Setup to Investigate Game-Based Model for Presenting Analogue Electronics Learning Material

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Abstract—This paper describes a implementation of a design for a game based virtual learning environment. The game is developed for a course in analogue electronics, and the topic is the design of a power supply. This overall task can be solved in a number of different ways, with certain constraints, giving the students a certain amount of freedom, the game is designed in such a way as to discourage a trial-and-error approach. The consequences of a wrong choice will be given in a safe, but realistic setting. The learning material is modelled in a MMORPG environment using storytelling and a virtual gaming environment.

Keywords-component; e-learning; analogue electronics; virtual reality

I. INTRODUCTION

Over the last two decades the use of internet based learning has seen a significant increase. As the technology is becoming more commonplace and the average learner has access to computers able to support them in the tasks of learning, universities and other educational institutions are moving into this market. The result is that the traditional role of educators in higher education is changing, with many being pressurised to get involved in the online “revolution”.

At the same time as this technological change influences everybody’s lives, there is also a shift in the underlying theories used to underpin the development of learning materials. A number of different pedagogical models are proposed to support e-learning[1], ranging across a spectrum from objectivist to constructivist models. It has become a common belief that the best model for teaching in higher education is the constructivist model[2, 3].

When creating learning material that follows the constructivist tradition the focus for the author of the learning material is on creating material that focuses on the activities performed by the students. Frameworks like the one described by Ferreira, MacKinnon, Ra[4] et al. are a huge help when constructing the material. A challenge for the authors of learning materials, in addition to the focus on getting the learner to perform activities, is that there must also be a sufficient amount of material constructed, and presented in such a fashion as to allow the learner the freedom to explore and navigate freely, or at least give such an impression.

It is also clear that most (if not all) people benefit from a social community setting when they are involved in learning activities. Access to others learners/supervisors to discuss their experiences and difficulties with or to try out ideas is helpful or even a necessity. Traditionally this social community is present in lectures and tutorials. The authors view is not that the only learning that can occur is face to face, but rather that social activities are an important and significant part of the process. As Mayes[5] puts it: “Lectures are occasions where the individual is confirmed as a member of a learning community.” One of the challenges in online learning is to create this feeling of belonging to a community.

Another challenge facing us as educators is that, as we know from school, young people are not always eager to do difficult things. When we as educators and tutors are faced with the challenge of getting them to do so, two choices are often available. The main option available to schools is to impose a curriculum on them, but as an alternative temptation, when profit is a stake, they can lower the requirements for a pass mark. For the gaming industry neither of these are an option, which gives rise to the 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, and can we use this in education?”

II. WHY COMPUTER GAMES

Online game setups have been and can be used as a basis for a learning environment. There have been numerous trials of this in the form of simulations, MUDs and adventure games[6, 7]. Over the last decade multiple virtual worlds have been developed for general communication between users from different parts of the world. Some of these are environments where people can meet and chat, while other environments give the user the possibility to contribute and create worlds and virtual objects by themselves. Major environments in this area that have been around for a while are e.g. Active Worlds[8], Second Life[9], and Twinity. Addition has been made to these by universities to try to utilise them as virtual universities.

The increased availability of high bandwidth connections to support multi-user, graphics-rich environments such as gaming environments supports the use of these gaming technologies for virtual learning environments.

A. The engaging nature of games

The concept of flow was introduced in 1975, through a study of people involved in activities such as rock climbing,
chess and dance[10]. They describe flow as a state of complete absorption or engagement in an activity and refer to the optimal experience. During optimal experience, a person is in a psychological state where he or she is so involved with the goal driven activity that nothing else seems to matter. 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. For example, if the activity is to demanding it may produce anxiety rather than flow. Or, if it is not challenging enough, boredom, not flow, may be the result.

Past research[11] has shown that the flow state has positive impact on learning. A more thorough explanation in connection with computer games for learning has been produced by Kii[12].

B. Natural interest from the younger generation

There are many people that are already familiar with the gaming format, and there seems to be more every day, which means that there is no requirement for them to learn this as a new environment for learning.

There is also the benefit of storytelling that in educational games it gives us, as creators of educational material, access to all the same emotional factors enjoyed by ordinary game creators, such as emotional attachment. Once you've hooked the audience emotionally, if you know how to manipulate them in the right way, you can keep and grow that audience for a long time, getting the students to spend more time and work harder at the learning material which should result in improved learning and retention.

C. Learning by doing

Keeping the students active and engaged is an important part of learning. [15] Offering the students the opportunity to explore a new environment is giving them the potential to use one of the most potent inbuilt feelings in humans, curiosity. With the power of hindsight most people will say that making mistakes is what they learned the most from. A popular phrase being: “People should be allowed to make their own mistakes”. One challenge for us as educators is allowing our students to make these mistakes in a safe environment.

Students in a simulation or any active environment are also actively encouraged to be creative. The simulations must give the students enough freedom to allow them to explore and make mistakes, as mentioned above. Giving the students the option to explore their environment does give its own challenges, the simulation itself is more complex to create, and requiring more effort in addition the students can get lost and frustrated. Techniques to help guide and direct the students in the simulation or virtual environment are discussed later under the headings of scaffolding and getting help.

In games players make things happen, they do not just sit back and let impressions and events wash over them. Video games are by definition interactive and will force the players to participate in activities not just be a passive spectator.

D. Hard fun

“Hard fun” is something that happens when people are involved in something that is both meaningful and satisfying to them. “Hard fun” is the “flow” that occurs when time flies because you are stimulated and engaged, without all the resources you need and dealing with a challenging problem. “Hard Fun” is hard but it is fun because you are able to perform a difficult task. The important part here is: difficult/hard and able to perform. Some are advocating taking the hard work and discipline out of learning. 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.

There are also many educators that argue for the role of frustration in the learning experience, or more precisely the resolution of the frustration. We as educators must always be careful with inflicting frustration on students during the learning process, however the final resolution of the frustration is a powerful stimulator and source of great joy, the major problem with this approach is frustration can and will turn many students off. There is a natural frustration when moving into a new area of learning. Many games setups, including the game described in this paper utilise scaffolding and increased help to struggling students to ensure that the students are not turned off the whole experience. This scaffolding technique is described in the design for our system. [15] On the other hand the system must not make the challenges to easy and turning the students off in that way. This topic is covered previously under the heading the engaging nature of games, flow and by Csikszentmihalyi[13].

E. Avoiding challenges in learning

One of many challenges facing educators today is that many students tend to shy away from areas that are perceived as difficult and as a consequence of this is often seem to want the easy way. The main two choices employed are then either force them, or (an alternative temptation when profit is at stake) lower the requirements for a pass mark and thereby creating a substandard education. Examining the computer game industry and how they approach the same challenges. The gaming industry challenge is that when starting out in an computer game there are a lot of elements that needs to be learned and often a whole unfamiliar world that needs to be introduced to the gamer. And the gaming industry cannot employ the often employed tactics from education: people cannot be forced to buy and play the games, and, in general, players do not want the short and easy option. For us as 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?” One 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”. This may be regarded as an extreme view, but it is an observable fact that at times learning can be a pleasurable experience.

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

F. A computer game design for learning

The author has previously published a design[15] for a games-based virtual learning environment that can form the starting point for any new learning game. The system design is focused 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 design basis for the virtual learning environment is a gaming format. There are several reasons for this choice, games are generally built to offer freedom for the player to explore the environment and material, computer games also focus on the actions and interactions performed by the player and require them to take an active role. Another key benefit are arguably that game environments are inherently constructivist, so that even apparently drill and practice exercises are used by the players to construct their own view of the games world. In addition the gaming format lends itself to support the known advantages of narrative from oral traditions and fits with the younger generation's interest in current trends in the entertainment industry.

The author is aware that many games have been developed for specific learning purposes that have been successful and may that have not been successful. But even the successful games have not been able to be reused for any other learning purpose apart from the content they were initially designed for. At the same time the development of virtual learning environments and learning objects has focused on reusability of materials as a prime concept.

Social relations between students during learning are an integral part of the authors’ philosophy for learning. Manninen [16] 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 [17] 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/chat/audio 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 have also shown that knowing and meeting people in an online environment or game triggers frequent playing and not the other way round.

Students meeting face to face after a game session will continue to discuss the stories that have unfolded in the game environment, and they will naturally continue to discuss other topics that were discussed during game-play. More information on this topic can be found in the previously published design for a learning environment by the authors.[15]

The authors have been engaged in a series of experiments, reported elsewhere[18-22], that have sought to investigate the use of games technologies as learning environments, considering two dimensions of instantiation of learning constructs, namely bespoke vs generic and extrinsic vs intrinsic.

III. STRUCTURE OF THE GAME

The prototype game described in this paper was created specifically to be run as an addition to a second year module in analogue electronics. The lecturer for the module had previously identified areas where students in previous years were struggling and felt that any additional way of presenting this material would be beneficial.

In our game-based learning environment the subject area is divided into topics and subtopics, which are then modelled as levels within the game. The different levels contain multiple quests, each representing some areas of material that the student should learn. These quests, model the learning material within the context of the game. The quest format is founded on the simple principle of setting a task for the player and then rewarding them on the successful completion of that task. If the player does not succeed the option is to go back and try again. The games are all set as online multi-user where all the different players are present in the same virtual environment, giving them a possibility to help each other during the game. During a quest the player can be given any amount of help, since the aim of the game is to learn, not to determine if the students are capable of learning on their own.

In addition to helping each other there are inbuilt characters in the game, referred to as NPC’s, that will help students along and supply them with pointers to information needed to solve the different quests. As the players are given a task, they are initially given a minimum amount of information apart from a problem description. Upon visiting the quest giver again that will either receive a small piece of information and/or a hint of where to find more help on solving the problem. This extra information/hint may point to more help modelled inside the game in the form of a wise man or it may be something outside the game like looking up some web address, or simply a direct pointer to a chapter in a textbook. As identified above, the aim of the environment is not to control where the student is obtaining the knowledge, just to aid them in learning. This is particularly important in relation to game-play, as players will often use “cheats” obtained from sources outside the game to progress past a difficult problem or onto a next level. In this instance, the “cheats” would involve learning the concepts the game is seeking to instil in the players, so this encourages the use of multiple sources of information, improving learning skills.

IV. LEARNING CONTENT IN THE ENVIRONMENT/GAME

The story behind the game is as follows. The player is stranded on an island. When they arrive at the island, they are met by a person who gives them a mobile phone. This phone has an empty battery, which needs recharging. The problem is, they do not have any charger. The task is to build an advanced
charger for their mobile phone, utilising the bicycle generator as the power source for that charger. To complete the task the students have to start out by buying discrete components to build the different parts of the charger. There are a number of different steps which must be fulfilled to whatever order the student prefers, to assemble the complete charger. Several of these are dependent on each other thereby forcing a certain order of assembly, while others are independent, based on the discrete components, thus allowing the students the freedom to explore the learning material on their own. When the charger has been built, it can be powered by an old bicycle generator on a nearby island. In this way, the player can contact the outside world to get help.

The students assemble the circuit in the different steps. Each of these steps contains elements that make it possible for the students to select both wrong and correct solutions, as in the real world. In most cases there will be set of correct and even larger set of incorrect solutions. For instance, when assembling a voltage divider, choosing resistor values that are too small will result in a circuit burning up, while choosing values that are too large will result in excessive output impedance, and a useless circuit. Within these limits, there are several working circuits, which the students should be able to calculate. The sheer number of different resistor values in the game is large enough to render a simple trial-and-error strategy impractical and the students are placed in the position of having to utilise Ohm’s Law to achieve a successful outcome. The use of Ohm’s law is both for the vale selection and the resulting power through the circuit. The students face three different outcomes for the voltage divider: the circuit burns up; the circuit doesn’t work (due to high output impedance, or wrong resistor values); or the circuit works correctly as desired. The students can attempt to solve the problem as many times as they wish, but as noted above the range of outcomes will exceed most students’ willingness to just guess the solution, and we found with reasonably confidence that successful solutions represents appropriate application of Ohm’s Law.

Another aspect of the games design is that the avatar representing the student does not have the inventory capacity or the funds to purchase all the various resistor values. The testing facility are also places a fair distance from the shop, (approx. 1 minute of walking in the game) so running back and forth is neither possible but neither fun nor practical.

The game is made up of 8 steps. These steps consist of more or less simple electric circuits. The players are to build these circuits on their own, using the supplied components. Each step can be made up of several intermediate steps. In order to construct more complex structures, some of the later steps are dependent on the fulfilment of preceding steps, while others are completely independent.

A player can start building any of 6 units at the start. These starting points are shown with bold frames in fig.1.

Fig. 1: Structure of game content

The error detector (OpAmp) can only be built after the three amplifiers have been completed. The construction of the last step (the constant voltage charger) can only be started after all the other steps have been completed.

This scheme is thought to give the students a thorough walk-through of the design of a stabilized power supply, including all the important calculations and considerations.

A. The game

Below are shown some screenshots from the prototype. Figure 1 shows the student acquiring components from the shop. These components are later used in the construction of circuits.

Figure 2 shows the journal, specifying the current task, and their work window (Inventory). In addition the chat window and messages from the system window can be seen.
for us in the scope of this prototype. We have however created small amount of 2d artwork to illustrate components, the effort involved in these simple drawings are small.

C. The trial

In evaluating the prototype the authors sought to gain information on several areas. These students are in the area of electrical engineering and we wanted primarily to know:

- Do the students feel playing the game improved their knowledge, and does it actually improve their knowledge?
- Do they enjoy this form of learning, and do they find it useful?
- Is a games-based environment a viable way to present this learning material, and what level of embedding of that material is necessary within the game?

We have also previously demonstrated that this approach will result in reuse and socialisation so that is not a primary concern to investigate in this setup.[23]

We have also previously placed learning material within games, so that the games environment becomes the vehicle for delivering the learning material and shown levels of reuse and socialisation. The experiments are all part of a series of experiment in order to establish what level of embedding of that material is necessary within a game, and what levels of richness and size of games area are required to create motivation and engagement. From this a methodological approach to the development of games for learning there has been developed and published a game for a few different engineering disciplines.[24, 25]

The students in the second year electrical engineering degree at the authors university was offered the game as an addition to the usual activities such as lectures, laboratories, and tutorials in a module on analogue electronics. The students are offered lab facilities where the client is installed for them in addition all the students have the option to download the client to their own laptops or home computers.

The game was introduced to the students in a tutorial and they were free to download the game to their own computer for both online and stand alone use. It was not an requirement for the students to use the game, the students was encouraged to use it and the week after the introduction to the game there were no other activities scheduled, giving the students ample time to try out the game. It was observed that nearly all the students elected to install and try out the game just after the short introduction was complete. Due to fact that the students had an option for offline use of the game usage statistics from the game server are not reliable, feedback from the students reported that a significant amount of them had attempted to complete the game.

A note here is that in this trial, as in previous trials, there is a particular group of students that are not interested in using the game, arguing that they don’t enjoy games and feel it more efficient to concentrate on traditional tutorials. This group tends to consist of what can be referred to the stronger students.

B. Development setup

Online games setups can be used as a basis for a learning environment. There have been numerous trials of this in the form of simulations, MUDs and adventure games[6, 7] During the last few years multiple virtual worlds have been developed for general communication between users from different parts of the world. Some of these are environments where people can meet and chat, while other environments give the users the possibility to contribute and create worlds and virtual objects by themselves.

The prototypes developed for the experiments described in this paper are an online multi-user game where all the different players are present in the same virtual environment. The prototype is based on the Torque game engine from Garage Games, in addition we have utilised the Torque MMO Kit initially created by Prairie Games Inc, but now maintained and developed by a group of users under a open source licence. The Torque MMO Kit requires several servers, SVN, IRQ and HTTP, C++ and Python development environments in addition to the Torque games engine and its suite of tools. The inclusion of tools for creating jpeg and 3D-models are also useful for creating artwork that fits with the theme of the environment. We did not opt for creating our own models, just altering models that were available to us. The effort required for creating 3d artwork, is substantial and was not a viable option.
From a general viewpoint the fact that these students not using the game is not a problem, since these students probably will do OK and are not the main aim for this experiment.

V. FINDINGS

The prototype was developed to provide an engaging game environment, in which we could investigate the value of such environments for learning, and particularly consider the impact of different levels of embedding of learning material within the game-play itself.

Observing the statistics from the server none of the students logged on to the system to any great extent after the initial trials. They may still have used the offline client and gained access to the same learning material, and some told us they did just that. But here is no other that anecdotal evidence for this.

The lack of continued play by the students after the first trial are somewhat disappointing, but more or less in line with some of our other findings. The environment needs to be rich with many game elements and a general rich environment with preferably many other simultaneous players to create increased levels of the desired engagement resulting in more reuse and socialisation.

The actual feedback from the students from the questionnaires is positive and encouraging. Students clearly find the idea of games-based learning strongly positive. However, these results do echo some of the studies on games that have been carried out, previously referenced in this paper, that enjoyment and flow can significantly improve learning uptake.

REFERENCES