Extending the design of games for eLearning to include affective computing elements

Olaf Hallan Graven[1], Lachlan Mackinnon[1, 2] & Liz Bacon[2]
[1]Buskerud and Vestfall University Colleges, Norway,
[2]University of Greenwich, Old Royal Naval College, London, UK
Olaf.Hallan.Graven@hibu.no, Lachlan.MacKinnon@hibu.no, l.mackinnon@gre.ac.uk, e.bacon@gre.ac.uk

Abstract-The use of human emotion in learning situations has been a feature of learning and training since earliest times, since it has been seen to speed and personalise the process. Research in affective computing has focused on providing realistic and appropriate representations of human emotions on computers, and using these to create more realistic emotional interactions between humans and computers. A strong driver in this activity has been the games industry, seeking to make games more realistic and engaging. The authors have been involved for some time in research on the use of games for eLearning, and this paper considers the use of affective computing techniques within such games. The benefits are seen as greater engagement and immersion of students, faster achievement of "suspension of disbelief", willingness to reuse and revisit learning materials, and the potential to introduce realistic emotions and stresses into the learning situation. Two similar but contrasting approaches, from the Pandora and Maritime City projects, are also discussed. The conclusion is that affective computing techniques can enhance games for eLearning, but only if skilfully applied and with strong production values, as poor application of affective techniques can render a game unusable and laughable.

INTRODUCTION

The existing research on computer games for eLearning has predominantly focused on gaining the benefits of player immersion in games for learning environments. The rationale has been that developing games for learning, or introducing learning materials into existing games, will transfer the impact of the gaming environment to the learning situation. Considerable research, carried out by the authors [1-5], has demonstrated that, while the transfer is achievable, considerable skill and effort is required to effectively marry game-play with learning in an appropriate and successful balance. This paper describes some of the background research carried out by the authors, and it's outcomes, before going on to consider the use of affective computing techniques in games for eLearning. General principles on socialisation and affective computing are discussed, and then contextualised in relation to games, and games for learning in particular. Two similar, but contrasting, projects utilising affective computing techniques for *serious games* are then described and discussed. Finally, the paper concludes on the value of affective computing techniques for eLearning games, highlighting some of the benefits and identifying some of the pitfalls and dangers.

Designing for active participation in learning activities

The theoretical argument for constructivism is that deep knowledge and long-lasting knowledge is more likely to arise from constructivist learning environments. The perceived benefits of a constructivist learning environment include absorption and synthesis of facts, linking the knowledge of facts with understanding of other knowledge domains, the enhancement of collaborative/cooperative skills and time. One of the key points of constructivism is to get the students involved in the process, and give the tutor the role of facilitating and supporting learning. Experience has shown that most students will, after some initial misgivings, elect to follow the active learning route and actively be involved in the learning process. The rationale for this is that it is simply more enjoyable.

Students learn more, and enjoy themselves more when they are actively involved, rather than just passive listeners. The presentation of material in books, papers, multimedia presentation, traditional lectures or web can all encourage the student to take an active role, use the lab for assignments or even just imagine the activities. However there are few forms of learning that, like games, entice, encourage and even force the student into activity. Computer games are built to activate and keep a player active with problems and tasks, through the whole period of play. An important aim here is that, in addition to keeping the player active, they also ensure the tasks consistently offer a challenging degree of difficulty.

Csikszentmihalyi [6] introduced the concept of flow, through a study of people involved in activities such as rock climbing, chess and dance in 1975. He describes flow as a state of complete absorption or engagement in an activity and refers to the optimal experience. According to flow theory, flow can occur when an activity challenges an individual enough to encourage playful, exploratory behaviours, without the activity being beyond the individual's reach. Flow has been shown to have a positive impact on learning, see Galarneau and Kiili[7, 8].

Many people are advocating taking the hard work and discipline out of learning. However, we would argue that this is not the answer. Rather, what we should be doing is finding tasks that will harness the passion of the student to the hard work needed to master difficult material.

Therefore, one main aim for us as designers of learning material is to design content in such a way as to allow different students to obtain the state of flow, irrespective of their different knowledge and abilities.

Social an emotional connections

Social relations between students during learning are an integral part of the authors' philosophy for learning. Manninen[9] has shown that the communicative aspect of current multiplayer games is enabled by a relatively limited set of interaction forms. The communication between players in the prototypes described in this paper is mainly via IRC. But the avatars do also have a limited set of emotions they can express within the environment. Studies by Kolo and Baur[10] have shown that many players not only connect to a online game in order to play but also to stay in contact with the fellow players, many players also connect to fellow players via messaging systems during game play. They engage via their characters in various social interactions from trading or fighting to entertaining other characters. Many players regularly meet the same characters online and address a relatively fixed group of playing partners. Kolo and Baur[10] have also shown that knowing and meeting people in an online environment or game triggers frequent playing and not the other way round.

In terms of affective computing, the work of Picard[11] is seminal, and she focused primarily on the ability of computers to accurately represent emotional states, and engage appropriately in human computer interactions within an emotional context. Considerable work in the games community has focused on the first of these goals, namely the accurate representation of human emotions on computers, in particular on avatars representing human characters in games. Although this work has also focused on dialogues and interactions between human players and these emotionally affective avatars, limited consideration has been given to the use of affective techniques to impact player learning. In the serious games community, however, projects such as Pandora[12] and Maritime City[13], which are discussed later in this paper, have used affective techniques to enhance training scenarios, by directly impacting the emotions of the trainees. The clear benefits of this approach are in increasing player engagement and immersion through emotional interaction more rapidly reaching *suspension of disbelief*, and impacting the effectiveness of learning achieved through greater realism and stress in the learning situation [9]. In terms of the concepts of *flow*, it is only when fully immersed in the game, with disbelief suspended and concentration entirely engaged with the gameplay, that flow can be achieved.

I. Computer Games in Learning

A. Learning from computer games designers

One of the current challenges facing educators today is the perceived lack of motivation and engagement in learning situations by out students, especially in topics that are, by the students, perceived as difficult of challenging. This forces us as educators to make choices on how to address this, two frequently selected major choices are either to try to force the students through by setting huge amount of coursework and supervision, or if the resources are not available lower the requirements for a pass mark. However, in the gaming industry neither of these options are viable, people cannot be forced to buy and play computer games, and, in general, players do not want the short and easy option. For educators, this raises an interesting question: "How do game designers manage to get new players to learn their games which are often long, complex and difficult, and even pay for the privilege?" An answer provided by Gee[14] is: "*The answer, I believe, is this: the designers of many good games have hit on profoundly good methods of getting people to learn and to enjoy learning.*" He goes on to claim that "*Under the right conditions, learning, like sex, is biologically motivating and pleasurable for humans*".

The notion of getting students hooked on learning, rather than seeing it as something they have to force themselves through, is every educators dream. The question that needs answering is:" How do we do it?"

From the many studies of learning that have been done, from Rousseau to Piaget, we know the benefits of revisiting the same learning material on a number of occasions, reinforcement, and drill and practice models. The effect of repeated exposure to the same information again and again greatly increases the likelihood that the information is retained and aids in understanding and learning. So it can be argued that in designing games for learning a major concern is to ensure that the game is used and reused by the participants. This is an aim we have in common with the commercial game producers. Deep learning requires the commitment of time and effort. The gaming industry have invested heavily into getting players to commit the necessary time and effort to master their games, the challenge for educationalists is to tap into the same feelings, getting students to devote the same time and energy to learning as they do to playing games in the evenings.

II. Embedding learning In Games

The authors have previously complete a set of experiments to determine that a games-based environment is a viable way to present learning material, and what level of embedding of that material is necessary within the game. Particularly we investigated what effect different levels of embedding of the learning material within the game context had on the player's perceptions of game-play and learning.

The design for the virtual learning environment was based on the utilisation of a multi-level, multi-player games based model and its inherent support for constructivist learning in a higher education environment.

The decision to adopt a game-based approach to the development of e-learning follows on from a survey of current state-of-the art support for lifelong learning that was carried out by the authors[1], a key element of that investigation being the different techniques to improve learning and retention through engagement of the learner.

A. Embedding vs Layering vs Bespoke development

The authors have considered placing learning material within games, so that the games environment becomes the vehicle for delivering the learning material. We have investigated several ways to create games for learning: layering on top [2]; embedding[3]; creating the game from scratch with just the learning material and no other game content[4]; and developing a game where the learning material is abstracted from the original context and the game is based on the abstracted elements[5]

The findings from this experiment indicate that the students liked the game, the game context, and found it a useful way to present learning material. The students claimed they found the game engaging, and we did observe a small amount of reuse, not as much as we would like, but some students did return to the game to play on. This is encouraging but demonstrates that there is a need to extend the game further to determine whether or not embedding really can generate the level of reuse we require to demonstrate the effectiveness of the approach. We need to determine whether the game was not engaging enough, or if there was not enough content to keep the students returning to the game.

In our previous experiment we looked at layering and found that with layering there was practically no reuse. We have looked into designing games specifically for purpose and found some reuse in those, but the problem with that approach is both cost and the requirement for expert knowledge, and we believe these eliminate this approach from consideration.

The evidence we have from this experiment is that embedding learning content into a predesigned game does achieve both the engagement we desire as well as some elements of reuse.

Emotional connection to a computer game

We know, from the enormous body of research that has investigated it, from Rousseau through Piaget to the current day, that learning through play is one of the strongest forces in human development, socialisation and the development of personality. Play, by its very nature, engages us at an emotional level in the current game or scenario, real or imagined, with which we are engaged. However, the formalisation of educational processes and methods, as we progress through education, tends to remove any aspect of play from learning. It can be argued that this is to the detriment of the learning process, and in recent times the development of games-based learning is an attempt to rekindle the relationship between play and learning. There are those who argue that this trivialises education, and that students do not give full weight to the ideas and concepts learned through games. However, even the simplest of children's games have strong and important conceptual and contextual learning associated with them, they are often quite serious in context, and although *fun* are not regarded as trivial by the players. A number of studies carried out in social sciences have shown that a significant proportion of the basic knowledge by which we live our lives is derived from playground activities as children[15]. Our research on the use of computer games for education has highlighted the balance that needs to be struck between gameplay and educational content, to ensure that the game remains fun, enjoyable and immersive, while also meeting the learning needs of the students. Gameplay is one of the intangible qualities of a game, and despite many attempts to classify and quantify it[16], clarity remains elusive. However, it is clear from the work that has been done that it is strongly tied to causality in the actions, decisions and progress of the game, and to the engagement of the player. Such engagement tends to have an emotional component, so different players prefer different types of game, and there are distinct differences on the basis of age, gender and culture in the types of games played. Since this is true for games that have been developed purely for entertainment, there is no reason to believe that such differences do not apply in eLearning games. However, another dynamic at play in eLearning games is the serious nature of the game, and how that impacts the view of the players. Our experience to date has demonstrated that students are willing to use games for eLearning at the behest of their lecturers, and will play the game and give positive feedback on the learning experience, but return and reuse of the game, the key goal that we aim to achieve, is fundamentally founded in gameplay. Therefore, considering the emotional engagement of the players in game design and building in affective capabilities/components, if well done and appropriately contextualised within the game narrative, can positively impact gameplay and thus improve the prospects of the game being successfully received by players.

THE USE OF EMOTION FOR ENGAGEMENT

We can demonstrate the use of affective computing techniques in terms of two similar, but contrasting, *serious games* projects:

Maritime City[13] is an immersive, game-based, educational tool, currently designed to train Social Workers, although the approach has wider applicability in training other Healthcare professionals. In the Social Work field in the UK, there is a set of standards for practice that students must meet before they can become a Social Worker. These are contained within the National Occupational Standards for Social Work, and fall into six “Key Role” areas[17]. Of the six, four directly relate to dealing with people face to face. However, providing trainee Social Workers with “real world” training scenarios is challenging. All students on this type of course should have a placement where they would hope to gain relevant experience, but this is not always feasible and not all placements can expose a student to the full range of experiences they need. Current solutions to filling in the

experiential and training gaps revolve around setting up role-play activities. However, it is well known that the quality of these can vary depending on the enthusiasm, commitment, and indeed the acting abilities of the students. A more consistent approach for all students would be desirable.

Due to the engaging nature of games, it was decided to develop a training environment using games technology that aims to help solve some of these issues and can be used alongside traditional teaching such as role-play, or potentially as a replacement for it. The environment is a virtual city initially developed using the Source game engine created by Valve Corporation[18]. It will eventually hold a number of different training scenarios that are interlinked and run alongside each other, however it currently has just one scenario focused around the Baby Peter Connelly (Baby P) case. This is an infamous case in the UK, which has brought to light a number of issues in Social Work practice, and the communication challenges when dealing with a child at risk. In this particular case, the child was deemed at risk but was not removed from the situation for a number of reasons[19], resulting in continued abuse leading to the eventual death of the child.

The game engine used was chosen as it provided excellent facial animation features, which gave developers the tools to create emotionally engaging characters that can convey emotional states through their facial and body language. This is particularly important as Social Workers must develop skills to interpret both verbal and non-verbal forms of communication. The facial characteristics used to display emotion in the avatars, coupled with the audio input provided by professional actors, are the key mechanisms by which emotions are conveyed to the trainee. This was based on a number of studies that have been undertaken in this area, such as that by[20] which demonstrated that avatars can elicit a response similar to that provided by a real human face and concluded that they could be used in training programmes however, there are still noticeable differences in various types of brain responses when comparing real and simulated faces.

In Maritime City, trainees interact dynamically within the scenario basing their actions and responses on the information they gain from the virtual clients, both in terms of factual information and the emotional representation. It is fundamental to social work training that trainees should be able to develop a non-judgemental, objective view of client emotions, in order to assess their coherence with the situation being presented and the factual information available. The Maritime City simulation and visualisation provides an opportunity for such training, with the added advantage that scenarios can be halted and analysed to highlight key points of learning or key failings, which is not possible to the same extent in interactive role-play. However, the key advantage in using computer based visualisation and simulation with the concomitant representation of emotional state, is in the consistency of representation of the scenario to all trainees, across numerous different training sessions, and in the ability to consult and re-run on the basis of mutually devised strategies.

Pandora is an EU FP7 Project[12] designed to use emotional affect in order to impact decision-making and enhance learning in crisis management training. The application under development is designed specifically to enhance and expand training exercises for Gold Commanders in crisis management. Individuals who carry executive responsibility for the services and facilities identified as strategically critical within these situations e.g. Police, Fire, Ambulance Service, Local Authorities, Health Service, are called Gold Commanders (in the UK), and are expected to work together to provide strategic solutions to a crisis. These crisis situations could be anything from a terrorism event, to problems caused by extreme weather, plane crashes, health crises (e.g. pandemics), or a combination of multiple types of event.

Gold Commanders are in overall control of the crisis, however they will not generally be at the site of the emergency, but typically co-located in a control room. They will set the direction and propose solutions for the tactical (Silver) commanders to implement, who give direction to operational commanders (Bronze), who are responsible for organising resources on the ground. Their objectives are to: save and protect life; relieve suffering; contain the emergency; provide the public with information; protect the health and safety of staff; safeguard the environment; protect property; maintain / restore critical services; maintain normal services appropriately; promote and facilitate self-help; facilitate the investigation / inquiry; facilitate community recovery; and to evaluate and identify lessons learned.

When a crisis occurs, human behaviour and preparedness is critical to the delivery of an effective solution and therefore the training of Gold Commanders needs to be as realistic as possible. It is therefore important to be able to simulate the information overload and related stress, together with the pressure in making decisions during a training session. Ideally the trainees should experience emotions of a similar nature and intensity to those that they might experience when dealing with a real emergency. To this end, within Pandora, trainee behaviour and emotional state are:

- Captured through the use of a pre-event questionnaire
- Monitored during training through direct biometric sensor inputs, self-reporting by trainees, trainer inputs, and using affective media effects and information manipulation techniques to induce changes to those behavioural and emotional states
- Reviewed and evaluated post-hoc through feedback and review

The key argument for the use of affect in the Pandora scenario is in the creation of affective ambience, by which we mean the use of multimedia assets and information management and manipulation to create emotional impact and engender requisite levels of stress in the trainees, at decision-making points. Although there is some consideration of the use of avatar representations of

emotion in the distributed mode of the Pandora Advanced Training Environment (PATE), the key affective representation is associated with the creation of ambience or atmosphere. A number of techniques from film and TV production have been combined with a number of known issues in information management and manipulation, to create a set of rules by which multimedia mashups can be created and made available to the trainees across a set of configured media channels. This provides the potential to induce stress in the trainees through the use of vocative inflections, video and image representations of crisis situations, and textual updates from those situations. However, the system can also induce stress through the corruption of media channels, incomplete information, missing information, noisy channels, and a variety of other techniques to diminish the certainty of information available to trainees at those points in the scenario where they are required to make decisions. Using this kind of induced stress the system can impact on trainees in terms of their self-efficacy, leadership capability, and existing personality traits, to determine their capability to make effective and appropriate decisions under stress.

The Pandora system also offers the opportunity to analyse trainee performance on the basis of a prior behaviour analysis based on questionnaire input, real-time and review feedback from within the scenario, and post-hoc analysis of behavioural and decision making performance. The benefits of such an approach are clear, in the ability of the system to introduce additional stress as required to impact the decision making of the trainees, and thereby more effectively replicate real-world conditions and determine trainee capability under stress and uncertainty.

A comparison between the two systems highlights both the similarities and the differences:
In terms of common features, they are both computer based simulations of real world scenarios delivered in an interactive environment, and both are designed to create an affective impact in a highly pressurised, stressful, decision making training simulation.

However, they differ quite considerably in their implementation and engagement with the trainee, for example:

1. Maritime City uses a virtual immersive technology to engage the trainee whereas Pandora primarily provides an augmented reality, rich multimedia environment (however, there is also a virtual distributed mode of the PATE).
2. The training takes place within a group dynamic in both cases. However, Pandora is focused on a collaborative dynamic, whereas Maritime City is based on an individual interaction, observation and feedback dynamic.
3. Maritime City is based on an entirely immersive dynamic, so the trainees will be engaged within the scenario continuously, and any analytic or discursive activity within the training group will require suspension of the scenario. By contrast, Pandora provides an augmented reality scenario for the trainees, which is designed to encourage group interaction and discussion, so there will be periods of activity between trainees outside of the Pandora system per se, so engagement is not intended to be continuous, although it is time-controlled.
4. Maritime City uses the affective computing technique of avatars that display emotion. According to the research[20] this approach will exercise stress on a trainee, although that perception may vary depending on how immersed a trainee feels in the game. The other areas which reinforce / accentuate the emotion represented by the avatar are the use of voice, and a limited effect from the use of body postures e.g. adopting a threatening pose, and some environmental information in scene setting. In Pandora we are explicitly manipulating the atmosphere / environment. Where we have avatar based characters then we seek to employ visual representation of emotion coupled with the use of vocative inflections. However, this is in addition to mashups of auditory, visual and textual cues at different levels of emotional affect, and information manipulation techniques in the form of missing, incomplete and noisy information, in order to create ambience and induce stress where it has an affective impact on the trainees and in particular on their decision making.

The script for Maritime City is deterministic as the interaction is pre-canned and all of the decision points are fully populated. In Pandora, if the trainer so desires, the PATE can be non-deterministic, which is a requirement given the nature of the people being trained, who are required as part of their role to be creative in generating solutions to problems. Although a scenario in Pandora is pre-defined and a large number of the decision points are pre-populated, the trainer has the facility to dynamically interject events and/or take control of one of the virtual characters in the scenario in order to respond to the queries or proposed solutions of the group. This is important in order to facilitate the realism of the interaction and retain engagement with the training environment.

III. Conclusions

The use of affective computing techniques in the design and development of computer games has been a growing and evolving feature as games narratives and interactions have become more complex and realistic. The impact of this on *serious games*, such as those used for eLearning, can be profound and, as has been demonstrated in this paper, can encompass a wide range of outputs to the player. As described earlier, the successful use of affective techniques in games for eLearning can lead to greater engagement, immersion and reuse, which in turn can have significant benefits in the development of well constructed learning for the players.

However, what is also clear from our research in this area is the need to ensure that any components or elements introduced into a game are properly contextualised, and appropriately utilised, relative to the narrative and gameplay. This requires considerable skills on the part of the developer, and the production values applied must be of sufficient quality, particularly in representing emotions through avatars, to achieve realistic or lifelike effects. Failure to achieve this will, at best, damage the gameplay and discourage replay and, at worst, may make the game unusable and laughable.

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