

# Literature Review for Gamification In Education

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The purpose of this paper is to explore the potential application of video games to aid educational development, particularly in Computer Science. The review of literature suggests points for and against this approach. The former is that potential exists to entice students into doing a course, motivating students to work harder and aid them in understanding the content. The latter is that there are social issues that need to be addressed such as the perception of video games, the possible gender divides and the potential for the games to cause unwanted behaviour in students. It is also evident from this paper that there is a lack of video game application to a university level entry Computer Science course, with focus being on the gamification of the content or game design, rather than using a game to teach and extreme attention to detail needs to be given when designing a game for a diverse audience.

## 1. INTRODUCTION

This literature review concerns itself with the relevant published information regarding education of learners, with the main focus on university freshman studying Computer Science, through the use of interactive media. The primary focus of this review is the use of video games (henceforth referred to as games) both commercial and non-commercial to fill this role. It addresses the view of games as a media purely for entertainment, why it is important for them to be considered for teaching people, why they are not prevalent in education, etc.

The concept of games has radically changed in past years with recent studies showing more educators advocating for its adoption into the classroom [Ruggiero 2013]. Designing and building new systems for engaging teaching is important in the modern world as students have a great deal of information that needs to be taken in and retained. This review serves to inform the reader about the state of using interactive media in the classrooms as a potentially effective form of encouraging enhanced learning and why it should be strongly considered as a way to teach intuitively.

## 2. RATIONALE

Sources tend to agree that we live in a digital age. Children grow up with and use a number of different types of computing devices in their daily lives [Kiryakova et al. 2014; Feldgen and Clúa 2004; Huang and Soman 2013]. Educators are aware that they need new and interesting ways of captivating students and focussing their attention on course work. Education systems are in a time of change and new ways to leverage technology should be considered to guide the current generation of students into the future.

Most students today are familiar with video games or at least the concept thereof. These games often provide hours of entertainment and distraction to multitudes of people of all ages. An example of this is the Facebook game "FarmVille" which reached over 80 million players in 2010<sup>1</sup>. This seems to be a natural fit to adapt into education and in recent years the perception of this media has slowly started shifting away from being purely for entertainment purposes.

Modern students are more willing to engage with each other through online or

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<sup>1</sup>Data taken from a report by ABC News in 2010. <http://abcnews.go.com/GMA/Parenting/facebook-met-farming-80-million-play-farmville/story?id=10608972>.

multiplayer video games rather than do this in a direct manner [Annetta et al. 2006]. The element of virtualisation, having oneself represented as a virtual avatar to other people, allows for real identity to be obscured and confrontation to be avoided. This, perhaps, removes the fear of ridicule that many students today suffer in the classrooms.

Games allow students to directly engage with the content that is being delivered. By introducing elements of design, creation and personalisation a student can have a much more meaningful and personal experience with this content and in turn lend more attention to it [Lee et al. 2004].

### 2.1. Levels of Education

Using games as a medium to teach concepts to people should sound promising, but there are restrictions to this. Factors such as age groups, gaps in interest based on gender and various others need to be considered when trying to achieve this.

There is clear evidence that children attending primary through high school do indeed benefit when using this kind of teaching methodology [Lee et al. 2004; Papastergiou 2009]. While the types of games for the primary school level are generally very basic, they still tend to have a very positive effect on the motivation of learners. A study [Lee et al. 2004] found that using a skill-and-drill approach to basic numeracy problems, children at these younger ages were able to solve questions at a higher rate than they would do through traditional schooling.

Much effort has been put into using games as a learning medium for higher level education as well. Whole introductory Computer Science courses have been restructured to incorporate visual based learning. Gaming elements are also being introduced to allow students to get immediate feedback for their tasks and have more fun while learning, leading to very positive results in the interest of the students and their achievements [Leutenegger and Edgington 2007].

### 2.2. Computer Science

Computer Science concepts can be difficult to understand and visualise as a student being exposed to the material for the first time. It is important to solidify the knowledge of students at the early levels if they are to be proficient in the subsequent years. Universities today try to encourage students to study Computer Science by introducing some form of game development into the course [Xu et al. 2008; Becker 2001]. The belief is that students, being interested in interactive media like games, will take the course with the goal of designing and creating their own video game(s).

This approach appears to have positive results, with a study showing that their university has seen increased enrolments and interest from students to learn about Computer Science [Leutenegger and Edgington 2007]. Yet the bigger problem remains: many students find the content and the process of studying boring and not engaging. Some attempts have been made to adapt the modern video game paradigm into education. Games such as Lightbot<sup>2</sup>, Code Combat<sup>3</sup>, CodeSpells<sup>4</sup> and various others have attempted to bridge the gap between recreational games and teaching programming. This is discussed later in this review.

<sup>2</sup><https://lightbot.com/hocflash.html>

<sup>3</sup><http://codecombat.com/>

<sup>4</sup><http://codespells.org/>

### **2.3. Social Elements**

Video games are still seen as just that: games. Education is generally not seen as something that is supposed to be fun, however the effects of a fun learning environment should not be discredited. Students that have fun often tend to go further in their efforts to learn and study harder [Becker 2001]. Becker notes the example of having her first year Computer Science students program a minesweeper game in ASCII. She observed that many of them worked harder than on conventional assignments and were inspired to look at extra-curricular sources to improve their games.

Contrasting the negative social issues that games in the classroom face, this media can have a large impact on the social interaction of students with one another. Many games of today feature some kind of multiplayer functionality, often pitting students together to try to outperform one another or to work as teams to accomplish goals that might not be easy for an individual to solve.

A paper written on the role of games in the classroom suggests that these games have the potential to cause anti-social behaviour in students due to the addictive nature of many of them, along with other negatives and positives [Walker 2003].

## **3. GAME TYPES**

There are many different types of video games, including genres such as puzzle games, action-adventure role playing games and first person shooters. Not all of these types of game genres are popular with every type of person and there is a great deal of personal preference that goes into whether a person prefers a particular genre over another.

While every video game has learning elements present, educational games aim to bring across specific learning outcomes and as such pedagogical aspects need to be considered.

### **3.1. Learning Style**

Every student is unique and while it makes sense that there will statistically be some overlap in the way in which students learn, it cannot be ignored that there is a multitude of learning styles that need to be catered for. Individual students may even have more than one learning style themselves.

A paper on the relationship between game genres and learning techniques showed that Prensky identified that learning content appropriate for Computer Science, such as logic, questioning, problem solving, etc., is probably best done through a genre such as a puzzle game or an open-ended simulation game. However, it is noted that they believe further research needs to be done in order to more accurately match types to learning styles [Rapeepisarn et al. 2008].

By combining studies done by Prensky (2005) and Chong et al. (2005), attempt was made to bridge the relationships between learning techniques, activities and game genres [Rapeepisarn et al. 2008]. Using this, it is clear to see that since there are many learning requirements for Computer Science a great deal of genres apply to it. There is no clear cut choice in terms of genres and it would bode well to incorporate different elements from different genres depending on the type of content that is intended to be taught.

### 3.2. Gender Influences

The identification and importance of gender equality in recent times makes this a serious point to consider in the research for adopting a games approach to teaching, with gaming still regarded as a predominantly male activity. Many studies related to gaming in the classrooms take account the representation of females with the majority of the studies reporting that interest in interacting with these educational games are very similar between male and female participants.

One paper mentions that of the students involved in the study, males interacted with some of the game projects on a more regular basis and made faster progress in others. However, she found that there was not much difference in terms of learning between the genders [Papastergiou 2009]. It is also noted that females tended to express appreciation towards female protagonists in the games, which would indicate that some kind of gender bias should be avoided in these kinds of educational games where possible as to avoid gender bias of players.

Another argues that the trend in decline for the application of women in Computer Science could be related to the lack of willingness of many departments to adopt a more real world view [Becker 2001], which includes the view of video games.

## 4. USER EXPERIENCE

One of the most critical aspects to the success of a game is the user experience. If a user finds an interface complex and difficult to learn they will tend to be less captivated and more reluctant to continue using a program. User experience is a difficult problem; not every person has the same ability to understand information presented to them and not everyone is open to the same approach/experience. Finding the most common and accepted way to present information to a user is very critical when designing a video game and especially so for a game that needs to keep students motivated to learn a subject that is perceived to be "boring" and "difficult" [Papastergiou 2009].

Chen speaks about the user experience in games and mentions the concept of "Flow". She describes this as the stage where focus is at maximum and a user enjoys the product the most [Chen 2007]. It is clear from this that a balance needs to be struck between the difficulty of the challenges that a game presents and the interest the challenges can generate. If the former is on too high a level, the user will become irate with the program. If the latter is too low a level, the user will be easily bored and not motivated to continue.

The paper by Chen also mentions one particularly interesting point: adaptive choices. By setting the game around the choices of a player, the flow can be adapted more easily and make the player's experience feel more personal.

## 5. RELATED WORK

There is a multitude of educational game content, often referred to as edutainment, that is prevalent today. These games target different audiences with the aim of teaching different content such as maths, physics, etc. or variations on a topic, such as different programming languages.

Currently, teaching programming is done through a variety of different methods. There is the traditional or conventional method that is still widely being used

today. This method involves learning the fundamentals in a more tutorial driven way with emphasis placed on reading and understanding work through lectures and prescribed readings. Among students this is considered to be boring, often leaving them feeling like the content that is covered or the way that they are being taught is not applicable to the real world [Prensky 2003]. This translates to these students finding the courses difficult due to lack of motivation [Papastergiou 2009]. Other methods have started to become more common, with games or the gamification of course content being used to combat this lack of enthusiasm and motivation in students.

Some of the major ways in which programming is being taught interactively and a discussion of issues revolved around them follow:

### **Robots.**

The Bryn Mawr College uses robotics and the programming of video games to entice students to pursue Computer Science as a major and to motivate existing majors to stay committed to the course [Xu et al. 2008]. This is a novel approach and according to the results of the paper, students enjoy creative exploration of Computer Science concepts.

The problems with this implementation is that the suggested price for the robotics hardware is as much as textbooks that students require for the course. The study also notes that students found inconsistencies in hardware irritating or frustrating.

If students are to engage in this kind of educative practice it would require the institution to provide the hardware, significantly increasing the cost of the course. Another alternative is that the students purchase the equipment themselves. This could prevent more students from studying Computer Science at institutions due to the cost of purchasing the hardware coupled with the already high cost of purchasing prescribed material for the course.

### **Video Game Modification.**

Game modification, or "modding", is the act of changing aspects of an existing video game into something of personal creation. This is a very wide practice and tens of thousands of these "mods" are seen in a number of commercial titles.<sup>5</sup>. An idea has been proposed to teach Computer Science, among other subjects, through game modding [El-Nasr and Smith 2006].

This practice leads to helpful visualisation of Computer Science concepts and there is the potential to highly motivate students, because they are potentially interacting with games that they play recreationally. While this is true, there is a much higher focus on game design than general programming skills. More often than not the learning to create modifications for games require specialised skills to be learned, such as learning how a specific game engine works or learning the tools for modding included with games.

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<sup>5</sup>11,996 video game modifications on the popular website Moddb as of the 27<sup>th</sup> of April 2015. <http://www.moddb.com/mods>.

### **Mini-languages.**

A study [Brusilovsky et al. 1997] describes "mini-languages", which is a simplified and scaled down programming language. This study shows how the use of mini-languages to visually teach beginner programmers can be an effective strategy.

As the paper mentions, the most popular mini-language "Karel the Robot" was used to introduce university students to Pascal for their programming course. This method allows for visual programming with direct feedback delivered to the user, but it is a dated method.

### **Sweet Switches.**

While not targeted towards University level programming, this is a program designed for younger students. Sweet Switches is a puzzle game that has specific objectives for users to achieve. The game-play is analogous to programming concepts and aims to inform a player of how things such as order, conditionals, loops and other basic computer science concepts [Daros et al. 2014].

### **CodeSpells.**

CodeSpells is a full 3D virtual environment in which a player can move around freely as an avatar and interact with the game world by creating magic spells (entities that have some effect on the world around them) through different methods. The video game was originally intended to teach younger students to learn how to program in Java. Players are given the ability to see the effects of the code that they type immediately.

A paper by the developers of the game states that it is a learning environment that does not rely on any additional information to be taught to the player [Esper et al. 2013]. They tested the early implementation of the game with freshman Computer Science students and found positive results.

### **Pex4Fun.**

There exist multiple online platforms that allows anyone to learn the fundamental skills of programming as well as advanced skills. One such service is called Pex4Fun. Educators can use this platform to provide an environment for students to learn basic to advanced programming concepts in separate virtual environments, allowing students to get direct and fast feedback for assignments that they do [Tillmann et al. 2013].

It provides a particularly interesting feature called a "coding duel". In these duels, players are given a puzzle that has been created by another player and the challenge is to reproduce the same behaviour as the author. This is how learning is gamified. By having one player create the challenge and another solve the problem that was created it gives a competitive spirit to the game, encouraging people to try to solve more problems.

The majority of attempts to gamify education has resulted in visual programming languages or conventional programming with gaming elements. Most of the educa-

tional video games that currently exist are 2D puzzle or platformer games aimed at a younger audience.

There is a need for a system that will allow students entering a university level Computer Science course with no prior programming experience to actively engage with the material being taught. This system would need to present the user with a non-juvenile experience and one that they can relate to.

## 6. CONCLUSION AND DISCUSSION

It cannot be ignored that today's students are living more digitally and therefore are more computer-literate by default. With the ever growing interest in video games it is important to try to capitalise on this technology and utilise it to positively affect education.

There are numerous game projects that are teaching programming skills to younger children at the primary and high school level. While there are efforts to apply gamification to Computer Science courses, there is a lack of video games that aim to teach introductory programming for this level. A lot more emphasis is placed on visual programming languages or programming with the aim of designing and creating a game. This is what this research project aims to address.

Teaching programming to students who have no prior knowledge or exposure is a challenge, especially today due to students finding the work and the process of acquiring the skills boring. The age of students coming into such a course is also a critical factor in deciding how to approach the design of the game. It is not possible to cater for every individual person out there. The design of the challenges and the setting of the content needs to be carefully considered so as to make it as neutral to all as possible while not seeming trivial and boring.

Since there are many different game types, picking one best type is not possible. Careful consideration must go towards the choice of game types as it could significantly influence the way that students perceive the game and enjoy or absorb the content. It is important that players are given choices and made to feel as if their choices matter and have an impact on their game experience, regardless of game type.

Games in the classroom can be used to create an environment of work and play. They can be used to encourage competition and exploration but must take heed not to distance students from each other through this same competition. It is important to evaluate how they can be integrated into classrooms, because evidence shows that they can be a very useful tool for existing students to learn new concepts and for new students to be enticed to do the course.

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