

Serious Games with Serious Aims

The Design and Development of a Serious Game for Construction Based Learners

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Abstract— For the purpose of this study, a serious game prototype has been designed and is currently being developed and tested with construction-based learners, to discover the effectiveness of serious games as educational tools within the industry. Serious games are commonly described as computer and video games that are intended to entertain learners while achieving a primary goal of education and training. Many studies and experiments have been carried out in order to test whether serious games have made it possible to play and learn simultaneously. Although the effectiveness of serious games as teaching and training tools is well established in the literature, some gaps have been identified. These include frameworks to transform traditional learning outcomes to game systems, serious game adoption and data collection, their relevance for affecting attitudinal change and the effectiveness of serious games in the construction sector. This study explores the effectiveness of upskilling training being delivered through the use of serious games rather than with traditional methods. In addition, there is a focus on the training of construction skills and the capacity for effecting attitudinal change within the construction industry. The research explores the opportunities provided by serious games to align with the learning characteristics of construction workers and to optimise the development of resources that achieve learning objectives effectively for this cohort.

Keywords- *Serious Games; Education; Training; Low-Energy; Construction; Data-Collection.*

I. INTRODUCTION

The overarching aim of this study is to explore the possibilities of whether upskilling training can be delivered more successfully through the use of serious games than with traditional methods. This research is specifically interested in the effectiveness of using serious games for the training of construction skills and the capacity for affecting attitudinal change. This paper outlines the initial stages and steps taken to design and develop the serious game prototype, additionally, it describes the preparation process of our primary study, taking place in mid-2020.

The rest of the paper is structured as follows. Section II begins by stating the project background and motivation. Section III reviews current literature surrounding serious games and their effectiveness as educational and training tools. Section IV illustrates the methodology and data

collection tools, chosen and utilised, in aid of this project. This section also demonstrates the results from the initial game design and development session and states the current stage of the project. Section V prepares for the next stage, which aims to test the serious game prototype with participants from our target audience. The potential challenges of future studies and how we plan to overcome these challenges are also presented within this section.

II. PROJECT BACKGROUND

In 2012, the European Union (EU) funded Build Up Skills Ireland (BUSI) [1] project conducted a skills-gap analysis of the Irish construction sector in relation to the capacity of the workforce for delivering low-energy buildings. One of the most significant conclusions of the report was an identified need for an introductory course on the principles of low-energy buildings for all building construction workers [2].

Build UP Skills QualiBuild (2013-2016), the follow-on project to BUSI, developed a Foundation Energy Skills (FES) course, with over 200 participants upskilled under a QualiBuild national pilot [3]. The focus of this course was knowledge of the underpinning principles of low-energy buildings and reinforcing the message of a need for a collaborative effort from all involved in the building construction process towards the achievement of quality standards. The FES programme focused on a pedagogical approach that would best address the identified knowledge gaps and need for attitudinal change amongst construction workers, which also considers the challenges, such as cost, equipment, space and time restrictions.

For the specific challenges of QualiBuild FES training, in upskilling an entire workforce, utilising serious games alongside traditional delivery methods offers greater flexibility of time and place. The potential contribution of serious games in construction skills training has not been explored in an Irish context to date. This study explores this potential for QualiBuild training and beyond.

III. REVIEW OF SERIOUS GAMES

Serious games include mixed media/reality and virtual environments created to meet user needs, through an interactive and engaging environment [4]. The significance of serious games has increased rapidly in recent years, with

an inclination of technological aptitude, from people of all ages [4]. In any instance, when a video game purpose is learning rather than entertainment, it is typically referred to as digital game-based learning or serious games [2]. Serious games have become a growing market in the video games industry [4] as well as a field of academic research [5]. The serious games industry is constantly evolving to tailor user needs and is currently a multi-billion-dollar market [6], which uses video games, simulations, extended reality environments, and mixed reality/media as training and educational tools for a variety of industries such as military, healthcare, and aviation [7]. In response to the recent desire for serious games to be implemented as a new training and learning tool [8], we need to further understand the ability, advantages, and disadvantages of using serious games as an aid to learning. The aim of serious games being used as a teaching and training tool is not to replace classroom teaching, but to add an alternative option to help learners understand a subject in new ways [9]. Recent studies have shown that many students prefer to learn by doing, rather than listening and trying to take in information traditionally. One study published shows that “though students felt as if they learned more through traditional lectures, they actually learned more when taking part in classrooms that employed active-learning strategies” [8]. It has been demonstrated that serious games can simulate a variety of working conditions and scenarios while avoiding potentially dangerous situations and costly field training [10].

Recently, serious games have been compared and evaluated against written texts, regarding their ability to convey knowledge [9]. A primary advantage of serious games when compared to written texts is that serious games illustrate a virtual world that visualizes the subject matter and uses real-life situations in a learning environment. These components help the user to learn, remember and understand [10]. Serious games may enable students to bridge the gap between theory and practice. However, they are not without their concerns. Teachers can make learning engaging and interactive for the learner, but textbooks and printouts cannot [8]. Additionally, few studies have identified the negative aspects of utilising serious games, stating that exposure to high fidelity entertainment video games leads users to prefer serious games to be as visually realistic as possible [11]. As a result, when entertainment video game users hear the term “game”, it could create unrealistic expectations in the learners [12], resulting in negativity during gameplay. Serious games often refer to the use of game design approaches when designing and developing a game [13]. Examples of this include incorporating a rewards system into the game to improve player motivation and enjoyment.

IV. METHODOLOGY

Our methodology has two goals: 1) to ease the comparison of serious games versus traditional learning methods and 2) to provide a systematic way to assess the effectiveness of using serious games as a teaching and learning tool. To achieve these goals, our approach covers the complete process of creating a serious game (Figure 1).

The target audience for this project is construction-based learners. Their age, gender, and experience within the industry are not necessarily contributing factors, as low-energy building training must be delivered to all construction workers regardless of these demographics. However, it should be noted that a large number of the construction worker demographics in Ireland are males, with an average age of 42 [14], therefore, our primary target audience is made up of males, aged 35-50. Our secondary target audience is construction-based learners of any age.

This study applies a dual methodology process. One of the primary methodologies chosen for the design and development of this project was an iterative design process. Iterative design is an adaptive process, whereby designers move through multiple cycles of conceiving an idea, creating a prototype that embodies the idea, running playtests with the prototype to see the idea in action and then evaluating the results. Based on those results, changes and refinements are made. The game is currently nearing the end of the Create Prototype Stage (Stage 3, Figure 1) and, in the coming weeks, will enter the first round of testing. Whilst developing the game, individual playtests are being carried out regularly, with participants of the same demographic as the target audience. Individual playtests provide initial data collection regarding the functionality of the game mechanics, to allow for refinement before the official playtest session takes place with the group of construction-based learners.

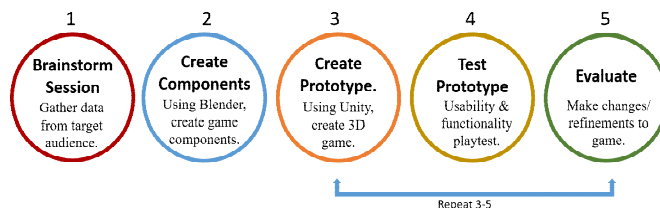


Figure 1. Iterative Design Process for Serious Game.

The second methodology chosen for the design and development of this project is a case study methodology. A case study was selected to determine the effectiveness, of using serious games to teach low-energy building principles and influence attitudinal change. At the end of the final playtest session, a set of two questionnaires will be presented to the participants. One questionnaire will focus on player demographics and personal details such as age, experience in the industry and experience with video games. The second questionnaire will gauge their knowledge and attitudes, related to the construction industry before and after gameplay. This method will allow the researcher to discover the success and failures of using serious games to teach construction-based learners low-energy building principles and allows comparison with current teaching and training methods.

The project in its entirety requires 3 sessions with our target audience. The initial fact-finding session, also referred to as Stage 1 (Figure 1), is used to determine the characteristics required for the game. Two additional playtest sessions will take place after game development.

These sessions will be used to assess the functionality and usability of the game and later will be used to test the success and failures of using serious games to teach low-energy building principles and their potential influence on attitudinal change within the industry.

Future studies in aid of this project, will test and evaluate the serious game with our target audience, to gather data regarding the effectiveness of using serious games to teach low-energy building principles and the potential impact of player attitudes. The playtest session, scheduled to take place towards the end of the project, will be evaluated by splitting the participant group in half. One half of the testing group will learn low-energy building principles using traditional methods, such as reading texts and attending a lecture. The other half of the participants will play the serious game with no additional help. This will enable the researcher to discover the possibilities of teaching low-energy building principles, using serious games over traditional methods. Both learning methods will be utilised, to try to deliver the same knowledge to all participants. Afterward, based on the data collected from the in-game data collection application and via questionnaires completed by the participants. User attitudes and knowledge obtained through the game can be measured and compared to prior knowledge and attitudes related to the construction industry.

The use of mixed-methods for the study will include, secondary analysis of existing literature and data and collection of primary quantitative and qualitative data. Proposed data collection tools to be used in aid of this study, are game testing sessions, an in-game data collection application, and participant questionnaires. The in-game data collection application tracks player data such as: how long the user spends in each level, interactions between characters, when a ‘help’ button is clicked and when a task is completed. Participants will be tested within the game in a variety of ways, these include, through decisions made by the user during gameplay, by having the player work through various scenarios within the game and through measuring player motivation and their desire to continue with the serious game. These methods of data collection have been chosen above others, as they are commonly used in game design and development. Previous studies, which have employed these tools have returned valuable results concerning serious game development and evaluation [8] [12]. These data collection tools, provide an opportunity to evaluate player responses in regards to the serious game. The use of these tools will ensure the game design and functionality meets the needs of the end-user and allows the research question to be answered.

A. Stage 1 – Brainstorm Session

An initial prototype design and development session, (‘brainstorming’) has been used as a way to connect with the target audience and discover their needs and wants regarding the serious game. The prototype design and development session took place, with a group of 8 male construction-based lecturers, aged 35-45. The participants have experience working and teaching in the area of low-energy

buildings and have contributed to the FES Learners Handbook. Their involvement within the construction industry greatly influenced the decision of what characteristics the game should include. Initially, questionnaires were distributed and data collected highlighted a clear vision of the type of interaction to be included within the game, which topics would benefit from a more hands on approach and what type of graphics (realistic/cartoon) would appeal. Through this interaction, the following results were collected:

1) The common areas, concepts, and skills that construction workers struggle most with are as follows: continuity of insulation, the effects of badly installed insulation, thermal bridging, effective airtightness and systems thinking (Figure 2).

2) Topics identified concerned Unit 3 of the QualiBuild Foundation Energy Skills Training Handbook (building fabric, air-tightness, and wind-tightness) (Figure 2).

3) It was decided a realistic narrative-based game would best suit our desired learning objectives. Through creating a narrative style serious game, the user can decide on the character they wish to be and can interact with the other characters within the game to give them a sense of perspective and empathy.

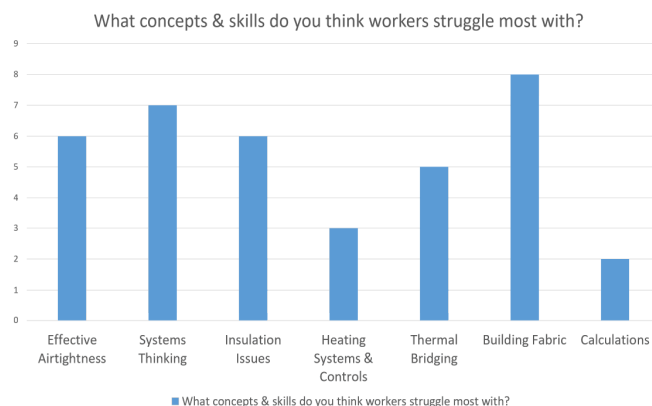


Figure 2. Results of Brainstorm Questionnaire

B. Stage 2 – Create Components

Through the collection of data, regarding areas that construction workers struggle with, it was made possible to determine the required learning outcomes for the serious game and to begin game design and development. Many elements within the game, were developed of which employ a multimodal approach to the presentation of course material, i.e., a combination of text, visuals, video, 2D drawings, and narration. A multimodal approach has been chosen as it creates a dynamic learning experience for the students. A multimodal approach was designed to help each student to achieve academic success in their way. Software and technologies were taken into consideration before the development of the game to ensure that it would be easily accessible and readily available for educational practitioners to continue using and adopting in the future.

C. Stage 3 – Create Prototype

Based on the data collected, the serious game prototype has been designed and is currently under development. The current game prototype allows the user to switch back and forth between first and third-person views and to interact and engage with different elements throughout the game (Figures 3 and 4). Examples of this include navigating and interacting with the 3D environment, entering the home, locating various documents and other interactive objects and engaging with family members within the home. The prototype allows the user to observe and interact with the learning objectives specified in section three of the FES Learners Handbook. The game enables the player to have interactive dialogues with other characters/ family members in the house, track user actions, allows the user to view the current score, hide and reveal window components such as walls, insulation, and cavities and locate problems from the pop-up checklist. It provides the user with an option to request help at any time by clicking on the ‘help’ button when clicked on, a pop-up builder appears to assist by filling in the knowledge gap required to continue with the game.

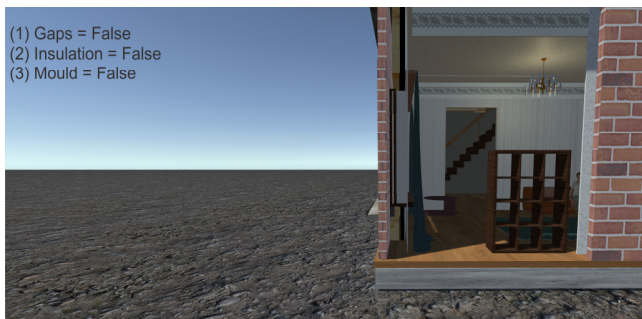


Figure 3. Gameplay First Person View



Figure 4. Gameplay Third Person View

V. FUTURE CHALLENGES

Stage four of the iterative design process for this project (Figure 1) will be held to collect and analyse data regarding the usability and functionality of the game. Using this data the game mechanics can be evaluated (Stage 5, Figure 1) and re-defined depending on the user experience and feedback. The next stage involves assessing future challenges, which

may occur during the testing stage of this study. Potential challenges for future studies include time management, to ensure the game has been adequately tested and is ready for the future study/ playtest with the target audience. Another potential challenge is incentivizing participation, there is a known obstacle of finding enough construction student participants to warrant a sound, evidence-based research project. A final, potential challenge is the experience and emotional responses, of participants using entertainment video games. If the participants are frequent video game users, they may find the game uninteresting compared to entertainment video games. However, if the user has no prior video game experience, it might prove difficult for them to grasp navigating and playing at first instance. This challenge has been anticipated by the developer and therefore a ‘walk through’ level at the beginning of the game has been incorporated, to help the user to navigate through the game and use command keys in an easy, non-treating environment.

VI. CONCLUSION

In conclusion, it has been shown in the literature that the significance of using serious games as training and educational tools has increased rapidly in recent years. Through reviewing current literature regarding serious games in different learning contexts, their potential effectiveness and how they are designed and developed, it is clear that serious games for teaching and educating are a valued pedagogical method. However, in order to implement game-based learning as a successful training and learning tool, there is a need to further understand the opportunities and constraints. Gaps within the literature include frameworks to transform traditional learning outcomes to game systems and data collection regarding the effectiveness of serious games in the construction sector and their relevance for effecting attitudinal change.

A serious game prototype has been designed and is currently being developed and tested using an iterative design process. An initial prototype design and development session has taken place and data collected throughout this session has been evaluated and analysed to discover the needs and wants, regarding the serious game design. Prior involvement of the brainstorm participants, within the construction industry, greatly influenced the decision of which characteristics should be included within the game. Through data collected via questionnaires, it was evident which interaction types are needed within the game. These characteristics include a narrative, a family living in the home, intractable characters and issues that need resolving. Results from this session also included, which topics would benefit from a more hands approach and what type of graphics would appeal.

The next stage of this project is to complete the working prototype and begin testing with a group of construction-based students to successfully discover the effectiveness of using serious games to teach construction workers low-energy building principles and their capacity for effecting attitudinal change within the industry.

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