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# Students @ play: serious games for learning in higher education.

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# STUDENTS @ PLAY: SERIOUS GAMES FOR LEARNING IN HIGHER EDUCATION

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## Abstract

The rise of digital games over recent years has been exponential. While many are used for entertainment, digital games have also begun to permeate education — which has lead to the coining of the term “serious games” [1].

Proponents of serious games argue that they hold enormous potential for learning [2], by embodying a range of pedagogical strategies. While some have adopted commercial games for use in the classroom, others have designed games specifically for educational purposes. However, designing complex and realistic serious games with limited budgets and resources is difficult. In addition, achieving a successful balance between the competing goals of teaching and entertaining is extremely challenging.

This paper describes a project undertaken at the Dublin Institute of Technology, which involved designing a serious game to teach food safety principles to undergraduates. The design strategy and process will be outlined, paying particular attention to the theoretical underpinnings of pedagogical design and game design. Results of initial pilots will be outlined.

The paper concludes by reflecting on lessons learned during the course of this project and by suggesting implications for the development and implementation of serious games in the wider Higher Education sector. Plans for future research in the area will also be detailed.

## Keywords
Serious games, education, situated learning, food safety

## 1. INTRODUCTION

The rise of digital games over recent years has been exponential. While many are used for entertainment, digital games have also begun to permeate education — which has lead to the coining of the term “serious games” [1].

Proponents of serious games argue that they hold enormous potential for learning [2][3]. Some games allow learners to acquire skills/competences in an engaging, interactive environment. More complex games, by embodying constructivist pedagogical strategies, allow learners to develop higher order skills. Many social games, for example massively multiplayer online games (MMOGs), allow players to become part of a community of practice which, some argue, is crucial for effective learning [4].

While some have adopted commercial games for use in the classroom [5][6], others have designed games specifically for educational purposes [7]. However, the latter option is not an easy one. Designing complex and realistic serious games with limited budgets and resources is difficult. In addition, achieving a successful balance between the competing goals of teaching and entertaining is extremely challenging.

This paper will present and discuss the findings of a project which involved designing and implementing a serious game to teach food safety principles to undergraduate Culinary Arts students. The paper will begin with a review of current literature on the use of serious games for learning. The

focus will then move to the Serious Gordon case study, with a description of how the gaming environment and the game play was designed and implemented for learning purposes. Results from initial evaluations of the project will be presented and analysed. The paper will conclude by reflecting on lessons learned and issues that emerged during this research project, discussing implications for the future of serious games for learning in Higher Education.

## 2. SERIOUS GAMES FOR LEARNING – A REVIEW OF THE LITERATURE

Although games have been used for purposes other than entertainment, in particular education, for a long time, the modern serious games movement is distinguished from these by the level of sophistication of its games. The current generation of serious games is comparable with mainstream digital games in terms of production quality and sophistication of design.

The emergence of the modern serious games movement can be traced back 2002 with the release of America's Army (www.americasarmy.com). Inspired by the realism of commercial games such as the Rainbow 6 series (www.rainbow6.com) the United States military developed America's Army and released it free of charge in order to give potential recruits a flavour of army life. The game was hugely successful and is still being used today as both a recruitment device and as an internal training tool [8]. Other examples from the serious game movement include Hazmat Hotzone (http://www.etc.cmu.edu/projects/hazmat_2005/), design to train fire-fighters to deal with chemical and hazardous material emergencies; and Yourself!Fitness (www.yourselffitness.com), an interactive virtual personal trainer.

Proponents of the use of serious games for learning argue that they hold enormous potential for learning [2][3][9]. It is argued that the multi-sensory environment offered by virtual gaming worlds caters for multiple learning styles or intelligences [10]. Research has also shown that, depending on their game design, serious games have the potential to facilitate different types of learning. In situations where learners need to acquire a skill or competence, it is argued that games can improve information retention because of the extensive opportunities afforded for drill and practice (where learners master skills or information through repetitive practice) [11]. The microworlds of games also allow educators to create learning activities that may be too dangerous or costly to replicate in the classroom [12]. In a gaming environment, students can for example, "blow" electrical circuits or mix lethal chemicals and observe the results. In many cases such gaming environments also provide strong scaffolding through implicit assessment and continuous feedback.

Such games can be seen to embody the principles of behaviourist learning theories — which focus on the measurable behavioural outcomes of learning [13]. However it is also argued that games hold considerable potential for developing higher order cognitive skills such as critical thinking, problem-solving, decision-making and collaborative social skills [3]. In addition, some empirical evidence shows that games can be effective tools for enhancing learning and understanding of complex subject matter [14]. Such games achieve this by embodying various pedagogical strategies including experiential learning [15], problem-based learning [16] and situated learning [4] in a constructivist learning environment.

Virtual reality games, where students are immersed in a virtual world and assume a specific role within that world, illustrate this. One such example is a video game called "Peacemaker" (www.peacemakergame.com), developed by a team at the Carnegie Mellon University in Pittsburgh. Designed to "teach peace in the Middle East" [17], this one-player game immerses the player in a complex and highly sensitive political situation where the player assumes the role of the Israeli prime minister or the Palestinian president. Within their role, the player must act and react to various events in order to establish a stable resolution to the conflict before his or her term of office is up.

Games such as these can be seen to embody a range of constructivist pedagogical strategies where are highly effective in facilitating learning. By immersing the player in a virtual world with its own political and social systems, the game creates an authentic meaningful context for learning to take place — that is it facilitates "situated learning" [4]. Such games also facilitate problem-based learning — where students actively construct knowledge through a process of information-seeking, analysis

and problem solving — a strategy which many studies have shown to have positive results for student learning.

Game playing — both single and multi-player — is often highly social. Many games have player communities which interact on a social level — both within the game and also via websites, discussion boards, blogs and wikis —- to discuss strategies and share tips for progressing further in the game — a process sometimes called "meta-gaming" [18]. This collaborative process further reinforces the social constructivist element of game playing — and the extensive opportunities for collaborative knowledge building. This social aspect of gaming is brought to a new level with the recent generation of massively multiplayer online games (MMOGs) and virtual worlds. One example is Second Life (www.secondlife.com) — a virtual world which increasing numbers of educators are exploring as an educational tool [19][20][21].

In addition to embodying a range of pedagogical strategies, one of the most pertinent features of games is their ability to motivate and engage, or their "holding power" [22]. The potential of digital games to engage players another key reason why researchers and educators have begin to show increasing interest in their potential for enhancing learning. Various studies have demonstrated that the use of games in a learning context can increase student motivation to learn [12]. This is sometimes reinforced by a sense of competition among players and consequent status within the game-playing community. Prensky (2001) recounts how the appeal of digital games for learning lies in their ability to motivate players and thus pull the player into the learning process without them realising it [9]. Prensky (2001) even suggests that games can be used to teach content that is not, in itself, intrinsically motivating — as the game features provide the motivational context.

Thus while games may have the potential to facilitate learning, not all results are positive. It is often claimed that much of the so-called edutainment software results in nothing more than boring games incorporating "drill and kill" learning [23]. Some argue that this is due to the fact that such games have been designed by academics who do not have a true understanding of the science and art of game design [24]. Similarly, it is claimed that educational games that are designed solely by gamers are more likely to fail as educational tools [3]. The answer, it is argued is "not to privilege one arena over the other but to find the synergy between pedagogy and engagement" — a challenging, and often difficult, task [3].

The section that follows details a project which aimed to fulfil these objectives of marrying pedagogy and engagement within a serious gaming environment.

## 3. THE SERIOUS GORDON CASE STUDY

### 3.1. Food safety in the kitchen — learning outcomes and underpinning theoretical frameworks

For workers in the food industry, food safety and environmental health education is of critical importance, and is in fact a legal requirement [25]. Thus in all third level programmes which prepare students for a career in this field, food safety education forms a key part of the curriculum. Likewise all related professional development training must include a food safety education component.

When beginning any curriculum design process it is recommended to establish a set of learning outcomes at the outset which will guide the design process [26]. Thus before embarking on the design process of Serious Gordon, a set of nine learning outcomes was first identified. Adopted from the Food Safety Authority of Ireland (2006) *Guide to Food safety training: Induction Skills (food service, retailers and manufacturing sectors* [25] these nine objectives were as follows:

1. Wear and maintain uniform/protective clothing hygienically
2. Maintain a high standard of hand-washing
3. Maintain a high standard of personal hygiene
4. Demonstrate correct hygiene practice if suffering from ailments/illnesses that may affect the safety of food

5. Avoid unhygienic practices in a food operation
6. Demonstrate safe food handling practices
7. Maintain staff facilities in a hygienic condition
8. Obey food safety signs
9. Keep work areas clean

These learning outcomes provided an important insight into the types of learning and skills development that the game needed to facilitate — which in turn determined the instructional and game design strategy employed.

Firstly it was important that students achieve longer term *retention* and *understanding* of the subject matter. Short-term retention is undesirable as food safety principles will be underpin of the successful careers of these students. In addition, *transfe*r of information and skills is important. Students must be able to apply their learning within the game to other situations not covered in the original learning context [24]. Secondly, it is important to note that a grasp of the *theory* of food safety and associated practices — or the "know what" — is insufficient in this context. Students must be able to *apply* these theoretical constructs in real-life practice — the "know-how". Thus problem-solving skills were an important goal.

Considering these goals, a variety of pedagogical models were eclectically drawn from in this study, including situated cognition/cognitive apprenticeship and problem-based learning. Based on these pedagogical theories, a high fidelity simulation/virtual reality approach was adopted as the game design strategy. The section that follows details how we aimed to facilitate the development of these competences through the game design.

## 3.2. Game design

### 3.2.1. Conceptualisation

As recommended by professional game designers, the first stage in the design process was to finalise the game concept [27]. This involved making decisions on fundamental design factors such as game genre and perspective, the player's role, game world, game narrative and challenges. In accordance with the educational underpinnings of the game, modes of scaffolding the learner/player were also decided at this stage.

As mentioned previously, this game was underpinned by theoretical perspectives including situated learning, problem based learning and motivation theory. To facilitate an immersive learning environment it was decided that a "representational" gaming environment — which aims to simulate as accurately as possible the real-life environment- was appropriate [27]. This immersive realistic experience is further enhanced by a first person visual perspective, in single player mode.

So that the game achieved each of the learning outcomes (as specified previously), the game narrative was designed around these. Thus the broad narrative structure is as follows: the player begins as a kitchen porter arriving at a restaurant for their first day at work. Over the course of the game, the player must negotiate various tasks (each of which relate back to the aforementioned learning objectives). In order to accommodate the nine learning objectives in a realistic manner, the player's role changes during the course of the game. For example, the player begins by negotiating tasks as a kitchen porter. When they progress to the next stage of the game, they become a commis chef with associated tasks and responsibilities. In order to provide a clear route through the game, a head chef character accompanies the player throughout, giving instructions and feedback. This character also provides key support and feedback, thus facilitating important learner "scaffolding" throughout.

### 3.2.2. Elaboration

Alter deciding on general game concepts, the game play and associated factors were detailed through the elaboration stage. At this stage, all details of game play were documented in a very specific and

elaborate storyboard which was developed collaboratively by both game designers and developers. This detailed documentation proved vital for all team members as the project progressed, particularly the game developers.

The first stage in the game elaboration was to design the game space or “level”. In order to make the game environment as realistic as possible, the level design is based on a set of real kitchen plans shown in Figure 1. However the notion of “virtual fidelity” — a concept which suggests that simulations need only remain true to the real world in so much as this enhances the experience of the user – was also adhered to. Thus in order to avoid player claustrophobia — which sometimes results from being confined to small virtual spaces - the level design of Serious Gordon incorporates a larger amount of empty space than world normally be found in a real life kitchen. Similarly, great lengths were gone to in order to make the game environment appear to stretch beyond the boundaries of the restaurant, and yet at the same time coral the player within the smaller space without their noticing. It has been shown that this approach to game design aids immersion in that the player believes themselves to be part of a larger world.

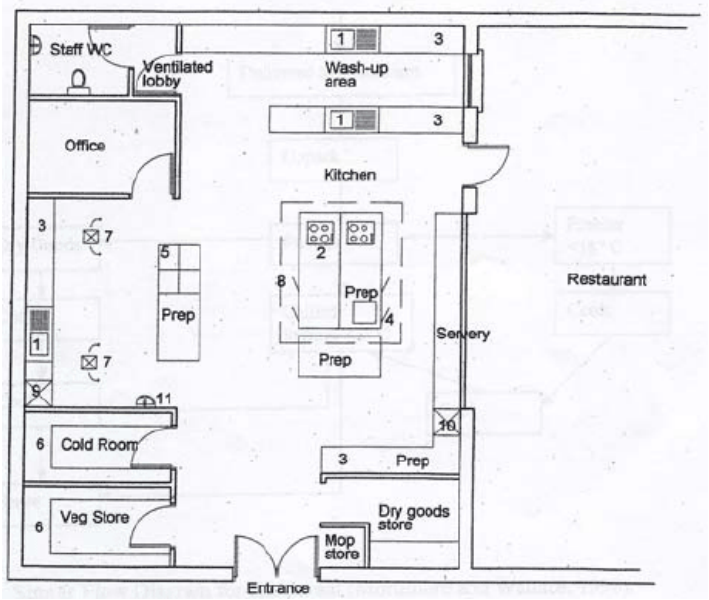


Figure 1. The floor plan on which the kitchen of Serious Gordon is based.

The game play — all aspects of narrative, player challenges and actions [28] — was then detailed. As mentioned previously, in order to realise the educational objectives of the game, each challenge relates to an aforementioned learning outcome. When designing these challenges various factors were considered. Firstly, with the game design literature, it is widely recognised that in order to maintain player motivation, engagement and “flow” [29], the game must present sufficient and balanced levels of challenge [28]. That is, the game should be neither too easy (or engagement may be reduced), nor too difficult (or frustration may ensue). Likewise as the player improves the challenges should increase appropriately. Thus the game begins with easier tasks, with higher levels of scaffolding. As the player progresses, the tasks become more challenging.

In accordance with the principles of cognitive apprenticeship and situated learning, scaffolding is also provided throughout the game [30]. This is provided through pop up windows — which are associated with various artefacts in the game, and which provide useful additional information and tips. As previously mentioned, the other avatars in the game environment also provide support, particularly the head chef, who accompanies the player throughout the game and provides auditory feedback.

## 3.3. GAME DEVELOPMENT

The development team on Serious Gordon consisted of two developers who worked full-time on the project over a period of ten weeks as part of a student internship. This small team was supported by experts in computer science and games development. Due to the scale of the project and the time

constraints involved, it was established at an early stage that the development of a complete game engine would not be feasible. Thus an existing game engine was used to create the game. After investigating a number of options, Valve's Software Source Engine (www.valvesoftware.com) developed to create Valve's Half Life 2 (www.halflife2.com) was selected. The Source Engine has a number of compelling features which include highly realistic physics modelling, the capacity for sophisticated scripting and the existence of an active and helpful community of professional and amateur developers. The challenge in using the Source Engine was that it was designed for developing a game so different to Serious Gordon that it was unclear if it could be successfully turned to this new purpose. A screenshot of Half Life 2 is shown in Figure 2 to illustrate this point.

Figure 2. A screen shot from Half Life 2, for which the Source Engine was developed.

With the engine agreed upon, the developers set about creating a series of proof-of-concept scenarios in order to experiment with the requirements of each learning task set out in the storyboard. This was an extremely useful stage in the development as it highlighted aspects of the Source Engine which would need to work in order to turn it to the task of developing an educational game. As each proof-of-concept scenario was developed, the project team met to determine how well the scenario matched the stated learning outcomes. In this way a cycle of hypothesis formulation, testing and revision was adhered to [3].

After the proof-of-concept development phase was complete, focus switched to developing the complete game. Serious Gordon is essentially script driven, with the head chef avatar leading the player through a series of learning tasks and responding to the player's efforts to complete these tasks. Again, throughout the development of the full game, the hypothesise-test-revise cycle was used in order to ensure that, while achieving the specified learning outcomes, the game remained playable and engaging.

The choice of Valve's Source Engine put a range of invaluable tools in the hands of Serious Gordon's development team. The most important of these was the Hammer editor which is used to develop the games environment and to add all of the scripting to this environment. Hammer allows developers to relatively easily create sophisticated virtual worlds, fill these with authentic objects and populate them with characters that react to the actions of the player.

While the Hammer editor proved an extremely useful tool, it was not without its problems. The first of these was that the assets pre-packaged with the editor are those used in Half-Life 2 and so were much too grimy and industrial for use in the modern restaurant environment required for Serious Gordon. This meant that a range of custom textures and objects had to be Developer which put a considerable burden on the small development team. Secondly the level of scripting required by Serious Gordon, and the free-flow nature of some of its scenarios, pushed the scripting capabilities of the Hammer editor to their limits which caused some further development difficulties.

The second tool used heavily in the development of Serious Gordon was Valve's FacePoser, a tool used to choreograph game sequences that control facial expressions, lip synching and body gestures.

Although FacePoser proved a somewhat unreliable tool, the results possible with it lend a great deal of realism to the game's characters.

As well as using the Source Engine development tools, a number of major additions were also made to the functionality of the engine itself, which involved making changes to the engine's code base. The first of these was the addition of an inventory system. The Source Engine does not have the capacity for players to pick up objects and give them to other characters in the manner that was required in Serious Gordon, so this had to be built into the engine. The functionality developed was used in scenarios where the player had to retrieve specific objects for the chef and for a clothing system introduced through which the player could chose to wear clothes appropriate to their current tasks.

The second major addition to the Source Engine was a change to the interface system in order to allow players to perform puzzle-based interactions. An example of this is a game sequence in which the player has to wash their hands correctly before entering the kitchen. In this scenario, after choosing to interact with a sink object, players are shown a dialogue box indicating that the available actions (shown on buttons) are to wet their hands, use the soap and dry their hands. Only by indicating the correct sequence of tasks, can the player successfully complete the tasks and proceed through the game.

This addition to the Source Engine was developed in such a way that the available set of options and the consequences of certain sequences of choices by a player could all be defined in a simple data file making the technique easily extensible. The addition of simple puzzles made some learning scenarios extremely easy to implement in a way that players, particularly those unfamiliar with games, could easily understand.

In spite of the difficulties in turning the Source Engine to a purpose leagues apart from that for which it was originally designed, from a technical perspective, the development of Serious Gordon was, on the whole, a successful endeavour.

## 4. EVALUATION

Initial evaluations have been carried out which aimed to evaluate the game from a technical and pedagogical perspective. To this end, a small focus group of ten participants was selected, each with varying levels of experience using serious games. Before playing the game, participants were asked to complete a questionnaire which aimed to determine (a) their previous experience of using games/serious games and (b) their prior knowledge of food safety and the nine induction skills listed in [25].

After an initial brief orientation session, participants were asked to play the game from start to finish. On completion of the game, participants were asked to complete a final questionnaire/test which aimed to evaluate (a) the participant's experience of using the game — e.g. did they find it difficult to navigate or confusing? — and (b) how many of the learning outcomes had been achieved by the participant as a result of playing the game.

These initial evaluations of the game proved highly positive. Technically, users found the game easy to navigate and control — orientation information provided alongside the game proved very helpful in this regard.

Pedagogically, the game proved successful in its aim of teaching learners induction skills required as part of food safety training [6]. Participants' responses showed that they had acquired much of the knowledge and skills as listed in the learning outcomes for the game. In addition, participants found the game a much more stimulating and motivating environment in which to learn skills which were normally taught through the use of text books. This correlates with the experiences of other educators using serious games as part of the education process [31].

It is intended that further, more comprehensive, evaluations will take place during the coming months. These will take place with first year students in culinary arts programmes at DIT (the original target audience of Serious Gordon), with the game being offered in the future to other students, including part-time students working as full-time employees in the food and hospitality industry. It is hoped that through these evaluations, significant feedback will be obtained which will allow the development team to further develop and refine the learning environment of Serious Gordon.

## 5. CONCLUSION

It is argued that serious games hold enormous potential for learning [2], allowing learners acquire skills in an engaging, interactive environment. The major challenge in developing serious games is "to find the synergy between pedagogy and engagement" [3]. This paper has described the development of Serious Gordon, which we believe succeeds in finding this synergy.

Serious Gordon sets out to teach the rudiments of food safety to undergraduate Culinary Arts students by immersing them in a virtual kitchen environment and by allowing them to play the role of a newly employed kitchen porter on their first day at work. Initial evaluations have shown that students not only achieve the learning outcomes expected, but also enjoy an engaging experience.

There are two major strands through which it is planned to continue the work started with Serious Gordon. The first of these is to perform a visual overhaul of the game environment. One of the challenges in using Valve's Source engine was that the engine's art assets are geared towards a grimy sci-fi environment, which does not translate well to a contemporary kitchen. Due to the size of the development team on Serious Gordon it was not possible to change the look of the game to the extent desired, so a second phase of the project will see a team of modelers and artists hired to develop custom assets for the game. The second major piece of work which is planned is a formal, large-scale evaluation of the system. In summary it is envisaged that Serious Gordon will constitute the first stage in what will become a larger, and continually evolving games development and

educational research project — allowing those involved to make a valuable contribution to knowledge and development in the rapidly expanding arena of serious games.

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