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Cross-Disciplinary Approaches for Developing Serious Games in Higher Education: Frameworks for Food Safety and Environmental Health Education

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Cross-disciplinary approaches for developing serious games in Higher Education

Frameworks for Food Safety and Environmental Health Education

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Abstract— **While some educators have adopted commercial off-the-shelf games for use in the classroom, such games may not always meet the individual requirements of lecturers whose courses are tied to specific learning outcomes. An alternative is to capitalise on in-house expertise in Higher Education and create serious games through cross-disciplinary team projects. This paper outlines such a project within one Higher Education institution. It describes synergies created across disciplines as a result of the collaboration on game design and implementation. It looks at tensions generated between the pedagogical requirements (of lecturers), entertainment objectives (of games designers) and technical excellence (sought by developers). Additionally, this paper looks at two serious games designed within this framework. Through reflections on the process and the product, this paper examines whether the collaborative process adopted within a Higher Education context can generate a product good enough to sit beside professionally designed games.**

Keywords- serious games; design; food safety; environmental health; Higher education

I. INTRODUCTION

The emergence of the modern serious games movement can be traced to various factors including the increasing permeation of digital gaming into leisure activities, the development of highly sophisticated gaming technologies supported by internet-based communities and increasing research activity supporting claims that games have the potential to facilitate various types of learning and skills development. While some educators have adopted commercial off-the-shelf games for use in the classroom [1], such games may not always meet the individual requirements of lecturers. An alternative is to create bespoke games for specific learning requirements. However, this can be time-consuming and costly. An alternative is to capitalise on in-house expertise within Higher Education institutions.

This paper outlines a cross-disciplinary approach to designing and developing serious games within Higher Education. It describes the synergies created across disciplines as a result of the collaboration on game design and implementation. It looks at the tensions generated between the pedagogical requirements of the lecturer the technical excellence sought by the developer. Additionally, this paper looks at the games designed within this context, outlining two approaches to serious games design for the food safety sector. Through reflections on the process and the product of serious game design within this study, this paper examines whether the collaborative process adopted within a Higher Education context can generate a product good enough to sit beside professionally designed games, which can adequately engage the learner, and which can satisfy the pedagogical requirements of the lecturer.

II. THE EMERGING FIELD OF SERIOUS GAMES

The term serious games [2] refers to games designed to do more than just entertain. Rather, serious games have ulterior motives such as teaching, training, and marketing. Although games have been used for ends apart from entertainment for a long time, the modern serious games movement is distinguished by the level of sophistication of the games it creates. The current generation of serious games is comparable with main-stream games in terms of the quality of production and sophistication of their design.

The modern serious games movement can be said to have begun with the release of America's Army[1] in 2002 [3]. Inspired by the realism of commercial games such as the Rainbow 6 series[2] 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. Spurred on by the success of America's Army the serious games movement began to grow, particularly within academia. Other offerings in the serious games field include Food Force[3] a game developed by the United Nations World Food Programme in order to promote awareness of the issues surrounding emergency food aid; Hazmat Hotzone, developed by the Entertainment Technology Center at Carnegie Mellon University to train fire-fighters to deal with chemical and hazardous materials emergencies.

Education still holds the greatest potential for serious games, with proponents of their use arguing that they hold enormous potential as learning tools [4]-[6]. On one level games can be seen as embodying behaviourist learning principles — where learners acquire and practice a range of skills and competencies while receiving regular feedback in an engaging, interactive and safe environment. On another level, more complex games allow learners to develop higher order skills in a constructivist learning environment by embodying

[1] www.americasarmy.com
[2] www.rainbow6.com
[3] www.food-force.com

various pedagogical strategies including experiential learning [7], problem-based learning [8] and situated learning [9]. In addition, the more recent generation of massively multiplayer online games (MMOGs) are highly social, allowing players to experiment with new identities, develop social skills and experience effective (and often ineffective) social practices in a range of political, social and cultural environments. In essence they allow players to become part of a community of practice, which according to Lave and Wenger [9] is crucial for effective learning.

To date, two of the most common approaches used to integrate serious games into Higher Education contexts include (a) adopting commercial off-the-shelf games for educational purposes and (b) designing a serious game for a particular learning context. While there are advantages and restrictions to both approaches, the latter approach is still relatively under-explored in the field mainly due to time and cost constraints. However, considering the significant multi-disciplinary expertise already residing within Higher Education institutions, it could be argued that the potential for harnessing such expertise in Higher Education is still largely untapped. This paper explores this untapped potential by presenting and analysing two serious games projects undertaken by a multi-disciplinary (student and lecturer) team within one Higher Education institution.

III. Case Studies

A. Setting the Context: Food Safety and Environmental Health in Higher Education

For workers in the food industry, food safety and environmental health education is a legal requirement [10]. Thus in all third level programmes which prepare students for a career in this field, food safety and environmental health education forms a key part of the curriculum. Within the Dublin Institute of Technology (DIT), current teaching and learning approaches within food safety and environmental health education conform largely to traditional teaching methods (lectures, hard copy handouts, group tutorials.) eLearning is also being used by increasing numbers of lecturers, supported by field trips where students have the opportunity to visit commercial premises to witness food safety practices first-hand. While these established teaching and learning approaches have been used for many years, they also have limitations. With food safety and environmental health education, it is considered paramount that students not only acquire the conceptual knowledge of the area: they must also be able to apply this knowledge in real-life, authentic, situations. In the real world, graduate students are expected to be able to adhere to food safety guidelines in their own practice, assess potential hazards in an environment and prioritise recommendations based on their environmental risk analysis: thus practice in observing and analysing such hazards correctly is essential. While practical classes and field trips to commercial premises aim to facilitate this, they also present limitations.

- It is rarely possible to gain access to those organizations who do not routinely carry out best practice. Yet this is often the time and place when students would learn most. In addition, if access is granted to a food premises with a dubious hygiene history, the chances of observing serious hygiene problems is minimised as the "Hawthorne Effect" ensures they are adhering to best work practices while under scrutiny.
- The inherently noisy nature of most food processing operations limits the opportunities for student-lecturer interaction on the factory floor.
- Many processes are enclosed for the microbiological and physical safety of the products and the physical safety of operatives, so little can be seen in practice.

For these reasons, and after considerable research and reflection, it was decided that serious games and the virtual worlds that serious games offer may represent a potential solution. In essence, they offer extensive opportunities for situated learning [9], which is required in this educational context, without the barriers of access that would occur in the real world.

B. A cross-disciplinary model for developing serious games in Higher Education

At the DIT, the adoption and promotion of learning technologies has been part of an institutional strategy since 2001. The formation of an eLearning support team at that time, with expertise in instructional design and technical know-how, has allowed for the adoption of mainstream technologies into the teaching and learning practices: currently, use of the virtual learning environment exceeds use of all other software at the institute. It was the need to move beyond the constraints of such platforms, however, that prompted the initial collaboration on serious games: when the head of eLearning support was approached in 2005 by a food-science lecturer about the viability of producing a simulation to teach food safety to first-year undergraduates, it became clear that there was an opportunity to explore new pedagogies as well as to produce materials that went beyond the mainstream of eLearning on campus. Lacking expertise in game design, but aware that undergraduate students within the school of computing were being offered such an option, an approach was made to lecturers within the school of computing (an overlap with the work of the digital media centre subsequently became evident). Drawing on unspent funds from a budget established in 2001 to support specific eLearning projects, the idea was that students from the games-design programme could be employed during the summer to work on games development with eLearning support and the relevant lecturer to see whether it might be possible to produce a credible game which could be used to teach the principles of food safety. It was envisaged that such a tack would give the undergraduate computer-science students the experience of working on a real-world project, while giving undergraduates on the food science programme an opportunity to learn in a way that might prove more engaging than traditional methodologies. It also would give members of the learning technology team and lecturers from food science an opportunity to work in game development from the ground up, helping them to understand the process and to get some grasp on pedagogies underpinning game design. In this way, it was hoped that the initial pilot

would create synergies at all levels which could lead to a sustainable model of in-house game development, and which could be adopted and adapted across different disciplines into the future.

C. *Project 1: Serious Gordon*

The first serious games project — entitled Serious Gordon — was undertaken during the summer of 2006. In accordance with curriculum design guidelines, before embarking on the design process, a set of nine learning outcomes was identified [11]. Adopted from the Food Safety Authority of Ireland Guide to Food safety training [10] these were as follows:

- Wear and maintain uniform/protective clothing hygienically.
- Maintain a high standard of hand-washing.
- Maintain a high standard of personal hygiene.
- Demonstrate correct hygiene practice if suffering from ailments/illnesses that may affect the safety of food.
- Avoid unhygienic practices in a food operation.
- Demonstrate safe food handling practices.
- Maintain staff facilities in a hygienic condition.
- Obey food safety signs.
- Keep work areas clean.

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

As recommended by professional game designers, the first stage in the design process was to finalise the game concept [12]. This involved making decisions on fundamental design factors such as game genre and perspective, the player's role, game world, game narrative and challenge. Modes of scaffolding the learner/player were also decided. To facilitate an immersive learning environment a "representational" gaming environment, which aims to simulate as accurately as possible the real-life environment, was selected [12]. This immersive realistic experience is further enhanced by a first person visual perspective in single player mode. The game narrative was designed around the learning objectives: 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 learning objectives). In order to accommodate the nine 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.

The development team consisted of two undergraduate computer science students 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 — Valve's Software Source Engine[4] developed to create Valve's Half Life 2[5] — was selected. The choice of Valve's Source Engine put a range of invaluable tools in the hands of the development team, including highly realistic physics modelling, the capacity for sophisticated scripting and the existence of an active and helpful community of professional and amateur developers. However, while extremely beneficial, the use of the Source engine was not without its problems. Firstly, the assets available were much too grimy and industrial for use in the modern restaurant environment required for Serious Gordon. This meant that a range of photo-realistic custom assets had to be developed, which put a considerable burden on the development team. Secondly, the level of scripting required by Serious Gordon, and the free-flow nature of some of its scenarios, pushed the capabilities of the Source engine development tools to their limits. In fact a number of major additions were made to the functionality of the Source engine itself by the Serious Gordon team in order to make it fit for purpose.

In spite of these difficulties an impressive prototype was created by the team. (A video of Serious Gordon can be viewed at http://www.seriousgames.ie or http://www.youtube.com/watch?v=zwKY6nbG6gU). To evaluate the effectiveness of Serious Gordon as both a motivational and a pedagogical tool an evaluation study was undertaken with a focus group of undergraduate students, of mixed gender and with varying levels of game-playing experience. Results of this evaluation were mixed. Pedagogically, the game showed potential as an effective learning aid with students reported an increase in their awareness of certain food safety concepts. The majority found the game a more stimulating and motivating environment in which to learn skills normally taught through text books. However it was notable that a small minority (mainly male "gamers") were not in favour of using games as part of college learning requirements, preferring to reserve such activities for their leisure time. On a negative note, participants without game-playing experience found Serious Gordon difficult, and in some cases frustrating, to play. Many had particular difficulty with the control scheme used (which was inherited from Half-Life 2) and found the game environment difficult to navigate. This is particularly interesting as the pedagogically-inspired drive to make the game experience as realistic as possible created the requirement for a sophisticated control scheme which was a barrier to an engaging learning experience for some players.

[4] www.valvesoftware.com
[5] www.halflife2.com

D. *Project 2: Contamin8*

The second serious games project — Contamin8 — was undertaken within a similar multi-disciplinary team model during the summer of 2007. Many of the lessons learned during Serious Gordon informed all aspects of Contamin8, including the pedagogical approach, the design approach and the technological platforms adopted.

From a pedagogical perspective, like Serious Gordon. Contamin8 also aims to teach the key principles of kitchen food safety. Drawing from the same content material [10] but recognising that a more limited number of learning outcomes may be feasible within the confines of the project, five learning objectives of Contamin8 were identified. It was envisaged that players should be able to:

- Achieve a high frequency of hand washing.
- Promote good practice by cleaning as they work.
- Avoid unhygienic practices.
- Recognise how food can be put at risk by microbiological hazards.
- Prevent cross contamination from raw to cooked foods and food contact surfaces.

In contrast to the three-dimensional immersive approach adopted by Serious Gordon, Contamin8 was developed as a simpler two-dimensional "click and drag" game, more in tune with the style of casual gaming [13]. Drawing from the lessons of Serious Gordon, this less complex approach was adopted to ensure enhanced usability and accessibility, and as a result, increased engagement and pedagogical effectiveness among all users.

Players are put in the role of a restaurant chef who must prepare orders (in accordance with acceptable practice) as they come in to the kitchen. Players increase their score each time they successfully complete an order. Players also gain points by minimising or preventing contamination — this is achieved by selecting the correct utensils and washing them at appropriate times, by maintaining correct storage and by adhering to recommended hand-washing practices. In order to increase motivation and challenge, players must complete each order within a specific time limit. In correlation with casual game design, Contamin8 presents a simple uncluttered two-dimensional user interface. The game is easy to navigate using a simple "click and drag" functionality to complete all tasks. Game play is based on the repetition of tasks (or the preparation of orders) — from a pedagogical perspective this allows players to learn from practice and re-iteration. From a game-design perspective, it correlates with casual game design principles which recommend "more of the same" in order to achieve additional hours of game play [13].

From a technical perspective, Contamin8 was developed by two undergraduate computer science students who assumed the roles of programmer and graphic designer. Learning from the difficulties encountered in Serious Gordon, the graphic designer role was crucial to the project, enabling the production of enhanced graphics based on locally available kitchen equipment. The platform used for Contamin8 was Playfirst.com's Software Development Kit called Playground. This platform was selected because it provided a rich variety of tools with which to build Contamin8. Additionally, as the underpinning platform to the hugely successful casual game Diner Dash, it was considered appropriate for the current project considering the design and thematic similarities between both games. The game was coded in C++ and LUA and game assets were created using Adobe Photoshop, Adobe Illustrator and Adobe Flash CS3.

A video of Contamin8 showing game interactions can be viewed at http://www.seriousgames.ie or http://www.youtube.com/watch?v=gsa-YFZRQ_0). With regard to evaluation of Contamin8, pilots are currently being arranged with undergraduate students groups. Results of these evaluations will be published in due course.

IV. Findings and Reflections

Post-project, various reflections can gleaned from the experience of using a cross-disciplinary team approach to develop serious games within a Higher Education context. With regard to the potential of such multi-disciplinary collaboration for serious games design, various lessons have been learned and insights gained. The team for both projects drew from a variety of pertinent disciplines — food safety, computer science, elearning and digital media. The merging of staff and students from such a variety of complimentary disciplines provided a rich and fertile foundation for the projects. However, because team members were coming from very different subject backgrounds, with different expertise and expectations, it also meant that at times communicating design ideas and reconciling contrasting notions of the game was difficult. In order to overcome such barriers, various strategies proved helpful in this context.

Firstly, weekly meetings of all team members created a focal point for the project's development and ensured momentum was maintained. As team members were scattered across various institutional faculties and engaged in other full-time work, it also served as an important forum where ideas could be brainstormed and re-evaluated based on the previous week's progress and weekly goals re-determined. In addition, weekly meetings became an important forum where all team members were updated by developers on the game's progress. As an additional method of keeping all team members up-to-date with progress, the developers on both projects also kept blogs.[6] These were useful, functioning as an information disseminator during the project, and providing a valuable insight into the design and development process post-project.

The rapid prototyping design approach used in both projects also proved to be crucial within the interdisciplinary team. Because members of the team were coming from different academic backgrounds, levels of experience and knowledge in game design, development, and pedagogy varied greatly. Rapid prototyping allowed the developers to create prototypes of the game at weekly stages, based on the previous weeks' discussions. This enabled all team members to envisage

[6] These can be viewed at http://seriousgordon.blogspot.com and http://contamin8.blogspot.com.

more clearly what direction the game was taking and if it fitted with their preconceived ideas and frameworks for the game.

On the negative side, firstly the absence of a graphics designer on Serious Gordon proved to be a major hindrance to the game development. Learning from this, the graphics designer role was deemed as essential when recruiting student developers for Contamin8. Secondly, at times during each project tensions arose between the technical aims and pedagogical agendas of different team members. For example, in Serious Gordon, the technical aim of using a commercial engine to develop the game had serious implications for both the usability and design of the game. Likewise, tensions arose between the game design features desired by developers (who were themselves gamers) and the pedagogical requirements of the lecturers. Serious Gordon provides an example: throughout the development of the game the developers were focused solely on the functionality of the game, including the production of highly realistic visual effects. The lecturer, while also concerned with the realism of the environment, was more focused on the educational "lessons" and content underpinning the game. With this focus on education, functionality and highly realistic effects, it was not until the game was evaluated by a lecturer external to the team that a fundamental graphical problem was identified — the inappropriateness of the grimy graphics (of Half Life 2) for a hygienic kitchen environment. This identification led to significant graphical amendments by an additional team member after the initial project had finished.

With regard to the game design, two contrasting approaches were used for both projects. While Serious Gordon was based on a complex three-dimensional immersive game, Contamin8 was underpinned by a simpler two-dimensional casual gaming style. The decision to switch to casual gaming style was a conscious one, informed by various findings. Firstly, developing complex immersive games in a Higher Education context within a limited time-frame is difficult. Considering time and cost limitations, it was felt that developing a simpler style game was more achievable. Secondly the evaluation findings of Serious Gordon showed that many students (non-gamers in particular) had difficulty navigating the game and using the game controls. Unsurprisingly, students that demonstrated least difficulty were those who were either gamers or who had used played Half Life 2 previously. Thus it was felt that creating a simpler game with basic navigation and controls would enhance usability and accessibility for all students. Thirdly, using the source engine Valve for Serious Gordon presented accessibility problems which needed to be resolved at an institutional level. Because of the platform and technologies used, certain software — the Steam games platform and the games Half Life 2 and Counter Strike Source — had to be installed on a PC before the game could be accessed. However at the DIT (as in many Higher Education institutions) such platforms are not permitted on institution PCs. In order to overcome such accessibility barriers in future projects, a technical pre-requisite of Contamin8 was that it should run easily on any PC without the need for additional software.

In conclusion, our experience on these projects has shown that while various barriers may exist to the development of serious games within Higher Education contexts, they are not insurmountable. Indeed, given the range of expertise and skills already in residing in our Higher Education institutions, it can be argued that this sector provides fertile ground for cross-disciplinary collaborations in the field of serious games design. While this potential has remained largely untapped to date, it is hoped that these projects will form a strong foundation for developing further fruitful synergies across the Higher Education sector, and for making additional valuable contributions to the field of serious games design.

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