An Effective Approach to Educational Games

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***Abstract* –** This paper discusses the efficiency of multiple educational game categories while imparting education, and presents a simulation based education delivery approach. This simulation aims to deliver knowledge through an upgraded version of traditional slide based lecture delivery, with key advantages being its non-programmatic, visual design technique, dynamic evolution of lecture flow and constant feedback to lecturers. It also aims to assess if it is justified for educational institutes to develop educational games as a means of stimulating students, and increasing their interest in studies.

Keywords – educational games; game design; virtual university

1 INTRODUCTION

An overwhelming number of universities, institutes and schools are trying to enter the game development business by creating educational games. From short stories to puzzles to simulations, educational institutes and several companies have invested a lot of money into research and development of such games in the hope of better and more stimulating education. Having seen the addictive grasp that video games have on children, educational institutes are vying for students' attention through games, mostly by attempting to provide entertainment alongside education. A number of research papers written in the past have experimented with control groups to measure just how effective education is when coupled with entertainment [5] [6]. While almost all of them unanimously suggest that the merger is advantageous to students, it remains to be decided how efficient it is.

This paper assesses the types of educational games along with their advantages and disadvantages. The types of games are presented in terms of gameplay categories i.e. the core techniques in which the game is played out. It also discusses why many educational institutes are trying to enter this business. The validity of games as a tool imparting education is also discussed, not through results of previous papers testing a small group of students, but by deductive reasoning and logic. Additionally, a product for easily imparting education is presented which tries to impart knowledge in the same fashion as traditional lectures, with key advantages being interactivity, feedback, and ease of design by professors. By using a visual design interface, professors can give lectures in a traditional fashion with very low cost of production. The product aims to aid the teaching process by allowing a university or school teacher to deliver a complex lecture in an automated fashion, so that he may better involve himself in research and improving educational content.

The product titled 'University@Home' is an easier way to impart education to students of all ages – from schools to undergraduate levels and even post-graduate levels – its highlight being cost efficiency, ease of production, interactivity and dynamic evolution of lecture flow. At its core, the paper attempts to find out if educational games are an 'efficient' way of imparting education.

2 LITERATURE REVIEW

There are a multitude of books and research papers that discuss educational games and their usefulness. A few of their ideas are assessed here.

2.1 GAMES AND 'FUN'

Every game player and developer associates games with 'fun'. Surveys have shown that the number of people who want to have 'fun' in games is very high [1].

To fully understand the term 'fun' we must consider it from a psychological standpoint. The present state of our brain is the result of millions of years of evolution, over 99.9% of which was spent as a primitive species that used to like to hunt and live in wild jungles, always falling into life threatening situations. In order to survive effectively, our brain evolved to flush the body with adrenaline at critical situations like fear and survival, which stimulate our emotional brain – the amygdala [3]. This stimulus has been and will be exploited in games. By enticing the players' brains with exciting challenges, thrilling sequences, cutthroat competition and fantastic worlds, games are using the most effective way to catch the human mind's attention. This technique never fails to excite humans as it is an emotional surge that has been passed on to us for thousands of generations. It is these surges that define 'fun' that affect us when we play computer games, and developers have extracted it to their advantage. As we no longer experience the primitive surges in our normal lives in the 21st century, it is not surprising why people get addicted to games and want 'fun' while playing.

2.2 FEATURES OF AN EDUCATIONAL TOOL

The core features that every teacher expects from an educational tool are integration with the curriculum and provision for testing and assignments [1]. The concerns about testing and assignments are expected, as without an effective channel of feedback, any form of education is pointless. Without a tool for assessment, no educator can ever know how effective his teachings were. He

will never be able to improve on his teachings and the whole process will be considered as mere information passing, rather than true knowledge delivery. While feedback for educational games is a feature that can be implemented without much effort, it is curriculum integration that really stands in the way of educational games from being widely adapted into schools and universities. Implementation of curriculum topics as gameplay elements is inherently challenging, as the amount of collective human knowledge is incredibly vast, while there are only a handful of exciting gameplay elements that provide adrenaline surges.

2.3 PATTERN RECOGNITION IN GAMES

Our brain is a big pattern recognition machine and games are readily absorbed by it due to the fact that they are concentrated chunks ready for our brain to chew on [2]. This strategy is what makes today's big games so popular and addictive. Once game designers create a set of gameplay elements, they re-use those elements multiple times throughout the game, in a variety of ways with minimal modification. When the brain faces a pattern for the first time, it tries its best to create an archetype for it, thus storing it in memory, so that it never has to think too hard about it again. These stored patterns are much easier for the brain to react compared to un-expected situations. Once archetypes are made, the brain quickly gets bored, and starts looking for new challenges. Game developers, knowing this strategy adopted by the brain, cleverly design their games to be exciting and easy to develop by mixing in a significantly large number of excitable elements in a game. Such a design strategy inherently cannot be used within educational games, as each excitable element stimulates the emotional brain, while knowledge is processed by the rational brain. When the two brains conflict, it has been shown that the emotional brain wins almost all the time [3].

This presents an interesting tradeoff that the educational game developer would have to make. If more entertaining elements are presented, then students would have fun, but ignore the learning part, while if more information is presented, no one would play the game. While this tradeoff troubles all game developers who design educational games, such a tradeoff may not really be required. Consider the vast number of students that have already gone through traditional face-to-face educational process. They have studied, given exams, taken interest in subjects, and excelled at their fields, all without using the primitive surges presented in today's games, as a source of motivation.

2.4 GAMES DON'T TEACH, THEY ILLUSTRATE

As discussed before, for traditional games, the notion of transforming abstract ideas into a concrete experience [4] has been exploited by creating fantastic worlds with incredible amounts of detail. The players are then given a mix of gameplay elements. The brain understands and commits these gameplay patterns to memory, and uses it whenever it encounters the pattern again. These mixed up patterns keep the brain busy and make the player think that he has got some value for his money and/or time. A similar treatment isn't possible in educational games as they have to deliver a large amount of knowledge to be considered as meaningful. Combining traditional gameplay elements into an educational setting is an inherently inefficient way of imparting education. While today's lectures give information directly and in a smooth flow, adding gameplay elements to the mix only distracts students (players) from the knowledge itself. It makes the student concentrate more about completing the gameplay objective than absorbing and analyzing the information presented. Research papers experimenting with students for their retention of topics through games, speak otherwise, but forget that the amount and scope of knowledge that they can impart through games is severely limited by their very design, which is why educational games are not yet, and may not be fully accepted at a university or even school level.

3 BACKGROUND STUDY OF EDUCATIONAL GAMES

The following section discusses the motivations behind educational game development, and then presents various archetypes of educational games on the basis of their core gameplay concepts, and analyzes their key advantages and disadvantages.

3.1 MOTIVATIONS OF EDUCATIONAL GAME DEVELOPMENT

Both institutes and companies know that many children have the tendency to become addicted to games. They understand that games are very popular amongst young people. The addiction is even more prominent with young children, due to the fact that the rational part of the brain (the frontal lobes) does not develop until a human has fully matured [3]. Institutes and companies that develop educational games are trying to tap into this potential. They feel that just like young students play games with great enthusiasm, they can be swayed into studying through games. This idea is one of the incentives behind why institutes try to develop educational games. This incentive is however flawed by definition. As discussed before, it is primitive surges that excite a young mind, and complex information, no matter how cleverly it is presented (assuming it 'can' be presented at all), simply cannot deliver the same adrenaline rush that "killing a monster" gives. This is unfortunate, but given how our brain evolved, it is not surprising. Educational game types used by people till now, are discussed in the following sections.

3.2 SHORT STORY BASED GAMES

Educational games of this category present a fixed number of topics, usually 5-6 per game, and tell a short story for each topic. By design, they are casual games that can be finished in minutes. These games have a modular or level based structure, each of which present

a new challenge like obstacle crossing or enemy avoidance/killing. For imparting knowledge, these games incorporate a small sample of a lecture through simple sentences. Each level usually ends with a few questions to test if the student read or heard the preceding sections or not. Since the information quality is simple and quantity is minimal, most students can easily remember and recall such information.

There are several problems with this approach to education. As a simple observation, consider a scenario of a hypothetical university or school adopting this style of teaching throughout all its courses. The team of game designers would have to think of an amazingly large number of 'short stories' per subject and per topic in order to teach anything close to the amount of knowledge today's schools and universities deliver. This problem is further intensified by the fact that the collective human knowledge is increasing exponentially. This style of education is not efficient from the student's perspective either. Seeing a list of thousands of short games having possibly disconnected story lines, or severely repetitive ones, he would not be able to learn effectively. Ironically, all educational games made till now have astonishingly simple story lines that can manage at their best to teach no more than 8th grade students. The world of education however consists of complex knowledge that may take time to register by the brain, and may take years to master. No game so far has managed to successfully capture the complexity of say, Calculus or Electrodynamics and teach these through a game which involves challenges, violence or exploration.

3.3 PUZZLE GAMES

Puzzle games that educate are either in 2D or 3D, and usually have little to no story line. These games use simple puzzles in a manner quite similar to the first category of short games. The only difference between this category and the above is the lack of a main story line in the game, which leads to this category having similar sets of advantages and disadvantages. These games, by their very nature, are short. This allows for quick explanations of topics, but covering multiple topics has the same problem as above. The learner is presented with huge lists to learn from, leading to in-coherence in learning style, and very low recall value. The elementary things learnt in games stay at best in short term memory for most students. Even if students got motivated or interested to learn the topic again, in order to better understand or revise the topic, they would have to go through the whole game all over again, which would make them face repetitive challenges, that does nothing but de-motivate and discourage students. Several websites have illustrative examples of such games [7] [8].

3.4 MANAGEMENT GAMES

Management games are one of the more widely used types of educational games. They are a 'fun' way to practically apply a wide variety of resource management skills in a simulation that closely resembles the flux of real world scenarios in management jobs. Their sole aim is to have sustainable survival for as long as possible, with the most resources. Since this game type touches one of our basic instincts – survival, it is not surprising that it is popular amongst many people, despite the fact that, by nature the game can be of indefinite length and is as repetitive as traditional video games. This also goes to show that our brain fiercely rejects any form of repetition in all walks of life, but when it performs an emotionally stimulating activity, it conveniently ignores the fact that any repetition is present. The only drawback of these games is that their applications are severely limited to resource management, business and building skills. These games also fail to delve into theoretical knowledge at the depth approached by business courses. Another drawback is that to play these games well, one needs to read the game manual to know how exactly everything would play out properly, without which many people would play badly or even fail the game [4]. This suggests that this category is unsuitable for being used as educational games. Examples of this game type are shown in [9] [10] [11].

3.5 REAL WORLD SIMULATIONS

There are two main sub-game types in this category, army games and social networking games. Army games like 'America's Army' are used for educating the public about army life. They are obviously exciting due to the multiplayer components that play out in a similar fashion to first person shooter games. Clearly, they have a very fixed purpose, and cannot be used for teaching a wide variety of educational topics. Social networking games like 'Second Life' and 'Active Worlds' however have seen a possible potential for lecture based education. Educators use a simple strategy with these games. Since they know that humans are gregarious and like social networking, they feel that they can effectively reach a large audience through such games. While the idea is feasible, it must be considered that when a player plays a social networking game regularly, he would switch it on for 'social networking' and not necessarily anything else. The reason behind this is linked to how we evolved as a social species, and how much we generally enjoy being with other humans. Studying is a mentally challenging exercise and few humans would engage in it when they switch on a social networking application. Additionally, since these games are trying to model real life, they are severely diluted in nature, offering the player a huge number of places to explore and people to talk to. Very less motivation is thus offered to a player to choose to go to an educational institute located in the virtual world, when he switches on the application. Further extinguishing any motivation that a player might have to get educated is the fact that most virtual education centers charge virtual money, that has to be either earned by paying real money, or by taking up a 'virtual job', as well as the fact that lectures in these virtual worlds can be accessed only when a real lecturer is playing the game

at the same time, who could be in a totally different time-zone, making education unfeasible for some students.

4 UNIVERSITY@HOME

Each of the possible game types discussed in the above sections suggest that there is probably no way available through 'games' that could effectively teach a wide variety of students, a large number of topics, and yet be easy enough to be designed by a game development team. Even in the future, games will remain archetypes of entertainment, as big scale professional games with professionally created epic sequences will always be more thrilling and fascinating for young children as opposed to a low budget educational game.

4.1 A SIMUATION BASED APPROACH

This paper tries to sidestep the idea of creating an educational 'game' and uses the concept of Real World Simulations, in the context of Universities and Schools, in a hope of imparting knowledge more effectively and efficiently. The following section presents a solution that can perform education delivery through lectures, which is flexible enough to be used for advanced learning, while still being easy enough to create by one person alone (the professor himself). The product titled 'University@Home' (U@H) aims to impart knowledge in the same way all students of the current and past generations are accustomed to. By delivering slide based university style lectures, U@H uses a tried and tested technique of knowledge delivery that has been used for several years by educators in universities. U@H is a simulation of a lecture hall in its most basic form, with a virtual lecturer, virtual students, and the student himself (the player). By using the free version of the powerful Unreal Engine 3 technology, U@H provides something that was a technical limitation in the past. The simulation provides a complete life-like model of a professor standing in a virtual lecture hall, delivering a lecture, complete with animations, gestures, and facial animation. Unlike the motives of traditional educational games, animation in U@H is not a 'tacked-on' component that is used to attract students. Instead, it is an essential part of a lecture – the very ingredient which makes a real lecture so different and engaging from a textbook. A combination of body and facial animation, coupled with an impressive voice are the elements present in a real life lecture that engage students to listen carefully. It is these things possible with lectures created with U@H, which allow students to receive nearly the same core experience of a real life lecture.

The key benefit of using a simulation such as U@H is that it is flexible enough to support all lectures being taught in the educational world that are presented with slides, or pre-recorded videos. In other words, integration into curriculum is present by its very design. It implements a unique feature of 'lecture interrupts' as shown in Figure-1.

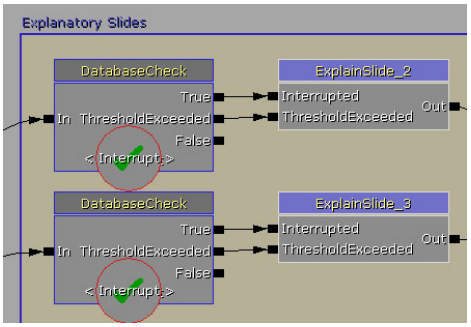

Figure 1 – Extra Explanation of Slides

Each lecture allows students to interrupt the virtual professor at any given time, following which the virtual professor can give detailed explanations on the topic being discussed. This is an advantage over traditional real life lectures, as professors usually have a time constraint in which to deliver the lecture, or the students themselves are hesitant to ask questions. Thus, students will be able to ask for doubts on topics in which they had problems during the lecture delivery itself, thus correcting the doubt as it arises, rather than at the end of the lecture. It goes without saying that these are not automated AI responses, but the pre-recorded voice of the real professor explaining the topic in depth. Although this adds to a professor's work in developing the lecture sequence, it also significantly reduces the number of students with simple queries he may have to entertain at the end of a real life lecture. The creation process of such explanatory sequences will be accelerated when several students study the prepared lectures. Every time a student interrupts the virtual professor for further explanations, and no explanation was present, a notification is sent to the professor so that he may prepare further explanations for that slide. This one time process lasting for an initial period of one or two months will help create a more effective lecture.

Besides the standard real-time delivery of lectures, a professor can also choose when to ask certain important questions, at any time throughout the lecture, as shown in Figure 2.

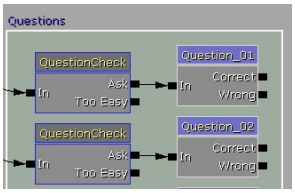

Figure 2 – Asking Questions during a lecture

These questions can either be multiple choice questions, or calculation based complex questions that require one or more word or numerical answers. At the beginning, during, and/or after the question, the professor can record his voices to various responses that a student might enter, to make the sequence feel as natural as possible, praising the student when required, or going back to previous slides and re-explaining concepts if the student answered a question incorrectly. This concept is illustrated in Figure 3.

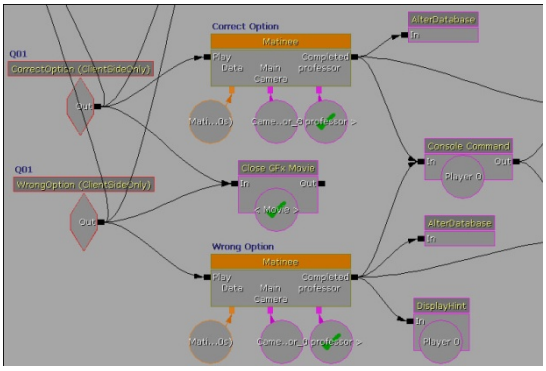

Figure 3 – Responses on answering a Question

The question system has also been extended to create an interaction session, with multiple options available to the student, each of which will produce a different response, allowing the student to converse with the virtual professor to clear a variety of doubts.

4.2 DYNAMIC LECTURE EVOLUTION

Each U@H lecture is designed to be a dynamically evolving lecture. Both the explanatory slides and the question asking components are linked to a database file. The database allows the storage of the number of times a student asked for further explanations at a slide, in a particular lecture, as well as the weight assigned to a question's outcome. For slides that perform further explanations, the professor can easily define a value that creates a threshold. Crossing this threshold will permanently include the detailed explanation in the main lecture. For the questions, each correct answer will increase the pre-defined weight assigned to it and each in-correct answer will decrease it. Once the weight crosses a threshold, a question will be termed 'Too-Easy' and will no longer be asked, as shown in Figure 2. This is achieved by maintaining a local database for each course and then uploading the database to a server, where the database is merged with a global database. This database has the advantage of the professor being able to view at any time where his students asked for further explanations, and how they performed. It also has an advantage from a student's point of view, as difficulties faced by previous students in a particular slide, will be automatically shown to the new user without his asking for a detailed explanation.

4.3 SIMULATION ADVANTAGES

In U@H, professors can choose to give all their real life lectures in this virtual form, which mimics their lecture delivery style as closely as they want. If a professor records his voice enthusiastically, and uses appropriate gestures selected from a pre-developed list, then his students would be able to recognize it as a real professor speaking, rather than dismissing it as an automated computerized voice. Using this lecture delivery approach can allow professors to take out much more time for their critical research work, by relieving them of their yearly routine of lecture delivery on the same topics. It will also give them time to update and add new lecture content. It will eliminate any omissions of ideas or details that occur while delivering a real lecture, something that could potentially confuse some students, or provoke several students to ask same questions after a lecture is over. A smooth lecture flow is possible with this system, as the professor during the design process itself can iteratively improve his lecture to any length possible. A side-effect of this iterative development is that a professor's skills at teaching a topic will be immortalized, and can be used for several years in the future, with modifications possible by any professor working with its source. The university adopting this system can transcend geographical boundaries by reaching larger number of students across the world. It also reduces infrastructural cost of physical lecture delivery and recording.

4.3.1 Design and Development Advantages

University@Home is advantageous not only from a delivery point of view, but a design standpoint as well. Each lecture is designed with the help of a visual design interface, requiring absolutely no programming skills from a professor. He can design a lecture with minimal effort. All he needs to do is record his voice for the lecture, break it down into clips of one sentence each, import it into the editor, and play it at appropriate moments. He can then import all his sound clips, and create automatic facial animation curves on any pre-defined virtual professor – made possible by the FaceFX technology in Unreal Engine 3. On importing lecture slides as images, and videos if required, the professor can start recording his lecture sequence in a tool known as UnrealMatinee, shown in Figure 4, which is a key frame animation editor that provides real-time feedback of any lecture sequence being created.

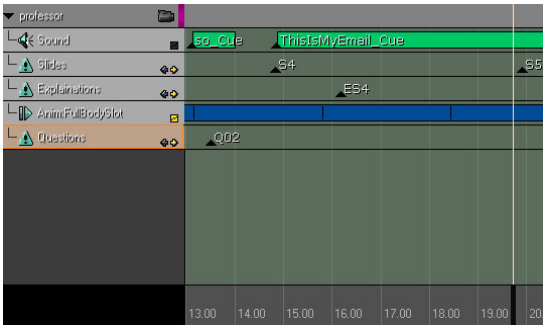

Figure 4 – Creating Sounds, Slide, Explanation and Question Events

To create a lecture, a professors needs to do no more than select when he wants a sound or animation to play, and then hit enter. Creation of questions is equally simple; as the professor needs only to create simple nodes in the visual editor that depict how the lecture flow will occur on different outcomes. These nodes have been depicted in Figures 1-3.

4.3.2 Key Advantages

The key advantages of University@Home thus, are that it can allow a certain level of interactivity by allowing students to ask for deeper explanations at any time. If explanations do not exist, then notifications are sent

periodically to the professor, so that he can add them and broadcast the message through a news channel on the course website. With low development time and cost, it can offer the best of both worlds of video recorded lectures as well as real-time lectures, as it allows the student to move back and forth the lecture at his own pace, skipping easy sections and having the ability to go back on more difficult topics. Being a dynamically evolving lecture structure, it differentiates itself from traditional e-learning tools and can allow new students to easily benefit from problems faced by past students. It also dynamically shifts the question set in and out of the lecture based on students that have gone through it. Lectures present on a student's hard drive obtained from registering and downloading the course from the website, can be viewed by them anytime and at any pace, allowing for learning as per convenience. Moreover, this tool is a dedicated educational product with one sole purpose – to provide an efficient educational simulation with the ability to teach a large number of subjects without un-necessary distractions present in other real world simulation games as discussed before in Section 3.4.

5 CONCLUSION

Educational institutes and companies developing educational games have been trying to gain the ever illusive attention of students especially when they are young, and when their minds can be molded towards studies rather than games. While they're hampered by obvious design flaws and huge development time and cost, this paper discussed some game types that have been developed, along with their suitability for education. On evaluating the design techniques possible for games, this paper suggests that the current generation of educational games don't deliver education as effectively as a real lecture would.

As a possible solution to the problem, a product 'University@Home' has been developed to act as a dedicated teaching tool, allowing for the key features of curricula integration, feedback, and ease of design by professors. It can also be used as a technique for delivering real-life lectures in a virtual world, which can be easily updated. It is not meant to replace professors, but simply to aid them. U@H can help them to be relieved of their lecture delivery routines and concentrate on key tasks like research, updating content and answering unique questions that a student might have after exhausting his possible doubts in a lecture. All of this attempts to make the lecture design as well as delivery as efficient as possible. By freeing professors from repetitive jobs, it will allow them to engage their brain in the more pressing challenges, thus increasing their efficiency as well.

While U@H aims to overcome the limitations of traditional educational games, it is not, and can never be as engaging and stimulating as a real live lecturer explaining a topic to a group of students. Simply put, our brains are most engaged, when they can actually feel and interact with another human. A simple analogy is of Social networking – humans perform social interactions through the internet many times, but it doesn't diminish their need to meet people in real life.

Future versions of University@Home will allow for multi-player interactions to fully stimulate students studying and make them feel as if they're in a real lecture hall in a real university. By adding such multi-player interactivity, it will be possible for students to further enhance their learning experience and will even allow real professors to teach in real time, rather than through a pre-recorded sequence. The multi-player experience will be best suited in delivering tutorial sessions, as they can involve a wide variety of questions being asked by students. For now however, a powerful single player experience is available to deliver a well-designed lecture to students, in a dynamically evolving fashion, with progress feedback to the professor.

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