

NEW HORIZONS FOR A WORKER-EFFECTIVE TRAINING METHOD IN THE AEC SECTOR

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Abstract

The training of site professionals is typically perceived as being monotonous, and ineffective in terms of information assimilation and retention. Furthermore, traditional training approaches such as lecture-based presentations, have been demonstrated to be unsuccessful at engaging site workers, resulting in decreased attention and motivation. This paper aims to develop the framework for gamified training, of site workers. It is intended to value the requirements that European H&S standards expect to be kept under surveillance. The outcome of this work is the definition of a new reward procedure focused on ongoing improvement via feedback to low-scoring individuals. Multiple screen boards are designed to facilitate key context interaction and possible reactions. This study outlines two theoretical applications of training, the first applicable transversally to many situations (i.e. Educational Construction Site Information Modeling) and the second as a site-specific solution based on its digital twin (i.e. Mockup Construction Site Information Modeling) intended to accurately foresee and train workers for dangerous operations.

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1. Introduction

The Building Information Modeling (BIM) methodology provides increasingly widespread applications within the Architecture, Engineering, and Construction (AEC) industry. From the modelling of aforementioned disciplines, a new one related to construction processes has been added, linked to the operations phase, which specializes more than a managerial 4D analysis by the in-depth study and which aims to understand how to improve site management from logistical, sustainable, health, and safety stance. Therefore, we wish to investigate a fundamental aspect of how these enhancements can be attained. To ensure the safe performance of activities, it must be remembered that the Directive 89/391/EEC - OSH recommendations must not only be stated in technical documents but must also be translated into good practice on the construction site. Therefore, instruction and training of personnel are required for this to occur.

The issue of correct training involves not only the theoretical information provided, but also, from a psychological standpoint, how this information is transferred. Therefore, it is necessary to develop a worker-effective training method for the AEC industry.

The purpose of this work is to investigate possible scenarios that can be developed as training with the support of gamification logics that have proven to be useful in terms of engagement and return on learning [1]. Specifically, the goal of this investigation is to determine whether or not a particular scenario can be developed as training [2].

A portion of the effort involved focusing on difficulties including 1) planning training requirements; 2) creating narratives that are appropriate for the location and fit the demands; and 3) dealing with immersive virtual reality (i-VR) technology.

2. Literature review

We will make an effort to provide answers to questions such as, "What is the definition of gamification?" Which areas does this pertain to specifically? What are some particularly noteworthy examples? How can we interact? In order to respond to these questions, we will construct a discourse that first offers the reader a series of definitions of gamification, distinguishing it from serious games, and then outlines the most typical experiences that may be achieved via the use of gamification.

The term "gamification" has been widely adopted by the scientific community, with its origins traced back to British programmer Nick Pelling. Pelling initially coined the term in 2002 to refer to playful applications that were not solely intended for entertainment purposes. This has been noted in various academic sources, including [3], [4], and [5]. The clarification of the distinction between Gamification and Serious Games is essential to fully grasp their significance, as they are two distinct yet complementary concepts, despite their initial chronological emergence. The use of the term 'productivity games' [6] in lieu of 'playful design' [7] is a frequently encountered phenomenon. However, it can be argued that 'gamification' has established itself as a widely recognized term. As per Detering's analysis, the term "gamification" encompasses a discrete set of phenomena, including gameful interaction, and gameful design. These concepts are distinguishable from established notions such as playfulness, and design for playfulness. To properly understand these concepts, it is worth to refer to the adapted Figure 1 from [8].

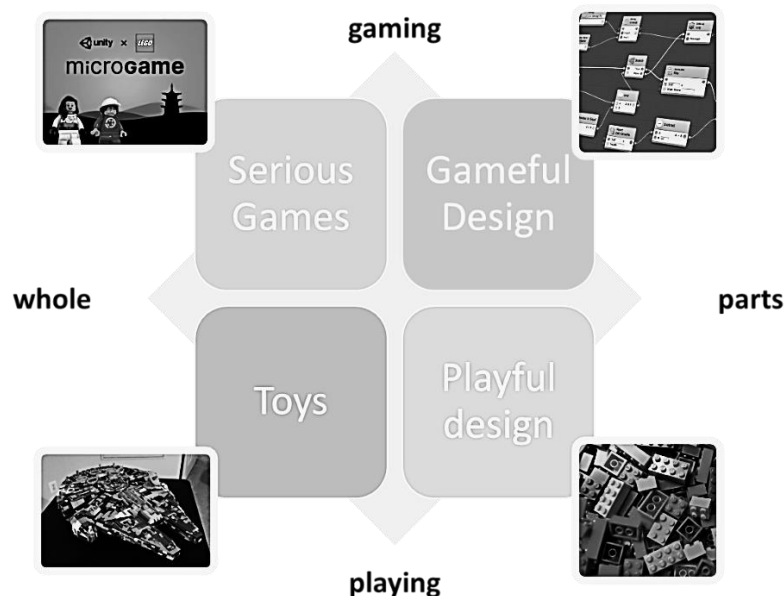


Figure 1 – Compass to navigate SGs and Gamification

The term "gamification" is currently used to refer to two interrelated concepts, the first trend pertains to the growing acceptance, endorsement, and ubiquity of (video) games in everyday use, as documented by [9] and [10]. The second concept suggests that video games, being primarily designed for entertainment, possess the capacity to motivate players to engage with them at an unrivalled level and for a prolonged duration. Consequently, it is suggested that game mechanics can be utilized to enhance the appeal and engagement of non-game products and services [11].

The rapid evolution of visualization technologies, such as virtual reality (VR), augmented reality (AR), and mixed reality (MR), has numerous consequences for the AECO industry. These visualization tools are facilitating new channels of communication and collaboration among stakeholders. The incorporation of gamification with visualization technologies has led to the emergence of new applications and effects, such as skills teaching, health and safety training, and behavioral investigations. These gamified applications resemble the fundamental structure of SGs [12]. Several references provided an increasing number of evidence, that by comparing SGs and traditional education methodologies in construction

health and safety training and skill development the former results as more effective than conventional training methods [13].

3. Development

In order to develop a training application, it was necessary to develop a logical method that would underpin the learning process in which the worker would participate. Two main areas were identified for this purpose. Figure 2 provides a concrete illustration of the relationship between the design and the development of the game and its components. The parts of the diagram are logically ordered: (1) description, (2) event, (3) criticality, (4) requested action, and (5) learning objective.

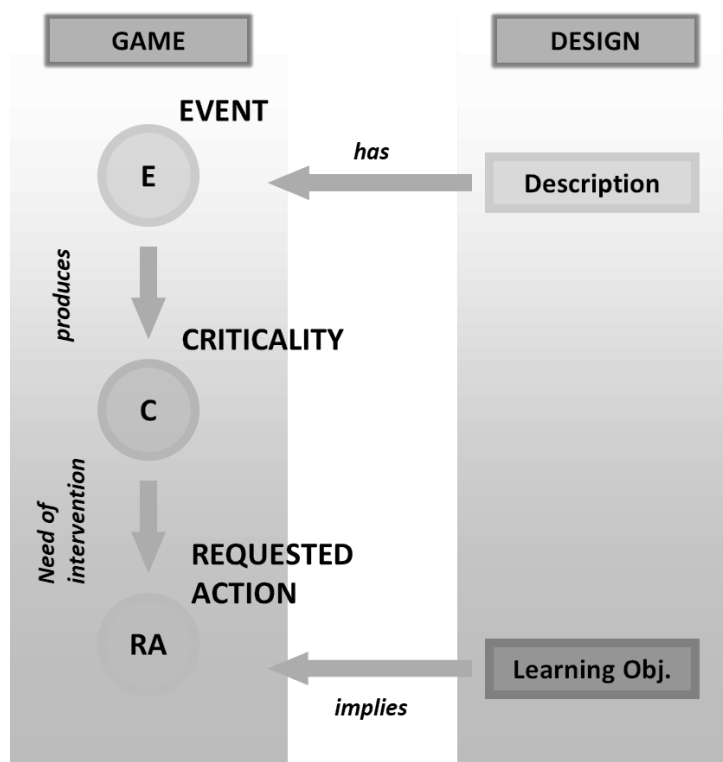


Figure 2 – Game/Design swim lanes

3.1. Description

The initial phase in the design industry is description. This is a normal language description and not a machine language description. The purpose of the description is to provide information to the developer and highlight, in connection to the process, the events that must be supported by the application. The objective is to offer indicators that enable the programmer to trigger the scene and level, hence initiating the event. The relationship between the description and the events is 1 to 1. For each event, a description must be provided to assist computer production work by elucidating the manner in which the occurrences are to unfold.

3.2. Event

The second part of the process translates the trigger in the game's description and references to the macro region of the game. This phase denotes the start of each scenario and level that will be encountered within the program. The trainee, the appointed work supervisor (AWS), sees many characters appear and then, in accordance with the functions that are expected of them, those characters immediately begin engaging in the activities that are the primary focus of the trainee's attention. An exciting opportunity lies in the possibility that events might be linked to the activities that are being systematized in the ergotechnical project. This 4D program, the GANNT schedule, can be

developed with finer precision, therefore this possibility represents a win-win situation. The events have been described and developed according to real scenarios experienced by the authors in infrastructure sites both in terms of operations and phasing.

3.3. Criticality

The most pertinent aspect of the procedure outlined here is the effective translation of the event's criticality. This section must be created with great care, as it is the linchpin of the success of the subsequent phase's response. The beginning event must be able to elicit the anticipated sensation of criticality so that it may be calibrated against the expected response in order to meet the learning aim. Criticality is developed with unfavorable on-site behaviors, such as the occupation of an excavator's buffer zone, rather than the execution of specific activities by non-expert worker or even (and probably more serious) the absence of control over personnel. These are only a few instances of the key challenges that the European Directive 89/391/EEC – OSH tries to disfavor.

3.4. Requested action

The required action is the fourth phase of this scheme pertaining to the game production stack. This phase involves the randomness of the learner's response, so it is only possible to identify the most pertinent action. If successful, it is during this phase that the necessary procedures to be maintained on-site are learned. This phase is the design's synthesis, which is centered on the ability to make the response acceptable and consistent with the learning objective, as detailed below.

3.5. Learning objective

The final phase, the fifth, consists of defining the learning objective, which is designed to highlight what you want the learner to demonstrate. This section again pertains to the design phase and not the construction of the application game, since it is derived from the comprehension and, consequently, synthesis of the regulations pertaining to worker health and safety. This phase works together with the required action phase, as it is based on what is described here that one must consider the learner's recognition and scoring for the activity accomplished. One could conceive of a scenario in which there is not just a net score but also an automatic and discrete evaluation that allows for nuanced scoring. Capable of recognizing not only possible optimally coupled activities, but also acts that, while not exactly accurate, have a decent degree of success or at least don't completely fail.

3.6. Application schema

The scheme derived from the preceding description is depicted in Figure 3, which illustrates how the learner, and the instructor can interact via the back-end control system. The beginning of the activity corresponds with the learner's first choice between a Head Mounted Display (HMD) for a more immersive experience or a straightforward but equally immersive display, depending on the availability of the offered resources. Following this option, the instructor has the ability to monitor and verify the learner's actions through his display. Depending on whether or not criticality is identified, data on the participant's behavior is collected and stored in a separate database for data collection. If the requested action is carried out, a new value is recorded in the data collection database indicating whether the action was accurate. In both instances, the choice is preserved and organized in order to provide the learner with a comprehensive report upon completion of the virtual training. If the learner takes the correct action and is thus able to not only identify the source of the hazard but also take the most appropriate action to resolve it, the System assigns a score corresponding to the difficulty of the resolved criticality. The triggering event procedure is then repeated iteratively until the training is complete. Through the confrontation with the learning objective, the trainer is then able to provide feedback to the learner by processing the data stored in the data collection database in order to produce an improvement in the learner and thus confirm more closely that the training objective is actually successful and can be deemed successful.

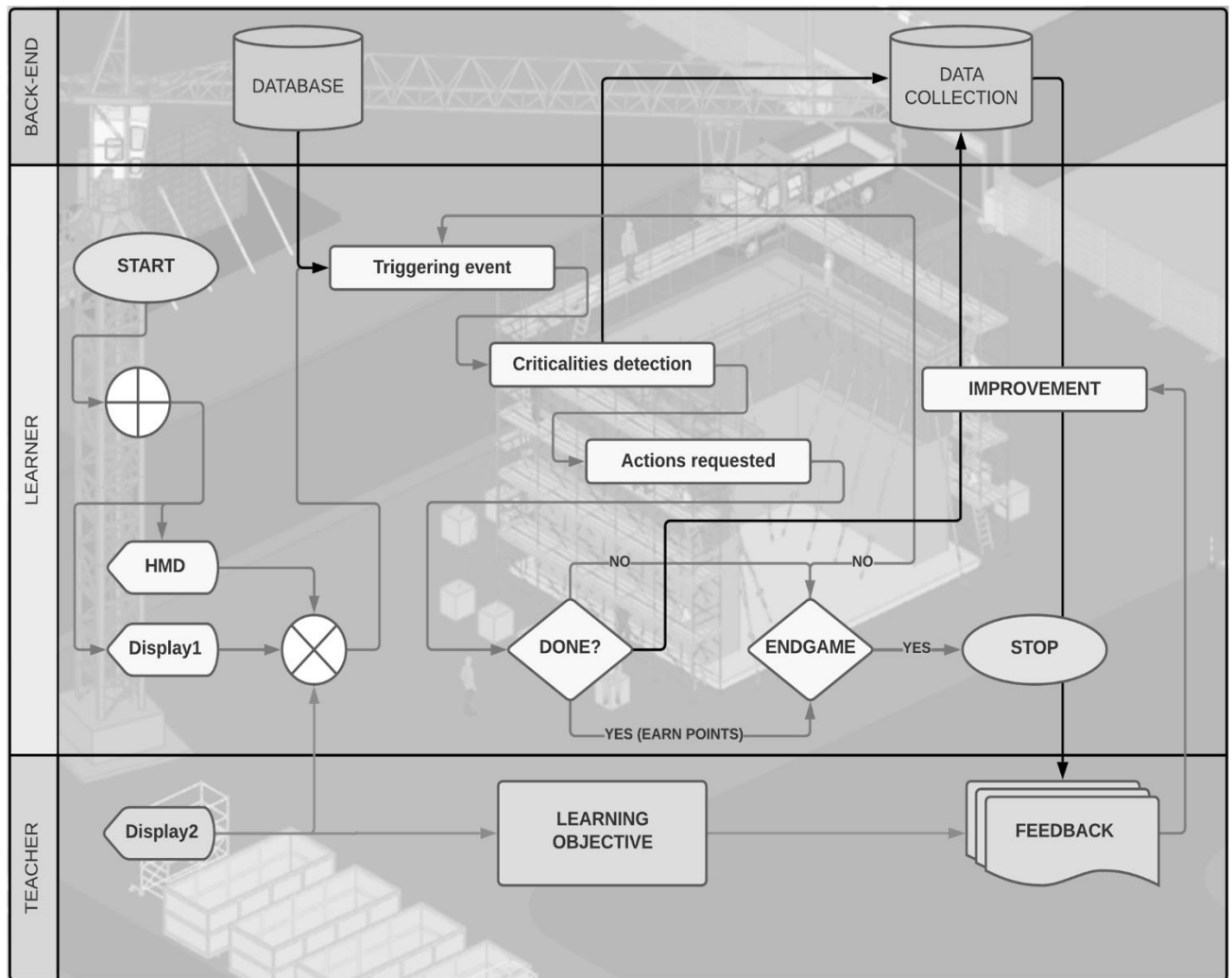


Figure 3 – Workflow

3.7. Scenarios development

In order to structure a worker-effective training experience, it was necessary to create a series of case studies that were representative of work in the context of infrastructure construction. The schematization proposed in the following image or table corresponds to that already presented in figure 2, where we find:

- Event;
- Description;
- Criticality
- Learning objectives;
- Requested action.

To enhance the specified fields, operational descriptions with a progressive time progression and a comprehensive breakdown of the work phases were developed. An illustration follows.

1. Provision of temporary transit prohibition barriers at overhead power lines using a box truck, unloading of the carrier in accordance with the procedure, and installation by an operating team

comprised of a team leader and an attendant, at the distance from the ground projection of the overhead power line specified by the applicable safety management plan (SMP). Elimination of the supply vehicle.

2. The delivery of a tracked elevating work platform (EWP) and a tracked mini-excavator on a low-bed truck, with ramps built up by the driver of the vehicle and machinery lowered to the ground by a qualified operator.
3. Using a mini excavator, prepare the space for the placement of aerial work platforms and the installation of prefabricated plinths for the building of overhead power line signal gateways. Planting topsoil in the region of the site. Installation of operationally configured EWPs at the northern gateway.
4. The delivery of prefabricated piles and plinths for the construction of portals using a hydraulic truck-mounted crane with caisson. Placing of plinths, raising of piles, and installation of signposts utilizing synchronized actions of a truck-mounted hydraulic crane and EWP driver, after stabilization of the vehicle by the driver, by an operating team comprised of a team leader and a competent worker.
5. Repetition of operations 3-5 by reversing the direction of the truck crane's arrival (to ensure the safety distances of the crane from the power line).

Event	Description	Criticality	Learning Objective	Requested Action
Start Level 1				
The dump truck for supplying the barriers appears	The box truck positions itself in the shadow of the ground projection of the power line	When handling a telescopic boom, there is a risk of contact with the high-voltage line	Checking the correct positioning of the box van in relation to the projection of the power line	The site supervisor places the box van at a safe distance
Two workers from the contractor appear	the two workers are supporting the activities to be carried out	Unidentifiable workers may not be regularly employed	Verification of workers' identity	
	workers must be identifiable and identified	Unidentifiable workers may not be duly employed	Verification that the names of the workers correspond to those indicated in the SMP	The AWS verifies that the names match the contents of the SMP
A worker starts climbing onto the body of a dump truck	one of the workers starts a potentially dangerous activity	In case of slipping, the worker risks falling and injuring himself	Check that no dangerous situations are created in relation to the activity	The AWS must provide a ladder to access the skip

Figure 4 – Events schematization

4. Conclusion

The purpose of this work is to try to conceive of and sketch out a potential worker-effective training program that would improve information retainment for safer construction sites.

This resource's potential applications are not limited to the training of workers with generic scenarios involving the use of specified equipment or machinery. The application seeks to achieve more tangible benefits through the use of this instrument for specific and targeted training on each construction site. Educational Construction Site Information Modeling (E-CoSIM) refers to training applications in which prevalent scenarios can serve as representative settings for typical situations. In addition, one can refer to Mockup Construction Site Information Modeling (M-CoSIM) for applications related to the construction site, which involves the development of a true geometric and information model that is representative of the reality in which workers will be required to perform their duties.

In both instances, it is believed that the proposed system will benefit the participation of employees in general and specialized training, and that the use of this resource will provide a tangible and direct advantage in mitigating risks on the construction site. The use of the M-CoSIM approach in this context is illustrative of the actual activities that will occur on the construction site, allowing the worker to practice and learn the correct procedures, even though mistakes that, unlike in the real world, will not harm him.

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