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Blended Game-Based Learning Environments: Extending a Serious Game into a Learning Content Management System

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Abstract— **Serious games have recognized potential as a means to tackle many challenges in education, ranging from stimulating increased learner motivation, to transferring challenging concepts in a novel and engaging form. They are commonly shown to work most effectively in blended approaches to learning, whereby the game plays a core role in a wider pedagogic approach, often based around an experiential or exploratory model. In this paper, we explore how the integration of a serious game, and more generally gaming paradigms, can be extended to a learning content management system (LCMS) to support a blended and holistic approach to their use in education. Through a case study within the EU-Funded Adaptive Learning via Intuitive/Interactive, Collaborative and Emotional Systems (ALICE) project, we demonstrate a technical integration of a gaming engine with a proprietary LCMS, and discuss the broader pedagogic benefits of such an approach. In particular, we note how this method can support an 'intuitive guided' or scaffolded approach to learning, where the learner is given the potential to explore a non-linear learning environment, whilst scaffolding and blending provides the guidance towards ensuring targeted learning objectives are met.**

Keywords: Blended learning, game-based learning, serious games, technology enhanced learning, pedagogy, learning content management systems

I. INTRODUCTION

Commonly, serious games are introduced as a fusion of entertainment and instruction, with a careful balance required between engaging gameplay and educational or behavioural goals [1]. Recent evaluations of serious games have shown demonstrable impact in a wide range of areas ranging from healthcare [2, 3], to simulator-based training [4], and classroom education [5]. A serious game is rarely presented as a complete alternative to an existing method of education or training; rather, the core potential lies in the value these games can add to more traditional or formal methods of instruction through careful blending with an existing curricula and technologies [6]. Considering this blending fully requires an understanding of the learners context and environment, as well as the various agents at work within the learning process and environment, and in particular the guiding and supporting role of the tutor [7]. However, it also requires that the role of learning technologies in supporting these blended approaches be fully realized in order to facilitate the effective use of these technologies in a blended approach.

Learning management systems (LMS) provide an established means for integrating a range of content and assistive technologies in a learning context. In particular, through the benefits afforded by the semantic web, these systems are increasingly able to provide content in adaptive and dynamic forms, responding to learner profiles [8]. As a principal means for introducing technology within educational environments as well as supporting novel technology-driven approaches, LMS systems provide an ideal vehicle for deploying serious games into formal education and training contexts. Hence, to date, the integration of gaming technology with LMS technology has been widely used: many LMS approaches contain games deployed through technologies such as Flash to operate within a browser-based system. However, their integration in pedagogic terms remains relatively unexplored, with little information transferred between LMS and game, and a clear division between LMS system and game environment. Considering instead the deployment of a game as a discrete learning object (LO) managed by a learning *content* management system (LCMS) offers a potential means for ensuring pedagogic as well as technical support for its deployment, allowing a game to be defined in broader pedagogic terms as a learning object. In this paper, we discuss how the state-of-the-art might be advanced to expand the notion of serious gaming to encompass more fully an intelligent tutoring environment, drawing on entertainment gaming parallels as well as an underlying pedagogy which supports an exploratory approach to learning [9]. Through a working demonstrator presented in Section IV, a proof-of-concept integration between the Intelligent Web Tutor system and Unity game engine is shown, allowing for the discussion of future work with this prototype in Section V.

II. BACKGROUND

Integrating serious games in formal learning is increasingly important to meet the needs of 'digital natives' [10], who have expectations of high engagement from digital media. However, technical deployment must be coupled with effective pedagogic blending into curricula, and presents new challenges in providing effective assessment and efficient achievement of learning outcomes. The reality is that game-based learning can be applied in a diverse and extensive range of forms, by no coincidence drawing parallels to the range of entertainment games which utilize platforms ranging from high-end purpose-built consumer hardware, through to low-end mobile devices and web platforms. Regardless of the technology used, the need remains to create models for blending game-based learning into curricula such that the game excels at addressing educational challenges, rather than relying on blending to address its shortfalls. The ability to foster intrinsic motivation is frequently cited as a benefit of game-based learning [11]. However, if this is the sole objective of integrating the game into a course, thought must be given to how this intrinsic motivation will transfer into other activities, and since peer interactions can play a pivotal role in such transfer [12], this is seldom a straightforward task. An essential case exists, then, to consider the additional benefits game-based learning might bring: for example the ability to abstract problems and scaffold the transfer of solutions [13]; the ability to comprehensively monitor learner interactions as a basis for feedback and understanding [14], [15], the ability to provide a platform suited to certain pedagogic approaches such as those which are collaborative or problem-based [16], or non-linearity and capacity for exploratory learning [9].

In any case, it is worth considering the pivotal role of the learner in accepting game-based technology. Established models for technology acceptance emphasize heavily the relationship between perceptions of ease-of-use and usefulness [17], and these can be particularly demanding to realize amongst demographics who see gaming as a purely recreational activity, or see a game-based interface as an unnecessary barrier to usability. There is little doubt that receptiveness to game-based learning is steadily increasing as the average age of entertainment gamers continues to rise [18], through a final note here is that any attempt to blend game-based learning into a curricula should give careful affordance to its learner demographic.

A parallel can be drawn between established typologies of learners (with specific regard to experiential learning [19], more generally [20]) into *sensing* or *intuitive* types, and their corresponding receptiveness to game-based learning as well as its effectiveness. Many strengths of game-based learning such as those noted above are suited well to intuitive learners but are accordingly poorly-suited to styles of learning which demand greater levels of structure as well as lower levels of abstraction. An intuitive learner is characterized by their ability to build their own conceptual models and grasp general concepts through abstraction or imagination, granting them a greater degree of intrinsic capacity to reflect on their experiences and transfer them outside of the direct context of learning when compared to *sensing* learners. Furthermore, the linear, process-based approach to learning more effective with *sensing* learners as well as their greater need for fidelity - a consequence of equating more directly perception to reflection – makes devising serious games for this group a demanding task. Therefore, the model presented in the next section makes the necessary assumption of an *intuitive-guided* approach to learning, which by its nature targets directly *intuitive* learners as those more likely to be receptive to game-based methods., as well as more likely to benefit from their use.

III. PRINCIPLES FOR BLENDED LEARNING WITH SERIOUS GAMES

In this section, several key considerations are discussed for implementing a serious game in a blended learning context. The underlying theme throughout is the extension of the pedagogic approach to encompass the broader technology-enhanced learning environment, though care is given to avoid overprescribing a given pedagogy, as this is inextricably linked to learners, as well as their tutors, context, and the capacity of the representational medium [21]. From an educational perspective, whilst simple tasks might perhaps be trained without great differences between gameplay and task, for example in the case of stroke rehabilitation [22], more complex behavioural or cognitive aims such as those defined towards the top of Bloom's established taxonomy [23] require a far greater degree of abstraction when converted to a game-based form. It is in these cases that a blended approach becomes essential: learners cannot be expected to learn through analogy if insufficient support ('scaffolding') is supplied to allow them to expand beyond their capacity to learn alone [24, 25].

A further issue with game-based learning is that, under a behaviourist approach, aligning learning outcomes to 'correct' in game actions is notoriously difficult [25, 26]. As previously mentioned, even to assume that encouraging the learner to perform in-game behaviours can lead to effective analogical transfer to real-world situations places an emphasis on the periphery of the learning environment, where unrealistic elements inevitably encroach on the experience. Even with experiential or cognitive models, some analogical transfer must take place between the artificial game-world and real-world application of learning outcomes. It is in this analogical transfer that the key challenge lies, as well as the case for a blended approach to learning: If we are to assume that the model of learning through simulation functions as intended (e.g. by crawling through smoke in-game, the player learns to crawl through smoke in real life), then we must also question what occurs around the limits of the simulation – through the same model, what stops a learner who discovers trial and error to

be an effective way of 'beating' the game to attempt trial and error when faced with a real-world situation? This is determined by the capacity of the learner to recognise the difference between game and real-world situation, and thus around this periphery it becomes particularly important to consider the range of the learner's zone of proximal development (ZPD) [24] – i.e. to what extent can they achieve this recognition alone.

If the solution is to scaffold the areas in which the ZPD alone does not encompass, then the immediate question becomes the form this scaffolding should take. Returning to the central theme of this paper, the benefits of extracting this scaffold in whole or in part from the game, and placing it instead in a broader e-learning environment, lie principally in the affordance to continue to focus upon creating a compelling or engaging game whilst relying on the broader environment to reinforce learning outcomes. To this end, this paper presents four essential considerations:

A. *Stimulating learning to occur beyond the game*

Game-based learning is inherently abstract to some degree. This is not unique to the medium: classroom instruction must also be translated by the learner to real-world application. However, game-based learning is often unique in the extent and nature of this abstraction. Therefore, the need for scaffolding or a more-able partner [24] is particularly relevant in game-based learning. By encouraging the learner to learn outside of the game itself, it becomes possible to require the learner to develop this scaffold, or at the very least allows for its absence to be highlighted for the educator. Yet doing so can conflict to an extent with game design: an intrinsically-motivating game should make the learner *want* to play it, so how can they be encouraged to move *beyond* the game in the development and application of their knowledge? One possibility is to require the learner apply this broader knowledge to defeat the game, for example using their knowledge of nutrition to tackle abstract problems [27] [28]. In effect, therefore, the game becomes the method of assessing learning, rather than transferring it, with the game's intrinsic motivation serving as a primary mechanism for engaging learners with this assessment and encouraging them to overcome it.

However, a contradiction also exists in the need to balance difficulty with learner ability: if a learner encounters a problem in-game that can only be solved outside of the game, unless some form of scaffold is provided, the result could easily be anxiety rather than engagement and flow [29]. One form this scaffold could take is a collaborative approach, in which peers or tutors assume the role of more-able partners, though this could in turn conflict with game design. A more general solution is to consider the various means in which learners might develop their own methods for problem-solving, and support each one: consulting with tutors, peers, or the use of online resources are all methods which could prove viable, and, returning to the theme of LCMS integration discussed later, are all supported in a broader technology-enhanced learning environment.

B. *Integrating game-based learning fully into the learning environment*

Guideline principles for integrating game-based learning into the curriculum are listed more comprehensively elsewhere [30], though it is worth noting the particular salience of many of these principles to blended approaches. In particular the pivotal role of the tutor can be particularly demanding to realize in an LMS environment, where first-hand interaction may not be possible. These best-practice guidelines often emphasize integrating the game closely into the curriculum, whereas a technology-led approach might consider instead how to integrate the curriculum into the game. Doing so requires going beyond the immediate confines of the game itself, and extending the game-based elements into their wider educational context, potentially allowing the exploitation of parallels between gaming communities and learning communities. Emergent content distribution and community networks for entertainment games, such as Steam, PSN, and Xbox Live, show parallels to the learning communities many LMS systems seek to foster. By extending the game-based learning concept beyond the game itself, and into the broader environment it is situated. Key issues with LMS systems often include ensuring sustained community-wide engagement with discussion forums or other social elements intended at fostering peer discussions [31], and the drawing on the community-building aspects of gaming may provide a potential platform for addressing these problems. The dynamics around communities of practice are well-defined [32], as are the positive impacts of technology on supporting these dynamics [33], and games and gaming metaphors could provide further potential for reinforcing communication amongst learners as well as forming new means for collaboration.

C. *Engaging the learner and sustaining flow*

A carefully considered approach to feedback has been noted as a central component of effective game-based learning [34]. If this feedback is no longer restricted purely to the game, but can be extended and blended into other material through integration with an LMS or LCMS, then the potential emerges to address a challenge common to game based learning: that the rapid frequency, low fidelity feedback best suited to engaging gameplay [35] may lack the depth and form to adequately support meaningful learning transfer.

With respect t to feedback approach, several studies have shown that game-based approaches can offer increased learning transfer when compared to pure simulations [4], as well as the need for this feedback to be frequent and limited in content; else it may be overlooked by learners more keen to engage with the game than read lengthy evaluatory content [35]. Game-based feedback must reflect a need for

sustained 'flow' [29] through careful balance of task difficulty to learner ability, and the nature and tone of feedback can provide an important means for sustaining this flow by focusing on small, manageable achievements. This has long been recognized by game designers, and reflected broadly across entertainment gaming genres as larger, long-term objectives achieved through a series of smaller, manageable (even trivial) tasks, the archetypal example being role-playing games [36].

D. *Considering the relationship between technical and pedagogic integration*

Thus far, this paper has focused on blending from a pedagogic standpoint. However, it is worth noting that from a technical perspective, there are two principal models for integration between game engine and LCMS which may function either in isolation or combination. Firstly a *tight* integration; whereby the LCMS and game share access to a single data store. This could, for example, be achieved include the game engine and LCMS both interfacing directly with a database management system. This allows for the provision of the game as a standalone executable, rather than a web plug-in, which may be preferable in situations where high performance is required However, it is worth noting that modern game engines such as Unity exhibit little performance degradation between web plug-in and standalone builds.

The benefit of the tight integration is the transparency of information between systems, which is delivered at the cost of flexibility and increased interdependence. By comparison, the second option is a *loose* integration, which exploits commonalities in API functionality to pass specific elements of information between game and LCMS. Such an approach is particularly viable in a web environment wherein client or server-side scripting languages can be used as a basis for passing information to and from the game engine. Output from the game can then be returned similarly by invoking client-side functions within the page. This has the advantage of allowing game and LCMS to be more freely interchanged with less interdependency.

Though potentially offering superior performance and availability of data, a tightly-integrated solution is likely to make subsequent component separation more challenging. In particular, if we view the game as a learning object, looser integration allows the game to be independently developed or interchanged without requiring modification to the overlying LCMS, or supports the creation and management of the game as a learning object within an LCMS. Hence, the loose integration may be more pedagogically desirable, allowing for rapid interchange of game-based learning objects, as well as the application of existing methods for assessment or content creation, drawing further on the representation of the game as a reusable learning object. In the next section, this paper describes an example of such a loose integration using the the Unity game engine and Intelligent Web Tutor (IWT) platform.

IV. CASE STUDY

The case study in this paper is presented through the EU-Funded Adaptive Learning via Intuitive/Interactive, Collaborative and Emotional Systems (ALICE) project. The purpose of the serious game within this project is to support an educational programme around the area of civil defence, and specifically building evacuation. The game itself builds upon the approach used in other evacuation simulators [37-39] of placing the learner in a 3D environment during an emergency and demanding they follow correct principles for safe evacuation. Images from the game are shown in Figures 1 and 2. A simple experiential model of learning [19] is implemented, coupled with a requirement for analogical transfer to real-world situations [40].

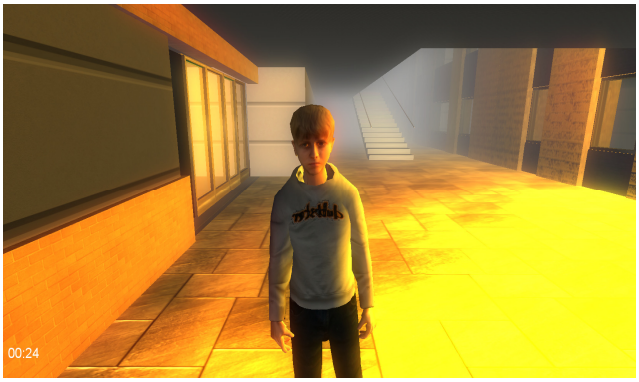

Figure 1. The game environment: a simulation-based approach is used to create a game build around an authentic real-world environment and characters.

The game engine, Unity, is integrated with the Intelligent Web Tutor system through the JavaScript functionality in the web page. Furthermore, the game tracks user interaction via a series of in-game 'checkpoints', which trigger an update to an XML file as the player passes. As the number of checkpoints is unlimited, detailed information can be captured on the routes used by players to exit both on an individual and collective basis. Effectively, therefore, the game creates a repository of information which can then be interpreted as a basis for feedback to learners.

Evacuation training is characterized by its need to change behaviour in learners, rather than simply transfer knowledge. As such, it is well suited to a game-based training context where simulative as well as pedagogic elements can be applied to reinforce correct behaviours in evacuation environments. Real-world training is often restricted by the difficulty in simulating the conditions under which real evacuations may occur, whereas games can exploit virtual worlds and game elements to create a sense of emergency. Nonetheless, careful consideration of the learning environment as a whole is critical to effective evacuation training, particularly as elements such as drill

and rehearsal have the potential to reduce immediate response to alarms due to overfamiliarity [38].

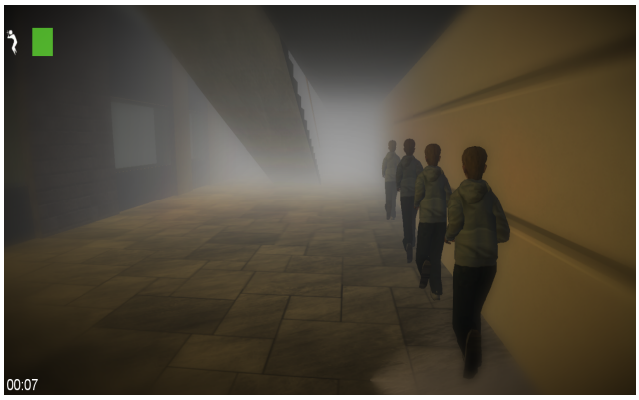

Figure 2. Crowd evacuating in response to a fire. Simple heads-up display elements give information to the player on smoke exposure (top left) and time elapsed.

To address these issues within the prototype, blending with the IWT system will be exploited to provide the learner with both immediate feedback in-game, and long term feedback through the LCMS system. Noting the relevance of an 'intuitive guided' approach to learning, the aim here is to provide the learner with the freedom to explore the game environment, including the outcomes of incorrect actions, whilst providing the necessary guidance and scaffolding both in an immediate form within the game, and to a deeper level through the LCMS and its integration into the broader learning environment. This allows for consideration of feedback through a multilayered approach, previously examined in terms of its suitability to game-based learning [34].

V. Summary and Conclusions

The case presented by this paper is one for wider consideration, particularly in pedagogic terms, of how serious games are integrated into blended learning contexts. In particular, this paper has focused on supporting intuitive learners through blended interactions than span both games and LCMS systems. Extending the scope of this work to a wider learning demographic which includes learners more amenable to less intuitive and more sensory approaches to learning remains an important avenue for future work, though the ultimate consideration here may be that serious gaming is not a ubiquitously effective method of instruction for all learner demographics. Rather, it could prove beneficial to focus upon the demographics for which it is effective, rather than compromise designs in an attempt towards universal appeal, particularly as this demographic is steadily increasing as young generations of 'digital natives' [10] mature. For these generations, intuitive learning is increasingly the norm: for them, the inner workings of digital devices seldom require understanding, and user interfaces emphasize the learning and application of concepts rather than procedures.

The evaluation within the case study has focused on a technical proof-of-concept. Evaluation on pedagogic levels, which will require more detailed user study, is the central topic of future study. This paper has presented a number of key advantages that might be afforded by an integration such as that demonstrated by the case study, but it is essential these advantages are understood in terms of educational objectives rather than technical feasibilities. Integration with an LCMS system is not necessarily viable for all serious games, particularly those aimed at web-based interventions around topics such as public health where the period of learner interaction may be in the region of minutes, and a need still remains for methods for game-based learning to be effectively realized in non-blended contexts.

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