive systematic efforts to develop a unified theory [77, 78]. Whereas grand theories are all encompassing in their nature, mid-range theories are bounded by their subject matter and therefore offer the kind of detail that can only come from an in-depth focused on contextualized design science research [79]. Consequently, mid-range theory building is suggested to be more specific to accommodate empirical data from a sub-range of the phenomenon covered by a general theory [80]. In other words, a mid-range theory of DSR in IS, shall attempt to strongly link kernel theory constructs with design facets of artifacts [81]. But what is a 'kernel theory'?

A 'kernel theory' is per definition a body of theoretical knowledge (e.g., concepts, principles, theories) that is drawn from natural or social sciences to govern design requirements [82, 83]. In design science, kernel theories can be employed to underpin and inform the design process of artifacts [20], by providing justificatory knowledge [84] that explain how and why the design of an artifact is sufficient for its purpose and scope. However, a common challenge with using kernel theories in DSR, is the difficulty to discern the relationship between high-level abstracted kernel theories with design goals of a mid-range theory development project [26, 84]. Another challenge of developing mid-range theories as to do with the difficulty of using existing frameworks for design theory development (e.g., [83]) to explicate design-related knowledge from kernel theories [26]. As a consequence, unlike the management, medical, sociology, and engineering literatures, where mid-range theories are frequently developed, the IS literature provides a modest quantity of examples on mid-range theories that were developed through DSR projects (e.g., [26, 85]).

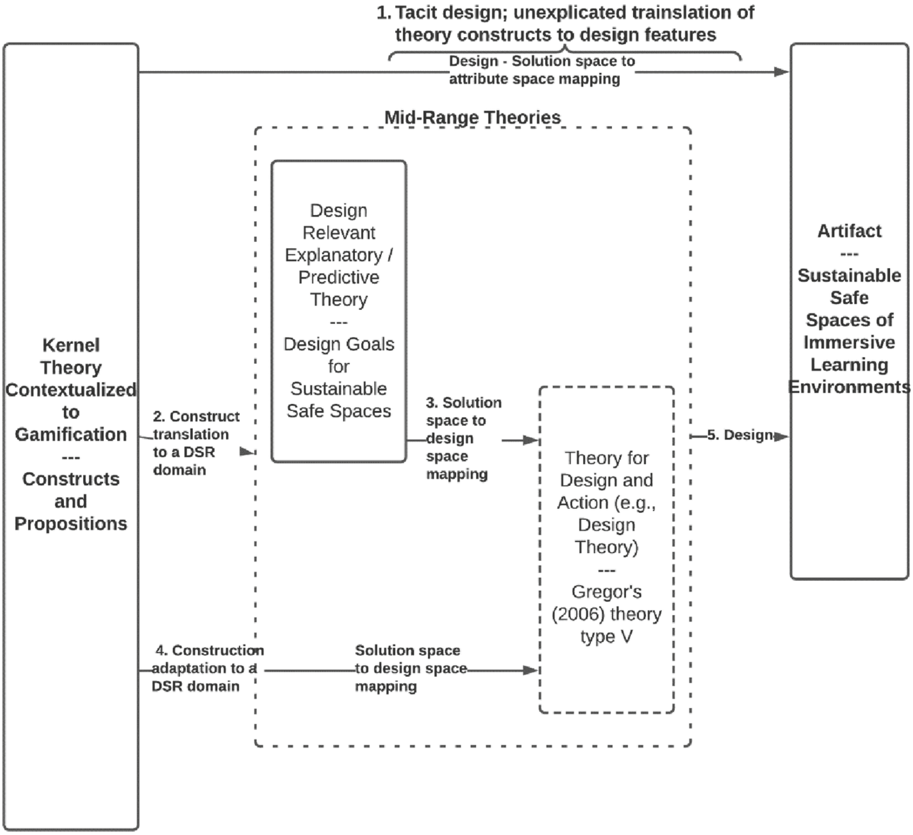

Fig. 1. Overview of a Proposed Mid-Range Theory for Designing Sustainable Safe Spaces of ILEs (adapted from [26])

As a way of advancing the discourse on developing mid-range theories through DSR in IS, for this study (as shown in Fig. 1), we focused on developing mid-range theories in form of Design Relevant Explanatory/Predictive Theories (DREPTs) proposed by Kuechler & Vaishnavi [26].

A DREPT is a mid-range theory that formally captures the translation of a kernel theory constructs (derived from both within and outside of IS) to the design realm of an artifact [26]. In other words, a DREPT augments the 'how' information of a theory for design and action [78] with explanatory information explaining why an instance artifact as the effects it does for the design space. Subsequently, the reason this study focused on developing a mid-range theory in form of DREPTs, is because of a number of reasons. First, DREPTs capture knowledge generated during a DSR project that is not captured into a high-abstract design theory [83, 84], but instead link the captured knowledge with explanations about a phenomenon that is derived from a kernel theory that incorporate design goals for the theory. Second, a mid-range theory of this kind, explains how and why design goals based on the theory achieve their intended novelty across contexts of artifact design [20]. And third, DREPTs is more abstract than a design theory proposed by Walls et al. [83] and is, thus, more broadly applicable to directly assist in the design of multiple instances of IVR applications for an ILE.

The framework shown in Fig. 1, is adapted from [26] to employ a design science-based gamification approach that help us develop a mid-range theory for designing sustainable safe spaces of ILEs. More specifically, the process of our design science-based gamification approach was executed as follows: (1) we employed a kernel theory that incorporates constructs and propositions from the gamification literature (e.g., [86]) and empirical material that captures knowledge on sustainable safe spaces of a designed artifact for fire safety training in IVR; (2) we translated and mapped the constructs and propositions of the kernel theory to the domain of designing ILEs that offer sustainable safe spaces for immersive learning experiences (e.g., [87]); (3) we mapped the solution space to the design space by extracting design goals that represent the mid-range theory's prescriptive knowledge. Consequently, the design goals were mapped with elements of sustainable safe spaces that are linked with game elements; and (4) the design goals are positioned as extant parts of the mid-range theory, which can be elaborated into testable hypothesis and/or principles of further developed theories [84, 85] for designing sustainable safe spaces of ILEs.

4 Establishing the Proposed Mid-Range Theory: A Case of Evaluating Fire Safety Training in Immersive Virtual Reality

In this section, we establish our mid-range theory through the following steps. First, we present the case setting of the DSR project of which this study extracted specific artifact design knowledge from. More specifically, we focus the artifact as a proof-of-concept and discuss its value for the empirical setting as proof-of-value. Then, we outline the identified kernel theory that draws on a synthesized body of knowledge on gamification. Thereafter, we operationalize the kernel theory into a set of the design goals that, together with constructs of our kernel theory, inform the prescriptive aspects (e.g., addressing the how-part of our research question) of our proposed mid-range theory.

4.1 The Empirical Case Setting: An IVR Learning Experience of Fire Safety Training

The empirical case setting of this study took place within a project of evaluating an IVR learning experience of fire safety training. The empirical case is a design science project following the Action Design Research (ADR) method [25] and was executed at one of the headquarters for the biggest train operator company in Sweden, named SJ. The cycle of evaluating the IVR learning experience, was manifested through a specific focus on evaluation of a designed IVR application for fire safety training, which is intended to become an integrated part of a future ILE for safety training. The IVR application had undergone two iterations of design and evaluation for Alpha and Beta versions.

More specifically, the evaluation process focused on establishing proof-of-concept and proof-of-value by: (i) evaluating the IVR learning experience of individual end-users/participants with an interest for how safe they felt during the training exercise; and (ii) evaluating the sustainable implications of conducting fire safety training in

IVR. Consequently, the evaluation phase took place between 2021–2022 and was conducted through direct observations of the IVR learning experience combined with semi-structured group interviews [88]. A total of 4 training sessions were observed and a total of 26 participants were interviewed. Subsequently, the training sessions were performed individually by each participant and the interviewees consisted of end-users (e.g., training participants) and organizational stakeholders (e.g., instructors), which were asked questions such as "In what ways did you feel safer in virtual reality than in physical reality when extinguishing fire?", "Why do you think it is better for the organization to do fire safety training in virtual reality?", or "How will the organization continue with safety training in virtual reality?". As a result of the observations and the interviews, we could establish proof-of-concept and proof-of-value, as justification for our kernel theory and as an empirical basis for establishing the mid-range theory.

Fig. 2. Proof-of-Concept: Instantiated IVR Artifact for Fire Safety Training

In DSR, a **proof-of-concept** is the point at which evidence exists to show that the described conceptual design of an artifact is feasible and promising, at least in a limited context [18, 20]. For the proof-of-concept of this study, we applied gamification to carefully extract and propose the gamification design implications that serve as the bridge between the artifact's functionality and meaningful engagement [60]. A **proof-of-value**, on the other hand, is achieved when IS researchers show that an IT artifact actually works for its purpose in the context it is implemented [89]. Both concepts were incorporated into the kernel theory.

For establishing a **proof-of-concept** we reviewed the overall impressions and thoughts among participants (end-users) of the IVR safety training sessions. We went to the organization where the proof-of-concept was established and interviewed the participants (e.g., train operators, train drivers, instructors of the training sessions) to see how pleased they were with their learning experience in IVR. The instantiated IVR artifact that mediated the immersive learning experience, was based on IVR technology in form of HTC Vive Pro Headset and a replica of a fire extinguisher that was connected to the IVR training environment (shown in Fig. 2). Through observations and interviews, we perceived an overall positive impression among the participants. In terms of their learning experience, they found meaning in conducting safety training a virtual environment in front of a physical one:

> *"The experience felt safer than doing it physically. I did not feel any threat from the fire and still I could learn how to use the fire hose to extinguish the fire"* (Train Operator 1)

"It was a different kind of experience, much more fun and motivating than, you know, looking at a powerpoint or something. This felt more like a video game… I could fail over and over again and still learn more" (Train Driver 1)

And when the participants were asked whether or not they would like to do other kind of safety training exercises in virtual reality, some of them answered:

"I mean, we feel safer doing dangerous stuff in a virtual reality… it still feels quite real, and we recognize the exercises, scenarios and so… also, it seems that we can do this individually without any organized effort as well, that is good!" (Train Operator 2)

"It is difficult to say for sure… hm, well, I think so, I mean, it is much safer and that is comfortable and perhaps that makes us calmer when a dangerous thing happens in reality… there are other scenarios, such as dealing with threats from passengers… that could be realistic to exercise in a safe space as well" (Train Operator 3)

Additionally, for establishing a **proof-of-value** for this study, we interviewed instructors (the organizational stakeholders) from the organization, who expressed a positive view on continuing with training their staff in IVR, by extending the repertoire:

"I definitely feel that this is the future, you know, especially because it is so safe to do things wrong without getting hurt in the virtual reality. People feel safe and they are not afraid to do wrong because it is also fun to practice like this. Little bit like a video game, you must finish your assignment and then you can do it over and over again in a rather entertaining way." (Instructor 1)

"Many of them [referring to the participants] felt safer to do this kind of training like this. I have done traditional fire safety training with them and that was much more stressful and demanding." (Instructor 2)

Finally, when asked about providing an outlook into the future of the organization's need of using IVR technology for safety training purposes, more systematically, the instructors answered:

We can see the value of doing more training in virtual reality, more systematically perhaps, if that is possible… the virtual reality is much safer for the participants, especially when we do safety training, they can fail without getting hurt. That is very appreciated" (Instructor 1)

"We have other training activities that might benefit from doing them in virtual reality because it is safe, secure, does not take time for transportation and it is quite fun. I can see that our, eh, employees think this is different and fun and quite realistic, I think so too as well… also I feel good that it is safer for everyone to train like this." (Instructor 2)

4.2 Structure of the Mid-Range Theory: Contextualization of Game Elements and Design Goals into the Mid-Range Theory

Having established a proof-of-concept and proof-of-value, we now move on to explicate the structure of our mid-range theory by focusing its constructs as design goals, and their relationship with constructs of our kernel theory. Previous DSR studies have largely lacked a systematic DSR approach to how concepts of gamification can be synthesized into constructs and propositions of a kernel theory [23, 63]. As such, the key role of using gamification as a kernel theory for this study was to contextualize gamification concepts in a way that informs the explanatory statements of our mid-range theory. Here, we followed Kuechler & Vaishnava's [26] guidelines for how to express the constructs and propositions of a mid-range theory. This allowed us to map the prescriptive elements of our mid-range theory with the explanatory statements of the kernel theory deriving from the literature on Gamification. At this stage, however, the proposed mid-range theory does not include any predictive elements because the theory's utility has not been verified across multiple contexts and can thus not yet be proposed to predict any specific outcomes.

Table 1 depicts the constructs, propositions, and contextualization of gamification concepts (e.g., game elements, game features) with elements of safe spaces in ILEs, whereas a detailed presentation of each design goal is provided below Table 1.

From the kernel theory propositions shown in Table 1, we infer (as the arrows in between the columns indicate) gamification concepts to inform the formulation of four design goals that constitute the prescriptive knowledge of our mid-range theory. The gamification concepts were inferred from reviewed literature on gamified safety training in IVR (e.g., [75, 90–92]). Moreover, the literature review informed specific game elements that are important to take into consideration when designing gamified learning environments for increasing extrinsic/intrinsic motivation among end-users. As such, we propose that the design goals are achieved by incorporating the linked game elements shown in Table 1. Consequently, the development of the design goals was supported by the DSR case through a number of ways: (1) the case helped us contextualize the design goals within a hands-on IVR training scenario; (2) the case helped us derive the prescriptive statements of the design goals from features of the fire safety training artifact; and (3) the case helped us evaluate the immersive learning experience in order to motivate a gamified approach for safety training procedures that are sustainable over time.

The **first design goal** was extracted based on kernel constructs that emphasize 'flow' as a central concept of gamification [75]. The reviewed literature on gamification explicated flow as a psychological experience that end-users of IVR enjoy, the more they engage with training activities over time [92]. Experiencing and seeking flow is similarly why end-users engage with games in a committed, repetitive, and safe way [90]. On this basis, we can reason that the literature provides examples on game elements that we map with designing for intrinsically rewarding repetitions through the accomplishments of missions and mastery of levels, which help stimulating a sense of flow in safe spaces of an ILE. For instance, simulation of missions, similar to missions in games that are exciting and fun to accomplish, can be defined to support immersion and sense of increased embodied presence in IVR [39]. The length and speed of an assignment can,

Table 1. Structure of Mid-Range Theory: Gamification Concepts, Game Elements, and Design Goals

Kernel Construct/ Gamification Concept(s)		Game Element Example(s)		Mid-Range Construct/ Design Goal(s)	Descriptions
Sense of Flow	➡	- Simulation - Missions - Levels - Speed	➡	DG1. Design for Intrinsically Rewarding Repetitions	Games tend to indicate to end-users that they have succeeded or failed in a simulated mission as well as what levels and expertise they have gained from their experience. Hence, designing for intrinsically rewarding repetitions require a safe space for control of speed and self-efficacy (e.g., person's belief in their abilities), which enables repeated engagement with activities in the IVR space
Entertaining Utilitarianism	➡	- Quests - In Game Rewards - Roleplay - Virtual helpers	➡	DG2. Design for Increased Situational Awareness	Games promote end-users with utilitarian motivations through quests and in game rewards, which increase situational awareness through incentives of positive actions and increased safety skills. Hence, designing for increased situational awareness can promote an entertaining form of utilitarianism that is extrinsically motivated through roleplays and virtual helpers (e.g., avatars) that enable a safe space for guidance and learning
Meaningful Narratives	➡	- Reminders - Customization - Narration - Clear Goals - Direct Feedback - Theme	➡	DG3. Design for Experimental and Interactive Storytelling	Games provide end-users interactive spaces for safe experimentation through customizable narratives and reminders of objectives. Hence, designing for experimental and interactive storytelling can provide clear goals through an exciting theme that facilitate meaningful learning experiences (e.g., valuable, and significant for the user's professional identity)
Motivational Autonomy	➡	- Tasks - Increased Difficulty - Badges - Performance Stats - Performance Feedback	➡	DG4. Design for Flexible Level of Mastery	Games offer end-users the freedom of choosing what challenges to undertake without becoming punished or risking embarrassment. Hence, designing for motivational autonomy need to provide end-users a safe space to explore increased difficulty of tasks, and evaluate their performance through direct or post performance feedback/stats that generate indicative rewards (e.g., badges) for increased autonomy over time

for example, be designed according to the difficulty of a training assignment; length is defined according to the number of objectives and given steps that need to be followed in order to achieve the objectives, whereas speed is measured according to how fast the assignment must be solved [93]. Additionally, the entire training experience is designed into different levels, which signify how far in the gamified training process the end-user has advanced [94], which provide them a sense of safety and control of self-efficacy.

The **second design goal** was extracted based on kernel constructs that emphasize 'utilitarianism' in an entertaining way. The utilitarian aspect is here defined as the aspect that mediates the achievement of a goal according to its applied fields (e.g., efficiency in training). As such, the aspect is based on a pragmatic inquiry of actions, consequences, and their values for a given training assignment [95]. On this basis, we can reason the main purposes of game elements are to achieve utilitarian goals supported by gamified behaviors and features in the IVR safe space [93]. For instance, in game rewards are game elements that the safe space can incorporate to engage end-users in utilitarian quests that are guided by virtual safety training helpers (e.g., embodied avatars) [35]. Here, role plays can be employed to provide end-users a comfortable way of increasing their situational awareness, without losing motivation due to the risk of feeling ashamed or embarrassed for failing their assignments [38]. Consequently, the elements can be designed to increase end-users' situational awareness through possibilities for explicit interaction with safety tools that help end-users to understand the situation [96], or implicit interaction through safety signages that simulate their awareness of understanding a utilitarian behavior in the situation [97].

The **third design goal** was extracted based on kernel constructs that emphasize 'meaningful narratives' that can be customized together with reminder of objectives (e.g., indicator of accomplished and not accomplished training tasks), which end-users encounter in a safe IVR training space [98]. The 'meaningfulness' of narratives derive from how intelligible the training scenario is framed and presented to the end-users. In other words, the scenario must make sense to the end-users, and as such, the framing of the training scenario gets more meaningful if the goals of the training scenario are presented clearly before and during the IVR training experience [99]. On this basis, we can reason that the narration of a safety training scenario needs to incorporate a given theme with clear goals that is conveyed through a creative and interactive form of storytelling, which allow the users to experiment in their safe IVR training space [38, 100]. Here, direct feedback is essential to incorporate through multimodal training features (combination of sound, visuals, animation, avatar behavior) that afford a safe atmosphere to increase the external and internal motivation of the end-users by demonstrating the validity of creative experimentation through a learning by doing [101].

The **fourth design goal** was extracted based on kernel constructs that emphasize 'motivational autonomy' that stimulates the end-users learning process and development of procedural skills, over time. 'Autonomy' is here defined as the condition or quality of being self-govern and self-determined [102], whereas it becomes motivational when the IVR training experience enables a safe space with the freedom of choosing the complexity of challenges and training tasks [103]. On this basis, we can reason that motivation and autonomy are afforded through game elements that allow the training tasks' difficulty to increase adaptably, depending on the sufficiency of users' performances [15]. Elements such as performance feedback and stats, accompanied with badges (e.g., ranking depending on quality of performance), are thus crucial to take into consideration when designing for flexible level of mastery that gets evaluated and refined in a safe IVR training space [74].

In summary then, the design goals can be achieved by DSR scholars together with design practitioners that develop ILEs for safety training purposes. The next step of operationalizing the design goals would thus be to follow the explanatory statements and contextualize the prescriptive elements of gamification, in order to gamify either a present or future ILE artifact. Moreover, the proposed design goals need to be achieved by following the prescriptive statements of safe spaces as a means for realizing ILEs that are not only gamified, but also secure for conducting safety training procedures. Together, the design goals can then be evaluated against settings that are in need of safety training procedures that support the sustainable development of organizations, with a particular emphasize on reducing physical injuries during safety training, increasing the well-being of training participants by preparing them under safe and secure circumstances of training, and eliminating the amount of pollution that is usually an implication of hazardous situations in the physical training space.

5 Discussion

Given the outline of establishing our proposed mid-range theory for designing sustainable safe spaces of ILEs, we discuss that our theory has implications for both practice and theory. Hence, in this section, we start by discussing the practical implications of the mid-range theory, with a particular focus on the design goals and their implications for designing safe spaces in ILEs that support organizations' safety training initiatives in a sustainable way. After that, we discuss the theoretical implications of our proposed mid-range theory, with an emphasis on how it contributes to the area of design science and gamification of IVR safety training.

5.1 Implications for Practice

If we start by discussing the implications of the design goals, we can see that all four goals put a strong emphasis on employee involvement in safety, such as raising their level of situational behaviour awareness by advocating gamified safe spaces that are designed to reduce the likelihood of workplace accidents and improve the effectiveness of safety management [38]. Many enterprises and organizations, as well as the general public, are advocating for a stronger emphasis on safety education and training to limit the potential for human error and consequently improve workplace safety [35], something that the design goals echo through their empirical illustrations from the case presented in Sect. 3. As the data material from the empirical case indicated, both the organization and their employees expressed to see a value in conducting safety training that is safe in IVR. This was confirmed through the established proof-of-concept, whereas the proof-of-value provided a snapshot into a potential of conducting additional safety training exercises in safe spaces of ILEs that are sustainable.

At this stage of our research, we understand that the design goals can support organizations to employ ILEs that support the social dimension of sustainability by providing their employees a learning experience that feels safe, and that increase diversity in participants' skills and performances [15]. Moreover, the design goals provide prescriptive knowledge [20], which can support organizations to target the environmental dimension of sustainability by reducing the risk of injuries, energy consumption, and pollution in situations where experimentation is needed but is dangerous and hazardous, such as for instance in the context of fire safety training [35]. Finally, we think that the design goals can support the economical dimension of sustainability by making the learning experience safe over time without risking to overconsuming organizational resources (financial, humans, technology). This is in particular a tedious task when increasing situational awareness in physical training environments, which are limited to budget and technological constrains, such as for instance in health care or safety education [38, 100].

Secondly, the gamified approach to designing sustainable safe spaces of ILEs, might increase the sense of motivation among end-users, by showcasing how their competence, autonomy, and relatedness, is augmented through enjoying and engaging tasks through meaningful training narratives [98, 99]. For example, game elements such as quests and missions have been proven to increase the lust and motivation for experimenting with the virtual surrounding and the affordances they provide [75]. These elements can be designed to confirm the embedded safety of the ILEs through for instance training assignments that are generally dangerous to experiment with in the physical reality, such as experimenting with training assignments in the manufacturing industry [75, 101]. And although the empirical case of this study supports that safety training in IVR might become more interesting when it is fun and exciting, which is a central tenet of gamifying IVR safety training experiences [64, 97], one case alone cannot justify the level generalizability among the gamified design goals of this research. It should thus be noted that we are not implying that all aspects of safety training in ILEs should be gamified, but rather, we propose the design of ILEs for safety training to incorporate game elements that increase safety and sense of autonomy among end-users. Furthermore, evaluating improvement in end-users' motivation is not a simple and straightforward thing to design for [60], Hence, as part of the design science approach [20, 26], it will be necessary to determine how to evaluate this in order to determine the practical viability of our proposed design goals.

5.2 Implications for Theory

Promoting gamification through a design science approach, and vice versa, has implications for how design science outputs [20] can be developed as mid-range theories [26] for designing a class of IVR safety training artifacts as ILEs. Gamification concepts can be used to guide the design of safe spaces in ILEs, which leads to meaningful IVR learning experiences that is theoretically informed through the mid-range theory's kernel theory constructs. As such, the proposed mid-range theory of this study was pragmatically driven from the serendipitous confluence of design science goals and gamification concepts. We not only were able to demonstrate the empirical connection of our theory with the synthesized body of kernel constructs, but we also did so in a manner that can contribute to theory development beyond DSR.

Our first key contribution here is the extension of mere IVR safety training to gamified safe spaces for training in a sustainable way. To do so, we combined constructs from the gamification literature that is adhered to increase behavioral change (e.g., [67, 69]), methodological insights and practical guidance on how gamify IT artifacts in general (e.g., [71, 72]), with literature on security gamification [23] that distills gaming elements for theorizing characteristics of sustainable safe spaces. Given that *safety* is essential to our gamification context and the proposed mid-range theory, we also suspect that safety would not have a beneficial relationship a non-gamified safe space that is immersive. Hence, beyond proof-of-concept and proof-of-value, we suggest that an extension of this research needs to examine each game element involved in designing sustainable safe spaces of ILEs. Our second key contribution is the novelty of our mid-range theory, which synthesizes elements of safe spaces with gamification concepts to improve the sustainable quality of safety training in ILEs. The novelty lies in the prescriptive and explanatory nature of the synthesis, which goes beyond design knowledge that is merely constrained to gamified ILEs alone or immersive training environments that are not gamified nor emphasize the importance of incorporating safe spaces that improves the sustainable development of organizations' safety training procedures.

Another consideration that needs to be examined is the proof-of-use, which in DSR (e.g. [19]) is demonstrated when the outputs seek to create self-sustaining and growing communities of practice around a generalizable solution, which in our case would be an ILE that provide sustainable safe spaces for safety training. Thus, proof-of-use is perhaps the greatest limitation and future research opportunity for this research. The first obvious issue and opportunity here is that of generalizability, in terms of further developing the mid-range theory into a design theory [84]. Although our mid-range theory is both theoretically and empirically grounded, it is not established across many organizations which limits the generalizability of our current results. We therefore encourage future DSR to employ our mid-range theory to other contexts that share similar characteristics and needs as the one we illustrated through the empirical case of this study.

6 Conclusion

In this paper we proposed a mid-range theory for designing safe spaces for safety training in immersive learning environments. The goal was to give context sensitive design guidance for especially designing training in hazardous or otherwise potentially dangerous environments. Our study advances a mid-range theory of gamifying the experiences of such training and proposes a set of design goals for developing such gamified learning environments. Consequently, we synthesize a body of knowledge on gamification into a kernel theory that informs the design process and justifies the underlying knowledge of our proposed mid-range theory. Moreover, we target the contributions of this study as sustainable for organizations and practitioners as we offer design guidance and proof-of-value of implementing immersive learning environments that are cheaper, safer, and easier to implement than traditional approaches of safety training. This allows for repeated training with less cost and no real danger for the trainees, without compromising with motivational factor of the learning experience The gamification approach should thus enhance the development of the skills that are trained and encourage repeated training by the participants. As a result, we think that a sustainable approach to safety training in IVR, should over time lead into better trained workers and better overall safety. The limitation of this study, however, is that we have not tested the proposed mid-range theory in other similar contexts. Hence, for future research, we propose to test the mid-range theory to evaluate its level of generalizability, validity, and empirical usefulness across contexts that are interested in designing and implementing safety training in immersive learning environments that are safe and sustainable.

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