A PRACTICAL INVESTIGATION INTO THE POTENTIAL FOR SERIOUS GAMES TO AID THE TEACHING OF GAME PROGRAMMING

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DECLARATION

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ABSTRACT
This practical study investigates the use of serious games to teach videogame programming. Literature on serious games is reviewed, considering the different markets they are made for. Literature on game-based learning is also reviewed, considering the arguments made by Marc Prensky and James Paul Gee for using videogames to assist learning and teaching, as well as various efforts to use games in educational environments. Afterwards, a 2D platform game is developed to help the user develop knowledge of the scripting language Actionscript 3, with sections of code missing that the user must complete in order to pass certain obstacles. The game is then used in a focus group session with five male university students in the first year of a course in games development, and their ability to overcome the obstacles in the level is observed. The participants face many issues while playing the game and no one is able to reach its end. Analysis of the focus group session reveals flaws both in the product and in the conducting of the focus group. However, evidence of collaboration between the participants is observed, and the game also appears to have some entertaining elements. Ultimately, it is advised that more research should be conducted exploring the concept of using serious games to teach game programming, as many of the flaws apparent in this investigation might not feature in a professional study.

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1. INTRODUCTION

1.1. Serious games and game-based learning

Videogames, like music and movies, are produced mainly with the intent to entertain and enrich. They appear to have succeeded in this respect, as the videogame industry has grown to an extent where it reportedly overtook the music industry in 2007 (Long, 2008), generating £4.034 billion in revenue in 2008 and £3.311 billion in 2009 (Remo, 2010). Part of the entertainment value found in videogames, some experts claim, stems from their ability to immerse players in environments with underlying rules and inner workings which are learned subconsciously. This is referred to as "unforced learning" (Prensky, 2006, p5) and Koster (2004) claims that this is the 'fun' looked for in a videogame. This element of videogames has been identified by professionals and used to create games with the intent to teach players skills to apply in real environments, or 'serious games'.

Serious games have a notable presence in many different industries. The growth of the serious games industry may be the result of the efforts of academics and professionals to emphasise the importance they see in using games to aid teaching. Gros (2007) claims that videogames can be effectively used for learning specific strategies and attaining knowledge, while Gillian Brown (2008) has suggested the ability of serious games to assist learning in all tiers of education, "from initial teacher training to professional development." Wisconsin University professor James Paul Gee has gained a reputation for promoting the contribution that videogames could make to better methods of education, particularly with his book ‘What video games have to teach us about learning and literacy’ (2003, second edition 2007). Jenkins considers him to be “the Johnny Appleseed of the serious game movement” (Gee, 2007). Similarly, Marc Prensky has made great efforts to promote the application of games to learning environments, writing books such as ‘Digital game based learning’ (2001) and ‘Don't bother me Mom - I'm
learning!' (2006). He is also the founder and CEO of Games2train, a company dedicated to the deployment of game-based learning in corporate and educational areas.

1.2. Serious games and game programming
The concept of game-based learning has been explored in various areas of computing, such as software engineering and programming. Claypool and Claypool (2005) have published a paper about their efforts to apply game design principles to a software engineering curriculum, to encourage active and more engaged learning. The results they encountered seemed favourable. Furthermore, the concept of active learning, which forms part of the argument for serious game deployment, has been explored with 'Alice', a graphical scripting environment designed to introduce users to programming, as well as help them to visualise concepts and procedures, through manipulation of 3D objects in a virtual world (Cooper, Dann & Pausch, 2000). However, while Claypool and Claypool's research entails a similar field, there does not seem to be any prominent use of serious games and game-based learning to assist the teaching of game programming. This study proposes the use of serious games for this particular subject, testing their educational and immersive qualities to identify if they can allow students to develop the necessary skills for game programming more easily and effectively. University courses in games development are negatively perceived by those in the industry. David Braben, chairman of Frontier Developments, considers 95% of video gaming degrees in the UK to be “simply not fit for purpose” (Cellan-Jones, 2008). Serious games could benefit game programming by allowing students to graduate from university courses in the subject with an increased level of skill, potentially addressing such apparent skill shortages. Furthermore, it could be argued that if serious games can assist teaching in any field, they can assist teaching in games development, due to the existing connection between the two concepts. Serious games feature as one of the topics covered in the teaching of game development; their development process is discussed, as well as exactly what they entail and the benefits they appear to have brought to the industries they target.
1.3. The investigation

In this study, existing literature concerning serious games and game-based learning is reviewed, covering works by Gee and Prensky, as well as efforts to deploy games in educational environments. To discover if serious games have the potential to assist the teaching of game programming, a serious game has been developed as an educational resource, for testing in a focus group session with students studying games development. If such a game proves helpful to these students, game programming education could have the potential to become a new market for serious game developers to work towards, while game programming courses could benefit from an improved rate of skill development.

2. LITERATURE REVIEW

2.1. Introduction

Videogames are frequently linked with violence, accused of either desensitisation towards violent scenes (Carnageya, Anderson & Bushman, 2007) or the incitement of violent behaviour (Anderson, 2004). Videogames are also accused of reducing the intellectual capacity of those who use them, advancing change towards an “infantilized society” (Will, cited in Johnson, 2005). However, arguments have also been made that videogames are benefiting society, improving the intellectual capacity of their users as a result of the complexities in their stories (Johnson, 2005). It is a topic of discussion that games can be powerful educational tools, in particular because they can transfer skills more effectively.

This literature review features the topics ‘serious games’ and ‘game-based learning’, considering books on the subjects and published schemes concerning their deployment. Arguments made in the literature are considered, as well any specific counter arguments made by others. The discussion of serious games features many examples and claims outlined in the books ‘Serious games: games that educate, train and inform’ (Michael & Chen, 2006) and ‘Developing serious games’ (Bergeron, 2006). Following this
topic, the review covers the subject of game-based learning. The works of two authors are reviewed on the topic – Prensky and Gee. The interpretations of game-based learning from both these authors are reviewed, discussing the arguments made in the books they have written. The literature review then considers different efforts to apply games, and the apparent learning principles behind them, to educational environments and purposes.

2.2. Serious games

2.2.1. Overview

Bergeron (2006, pxvii), defines that a serious game:

“has a challenging goal, is fun to play and/or engaging, incorporates some concept of scoring and imparts to the user a skill, knowledge or attitude that can be applied in the real world.”

Susi, Johannesson and Backlund (2008, p1), on the other hand, argue that many more definitions are thought to exist and that defining the concept is a key issue for discussion. Sawyer and Smith (2008) accuse many serious games developers of producing definitions based on their particular output, therefore disregarding the wider scope for serious games. However, Susi et al. claim that a core meaning is generally agreed on, that serious games are games used for other purposes than entertainment. It has been claimed that the term ‘serious games’ was devised in response to concerns that games are not educational (Clarkson & Brook, 2007). In addition, some have the opinion that the term ‘serious games’ sounds self-protective or like an oxymoron (ibid.). However, serious games have still succeeded in attracting a significant number of research projects, such as the Games-to-Teach Project and the Serious Games Initiative. (Squire, 2006a, p1).

According to Michael and Chen (2006, p47), serious games exist for the military, government, healthcare and education markets, as well as for corporate environments and groups with a political, religious or artistic agenda.
2.2.2. Serious games and middleware
The budgets for serious game projects are thought to vary from tens of thousands of dollars to tens of millions of dollars (Waters, Bassendowski & Petrucka, 2008). Furthermore, while the entertainment games industry is considered to push new technology to its limits, the markets for serious games allegedly tend to use more dated technology (Michael & Chen, 2006, p31), with the exception of the military market. Therefore, the development of serious games is often assisted with the use of middleware products, such as game engines, in order to produce a higher quality game in a shorter time period. Stapleton (2004) lists ‘VR Phobias’ and ‘Biohazard’ as two examples of serious games developed through modifying existing game engines, with notable cost reduction as a result. Stone (2009), meanwhile, argues that reuse of the software forming the groundwork for products such as the ‘Unreal’, ‘Quake’ and ‘Half-Life’ games helped the serious games community to succeed and expand through the 1990s. However, caution should be exercised to ensure that the use of middleware products do not limit developers’ creativity, due to the level of abstraction they provide (Bergeron, 2006, p90).

2.2.3. Military serious games
The military has ostensibly made the largest contribution towards the serious games industry. Some claim that the term ‘serious games’ makes them initially think of military projects with large budgets (Blackman, 2005). The military also appears to have exercised the thinking behind serious gaming long before it manifested in electronics, in the use of ‘wargames’ such as chess. Chess, with origins allegedly dating back to the seventh century AD, is considered to provide a stylised but effective representation of warfare before the use of gunpowder, and officers were trained using chess with intent to improve their performance on the battlefield (Michael & Chen, 2006, p49). The true origins of wargames, however, are thought to predate chess and potentially even written history (Perla, 1990, p15).
More recently, the military has made significant use of the technology behind videogames to produce what could be the most successful serious game in recent history: ‘America's Army’. Launched on 4 July 2002, and developed using the game engine for ‘Unreal Tournament 2003’ (Bergeron, 2006, p30), America's Army intended to promote the US military by giving players a realistic experience of carrying out missions as part of the army. In two years, the game had allegedly been downloaded over 17 million times and gained a community of four million registered players (Michael & Chen, 2006, p56). However, the game is considered to be a propaganda tool (Nieborg, 2006, p7) and it has been criticised for suggesting accurate soldier experiences but disregarding issues such as separation from family, conflicts between duty and personal values, and social contexts affecting combat (Brown, H.J., 2008, p75).

2.2.4. Government serious games

Even before the advent of serious games as currently known, governments were claimed to benefit from the use of games to analyse and solve specific problems (Abt, 1987, p89). More recently, serious games have been created for governments at various levels, including, among others, national levels and state or provincial levels (Michael & Chen, 2006, p83).

Concerning the national level, numerous versions of the game ‘America’s Army’ are thought to exist for different areas of government, such as the US Secret Service (Nieborg, 2006, p3). Furthermore, simulations such as ‘Angel Five’ have allegedly been used to train agents in the American Federal Bureau of Investigation (Michael & Chen, 2006, p85). An example of a serious game created on a state level is ‘Caltrans Project Management Simulation’, created in response to changes in the structure and procedures of project management in the California Department of Transportation (Caltrans). The purpose of this game was to transfer project management skills to non-project managers (ibid., p94).
In the US, a significant incentive to develop serious games for the government concerns the available funding opportunities. Special programs have been established to grant government funding to approved projects (Bergeron, 2006, p301), including the Small Business Innovation Research (SBIR) program, which could directly provide developers with up to $800,000 in early research and development funding.

### 2.2.5. Healthcare serious games

Serious games for healthcare are argued to have the biggest impact on the welfare of individuals and society (*ibid.*, p38), and this market can be subdivided into three categories: consumer, guided consumer and professional. Healthcare games in the 'consumer' category can be used without the intervention of a healthcare provider, and are often available on the internet. An example of a consumer healthcare game is 'MyPyramid Blast Off', designed to help young children learn about the basic food groups, while encouraging them to eat healthy and stay physically active (French, Howell, Haven & Britten, 2006). Meanwhile, healthcare games in the 'guided consumer' category are typically used under the supervision of a clinician. A noted portion of this subcategory uses Virtual Reality Therapy (VRT) technology (Hoffman, 2004), with intent to treat phobias (Carlin, Hoffman & Weghorst, 1997) and Post Traumatic Stress Disorder (PTSD) (Difede, Cukor, Jayasinghe, Patt, Jedel, Spielman, Giosan & Hoffman, 2007), as well as ease the pain from certain medical procedures (Hoffman, Patterson, Carrougher & Sharar, 2001). On the other hand, 'professional' healthcare games are used by clinicians themselves, with the intent to develop and maintain their clinical skills. Example professional healthcare games include 'Cardiac Arrest!', a game that puts the user in the role of an emergency room physician (Bergeron, 2006, p44), and the 'Augmented Reality Medical Simulator - Auscultation', an augmented reality game where an instructor or stand-in wears a sensor vest that randomly generates an affliction which the player has to diagnose (*ibid.*, p45).
2.2.6. Education games

Serious games also exist for use in educational settings, such as ‘Power Politics III’, a US presidential election campaign simulator which was made free to use in classrooms from spring 2005 (Michael & Chen, 2006, p123). Many discussions concerning the potential for videogames to assist learning have focused on the use of videogames in the education sector. It has been argued that the entire concept of ‘serious games’ originated from the concept of ‘edutainment’ products developed in the 1990s, aimed at young children and with intentions to educate through entertainment (ibid., pxv). Edutainment is considered to have mostly failed as a concept (Egenfeldt-Nielsen, 2005, cited in Harteveld & Bidarra, 2007), possibly because edutainment products were developed by academics rather than videogame developers, resulting in "boring" games using “drill-and-kill” learning (Mac Namee, Rooney, Lindstrom, Ritchie, Boylan & Burke, 2006). During the first Serious Games Summit in 2004, David Thomas, of Buzzcut.com, advised developers to avoid taking “the icing off the video game cake” and applying it “over the liver of learning” and expecting successful results (Michael and Chen, 2006, p30). Serious games are considered to be distanced from the concept of edutainment.

2.2.7. Corporate games

Before serious games were used in the workplace, corporate training had been implemented through courses of ‘e-learning’, consisting of the use of computers and the internet for education (Nichols, 2003). However, the act of producing electronic versions of existing induction courses has been argued to generate no progress in training, and that simply reading and watching screens does not guarantee sufficient transfer of knowledge (Neill, 2009). As a possible result, serious games have been developed for the purpose of training within the workplace, which are considered to help maintain interest and make the training more entertaining (Rankin & Vargas, 2008). PIXELearning Ltd. is a company with experience developing e-learning solutions that started developing corporate serious games in 2002 (Michael & Chen, 2006, p152). These include business simulations, which have been described to typically place the player with responsibility for a company,
department or project, with a predefined scenario to handle and a set learning objective to achieve. Games like these are claimed to impart skills more effectively than ‘click-to-continue’ videos (ibid., p153).

2.2.8. Serious games with an agenda
The ability of videogames to influence opinion and behaviour has featured in many discussions, as well as many conflicting articles (Kirriemuir & McFarlane, 2004, p10). At the Serious Games Summit in 2004, Debra Lieberman claimed experiences in games to be "real", due to the nature in which players respond to them (Michael, 2004). To this end, companies such as Persuasive Games exist, creating games, described by founding partner Ian Bogost, as “rhetorical tools” using “simulated experiences” for informing, persuading and influencing (Michael & Chen, 2006, p204). Persuasive Games’ portfolio includes the game ‘Howard Dean for Iowa’, created for the 2004 US presidential race to inform supporters of Dean’s policies and what they can do to support his campaign (Bogost, 2006). Games with similar intentions are also created by religious groups, including the evangelical game ‘Left Behind: Eternal Forces’, in which the player must convert neutral entities to Christianity or kill them (Brown, H.J., 2008, p105). In addition, games exist to express an artistic message, such as ‘9/11 Survivor’, in which the player must attempt to escape from the World Trade Center in New York directly after the 9/11 terrorist attacks (Radtke, 2008, p85). However, games with such agendas have potential to cause offence, including, for example, the “public outcry” against ‘9/11 Survivor’ (Michael & Chen, 2006, p223) and claims that ‘Left Behind: Eternal Forces’ “dehumanises” non-Christians (Greene, 2006).

2.3. Game-Based Learning
2.3.1. Overview
‘Game-based learning’ concerns the use of games, or the principles underlying them, for teaching and learning. The concept could have come about as a response to claims that learning processes are being hindered by a lack of ability to engage students (Pivec, Dziabenko & Schinnerl, 2003), as
well as an alleged demand for interactivity in learning environments (David, Werbin & Shaw, 1997). Numerous arguments have been made to promote game-based learning. These include the research carried out by Marc Prensky and James Paul Gee, who offer their own interpretations of game-based learning and the contributions that appropriately used videogames could make to learning and teaching.

2.3.2. Marc Prensky

Marc Prensky is the founder and CEO of Games2train, and his book ‘Digital Game-Based Learning’ (2001) has ostensibly caused much debate over the use of games for teaching. In this book, he provides an overview of what he refers to as ‘Digital Game-Based Learning’ (DGBL), discusses how and why games are able to teach, provides examples of how organisations are using the concept and advises how to implement it. One of the points he argues concerns the differences between older and younger generations. He considers current students to have, for example, a faster pace of thinking, a preference for more active methods of learning and an interest, rather than an aversion, towards new technology. He refers to younger generations as “digital natives”, and he argues that the education system, populated by “digital immigrants” with reluctance to accept change, has not evolved to reflect this, and is failing to maintain students’ attention but is instead causing frustration. He proposes DGBL as a possible solution to communicate to these “digital natives” more effectively, therefore keeping them more engaged and more willing to learn.

Prensky has produced many more articles on this subject, including the report ‘Engage me or enrage me’ (2005), focusing on his claims about the education system’s apparent inability to keep students engaged in the classroom. He has also written the book ‘Don't bother me Mom - I'm learning!’ (2006), elaborating on the practices of “digital natives” and how their “digital immigrant” parents can communicate effectively with them and assist their learning. Furthermore, he has discussed his arguments in venues such as the Handheld Learning 2007 conference, where he elaborated on the views
expressed in his books, and claimed, for example, that revisions should be made to curriculums, including a removal of the use of multiplication tables due to their roots in memorisation and an increased emphasis on more modern skills such as programming (2007).

However, Prensky's arguments for DGBL have drawn criticism. For instance, Bennett, Maton and Kervin (2008, p777) accuse the literature surrounding Prensky's ‘digital native’ theories of having little supporting empirical evidence, and they also suggest that Prensky might be basing some of his claims on anecdotal evidence and “appeals to common-sense beliefs”. They also cite studies on young people and their technology usage to claim that current technology is not influencing learning styles as significantly as Prensky argues (ibid., p778). Furthermore, in a review of Prensky's work, McKenzie (2007) talks negatively of Prensky’s “insulting” distinctions between digital natives and digital immigrants, and claims that Prensky's arguments lack “any evidence of data”. However, McKenzie's criticisms use a notable amount of emotive language, lacking the cautious scepticism expected from a piece of academic research and they therefore could be seen as irrational and unprofessional.

Prensky (2003b) has discussed some of the criticisms made against him. In response to a claim, for instance, that his work frequently makes over-generalisations (VanSlyke, 2003), he argues that his work intended to highlight growing trends rather than make judgements pertaining to entire groups. Furthermore, he argues that some are reacting negatively to his work because they feel he is proposing a complete change to the education system, when he is instead proposing that the education system is updated to reflect the needs of current generations. A particular point that may be of interest to discussions like these is that even in Prensky’s earlier work (2001), while he talks favourably of DGBL, he considers it neither to be the only way to educate current students nor a suitable solution to all problems in education.
2.3.3. James Paul Gee

Another supporter of game-based learning, James Paul Gee contributed to the field with the book ‘What video games have to teach us about learning and literacy’ (2003, second edition 2007). In this book, Gee proposes 36 learning principles present in games, based on both personal accounts of playing games and the accounts of others. These principles are covered under six subjects: semiotic domains, learning and identity, situated meaning and learning, telling and doing, cultural models and the social mind. He provides examples of these principles in action. One of the arguments he makes is that videogames encourage active and critical learning, while enabling players to appreciate design principles and master “semiotic domains”, recognising connections between different modes of information (i.e. images, words, actions and symbols) (p41). Another argument entails the ability of videogames to facilitate learning by encouraging repeated practice of a skill in an interesting scenario, before placing obstacles for which routines of play must be changed, while offering players opportunities to operate just within their capabilities (p68). Ultimately, Gee argues that while videogames should not be “co-opted” for academics’ purposes (p215), and while there may be potential for negative lessons to be learned (p216), the learning capabilities present in games are significantly supported by research in learning sciences (p218). He argues that all the learning principles he has discussed have the potential to benefit learning in schools. He also warns that students could develop undesirable opinions about school if they find deeper learning principles present in their popular culture. Furthermore, he considers games to be a new form of art, at the beginning of their potential to entertain and inform. He claims that he may have learned more information by writing this book than anyone might learn by reading it (p219).

Like Prensky’s work, critical reviews have also been written about Gee’s book, including an article by Prensky (2003a) himself. Prensky’s criticisms towards Gee’s book focus on his style of writing. He accuses Gee of applying too much jargon in the book, claiming that academics often do this to be associated with certain phrases, at risk of deterring non-academics from their
work by doing so. In addition, Prensky feels that Gee is too concerned about connections with the field of learning science, and he therefore does not make the argument for learning through games as effectively as it could have been made. He then interprets Gee’s learning principles in his own words to demonstrate the difference that simpler language could have made. Furthermore, he suggests that while he supports such jargon in literature for use by academics, he feels that it could impact on the merit of any original research, and that the expectations for academic writing should be reviewed. However, despite these criticisms about the language used, Prensky agrees with the points raised in Gee’s book, as he feels they add many new ideas and hypotheses to the argument for games-based learning.

2.3.4. Deployments of game-based learning
Attempts have been made to deploy game-based learning in real scenarios, and the results have been presented for discussion. At the Best Practice Session at the Handheld Learning Festival 2009, Dawn Hallybone (2009) discussed the use of games to assist learning in her junior school. She argued that children “learn through play”, and that traditional teaching methods discourage this. She discussed how her students used the game ‘Brain Training’ to develop their mathematical skills, and she argues that this game enhances the curriculum, as it motivates users to improve their mathematical skills and their letter and number formation. On the other hand, studies have been carried out claiming that Brain Training might just improve users’ ability to play that game and not their overall thinking (BBC NEWS, 2010). As well as ‘Brain Training’, Hallybone discussed the use of the game ‘Professor Layton and the Curious Village’ in the classroom, and how each student would write about parts of the game they liked, as well as what would feature in their own “curious village”. The Office for Standards in Education, Children’s Services and Skills (Ofsted) ostensibly supported these efforts in game-based learning, approving the use of “innovative technology for mental calculations”. Ultimately, Hallybone argued that it is not about the games themselves, but about giving students stimulus to inspire their writing.
Another attempt to apply game-based learning consists of the efforts of Claypool and Claypool (2005) to use the game design process to teach software engineering. Claypool and Claypool claim that videogames can effectively combine the ideals of software engineering, and that game development emphasises a need to develop a variety of skill sets, from high-level design to low-level implementation (p123). To test their ideas, they devise and implement a series of project modules based on game development, integrating games into an existing course in software engineering. They then evaluate the success of the course, based on the grades of the students in comparison to that in a traditional software engineering course, as well as the qualitative feedback provided by the students. Their results argue that many more students enrolled in this course than would have traditionally been expected, and the course distributed a significantly larger number of ‘A’ grades (p126). Furthermore, their collated qualitative feedback suggests that the course was effective at engaging and maintaining the interest of the students. Claypool and Claypool suggest that more extensive evaluation should be made, perhaps by comparing students’ performance both before and after the class. They also encourage long-term evaluation to determine the lasting effects of game-enhanced teaching in software engineering.

There is one particular effort to implement game-based learning that could be used to cast a decisive verdict on the entire concept. In 2009, a public (i.e. state) school was launched in Manhattan, New York, allegedly based entirely on the concept of game-based learning (Hsu, 2009). Named ‘Quest 2 Learn’, the school appears to be significantly influenced by research such as the work by Prensky and Gee. It claims, for instance, to use a pedagogy adapted to fit the alleged needs of the 21st century, with students engaging in active learning, and taking on the identities of mathematicians, scientists, writers, historians, and designers (Quest 2 Learn, 2009). Hsu reports that the school conforms to New York education standards, and the students take the same examinations as those in other schools. Jenkins (2009) suggests that if this school was to succeed in its intentions, then it could stand to be a significant catalyst for change in the way teaching and learning is carried out.
2.4. Conclusion
This review has discussed the concept of ‘serious games’, games used for purposes other than entertainment. It has discussed, with examples, the different markets for which serious games are created and then sold to, including the military, government, healthcare, education and corporate markets, as well as groups intending to express political, religious and artistic messages. The review has also discussed the concept of ‘games-based learning’, the use of videogames or their underlying principles in educational environments. It has discussed the interpretations of this concept by Marc Prensky and James Paul Gee, and considered counter arguments raised against their work. It has also discussed efforts to deploy game-based learning in educational settings, including the use of games in a junior school, the creation of game-based project modules in a course for software engineering and the launch of a school with a main focus on using games for learning purposes. The arguments, counter arguments and examples raised in this literature review were taken into consideration during the development, implementation and overall conclusions of this investigation into the use of serious games to assist the teaching of game programming.

3. METHOD
3.1. Design
The serious game developed for this investigation is a 2D platform game, where the user has to move a robot to the end of three levels, moving left or right and jumping where necessary. However, the game is given to the user in a state where some of the code is missing, preventing the robot from being able to function properly or pass the obstacles in the level. The user has to click on signposts in the game and read the text boxes describing different concepts in the chosen programming language, before closing the game and changing the actual programming of the game through the development environment in which it was created. The signposts inform the user what code they need to enter and where they need to enter it.
This idea was chosen because it could give the user experience of entering code in the chosen development environment, while directly showing them the results of their input, therefore allowing the game to test Gee’s active learning principle (2007, p41). Furthermore, this idea allows for more effective demonstration of the programming concepts discussed with less complex programming requirements for the game itself. The game does not need to be programmed to remember what has been taught to the user and what they have done to clear the obstacles in each level. This is already done when the user applies changes to the actual programming of the game and clears the obstacles relevant to those changes; all that the game needs to be programmed to remember is the current level the user is playing. However, requiring the user to edit the game in its development environment increases the chance of software errors or unwanted tampering, as the user has direct access to the code and therefore the ability to compromise the game (Aucsmith, 1996). In circumstances like this, supervision of the user’s progress through the game could be of significant importance to ensure no deviation from the game’s intended path.

3.2. Methodology

One focus group session was carried out for the investigation, in a room near the Learning Centre in the Park campus of the University of Gloucestershire. The game and development program were installed on the machines to be used by the participants. Privacy of the participants was considered, as this a crucial element of focus group research (Morgan, 1998, p87). However, the focus group session needed to be filmed for later analysis. Therefore, the participants had to sign a consent form stating that they agreed to be filmed as part of the session, that the session would operate in compliance with the ethical guidelines and policies of the university and that all recorded data would be destroyed after the submission of this paper. The participants were informed of the nature of the investigation, the subject matter surrounding it, what was expected of them and how long the session was expected to last. The participants then played the game while the host supervised, offering advice and assistance where necessary. This approach was chosen to
identify if supervision was necessary in order to ensure that the aims of the serious game could be met.

The investigation aimed to collect qualitative data, and at the end of the focus group, the participants completed a response form and the host asked them for feedback regarding the concept behind the investigation, as well as this particular implementation. The response form also requested such feedback, so any participants who did not want to communicate any concerns directly to the host could write them down in confidence. The decision to record the playing of the game and the feedback was made to allow for the collation of useful data from which to draw conclusions.

3.3. Equipment
The serious game was developed with the software application 'Adobe Flash CS4', using its scripting language 'Actionscript 3' (AS3). This scripting language was chosen because it is object-oriented in its approach (Elst, Yard & Jacobs, 2007), which it has in common with many currently popular programming languages such as Java and C++ (Horstmann, 1997). Furthermore, as the foundations for object manipulation (i.e. moving objects around a screen and changing their size) are already in place with AS3, the language could allow more opportunity for users to see the results of their code presented visually (Crawford & Boese, 2006). Therefore, it was considered an appropriate language to help those new to programming to learn core concepts. However, the decision to develop the game in Adobe Flash CS4, rather than its product predecessor 'Adobe Flash CS3', resulted in a need to install the newer application on all the computers used in the focus group session, with time-limited 30-day trial licences. While this did not appear to affect the operation of the focus group session, it was an avoidable mistake, as Adobe Flash CS3 would have been adequate for the game's development and deployment.

The game was developed on a personal laptop computer with the operating system 'Microsoft Windows 7' installed, while the computers used for the
focus group were desktop computers using 'Microsoft Windows XP'. Adobe Flash CS4 is designed so that the SWF files it generates can be accessed on any computer that can run Adobe's 'Flash Player 10' program – i.e. computers using Windows, Mac OS or Linux, among others (Bangeman, 2007). Furthermore, the use of basic graphics and minimal sound in the game prevented a significant system resources requirement. However, this development approach failed to account for differences in performance that could emerge on other computers. An observed result of this was that some computers did not load the sound files as quickly as others during the focus group session, which could have impacted on the quality of the product.

3.4. Participants

Five male university students in the first year of a course in games development participated in the focus group session. Some of these students claimed (in their session response form) that they were somewhat confident in their knowledge of Actionscript 3, while others claimed a smaller (but still present) level of confidence, and some claimed no confidence at all. These participants were suitable for the investigation because it had potential to help them build their knowledge of AS3, or test the knowledge they already have.

These students were requested to participate in the focus group by the advisor of this investigation's author. Usability-based focus groups have been considered to usually have five participants (Jordan, 1998), and it could be argued that this focus group session has traits matching a usability investigation, as it is testing the participants' ability to use the game. Therefore, the session had a good number of participants. Furthermore, this collection of participants appeared to conform to the recommendation by Greenbaum (1998, p35) that “groups should be as homogenous as possible”, especially when considering that all the participants were of the same age range, i.e. between 18 and 21. However, with this approach, it was not possible to identify whether or not the results of the focus group were influenced by local biases. Also, the investigation could be considered unprepared for any possible deviations from the data collected in the focus
group that could be encountered with female participants or those of other ages, either in opinions towards the concept or how they might play the game developed for the investigation. If tasked with a similar study in future, the author would attempt to gather participants of both genders from all over the country (and even from overseas if possible), in order to collate data with more potential for variation.

4. RESULTS
The participants signed the consent forms, detailing what was expected of them, informing them that they would be recorded on camera and notifying them that the focus group session would run for no longer than one hour. They were then informed about the concept of serious games and the nature of the investigation, before proceeding to play the developed game. Interestingly, one of the participants, when starting the game, uttered the words “I hate Actionscript and Actionscript hates me.” The host of the focus group supervised the session to offer advice and resolve problems that the participants could not fix. The session lasted approximately 50 minutes, at the end of which the participants filled out a response form and answered some questions concerning the game and the nature of the investigation.

In practice, the outcomes of the focus group session were not what the author had hoped for during the design of the investigation. Firstly, despite efforts to prevent this, there were faults in the game’s written communication that resulted in players making avoidable errors, causing confusion and potentially hindering their ability to learn the required knowledge. Furthermore, because of certain techniques used in the programming of the game, some of the code the participants had to enter seemed to be more complex than what they were able to expect, an issue which was only resolved after they were told by the host what to enter. In addition, while efforts were made to protect the game from issues related to its use within its development environment, relevant bugs were still encountered. To resolve this, the participants had to be informed not to press certain buttons on the keyboard, although the impact of
this issue might not have been significant, as these buttons were distanced from those needed for the game.

None of the participants were able to finish the game, despite its short length. The focus group session was ended when the host decided it should not operate for any longer. While giving feedback, one of the participants claimed that they did not initially understand how the game was meant to be played; they thought all the code was supposed to be entered in the actual game, rather than in its development environment. Furthermore, even after the focus group, one of the participants claimed to be so unskilled at Actionscript that, "I haven't got a clue where to begin." However, despite the game seemingly failing to achieve its aims, every participant claimed to like the idea behind the investigation – one participant said that “I liked the concept...I think that could teach people a lot”, to which the others agreed.

5. DISCUSSION
5.1. Errors made conducting the focus group

One of the issues that could have contributed to the arguably unsuccessful outcome of the focus group session was the errors made by the host. While introducing the session, the host initially forgot to mention the controls for the game, as well as the precise details on how the game was supposed to be played. As a result, the participants appeared to struggle to start the game. These issues could be the result of insufficient preparation, and if tasked with a similar project in future, the host would invest a greater amount of time towards preparing the session, as good preparation is thought to lead to good results (Hamm & Dunbar, 2008).

Furthermore, in a number of instances where there were errors in a participant’s code, the host solved the problem and informed the participant of the nature of the error. While this approach did attempt to communicate the relevant solutions to the user affected, it may have introduced a level of moderator bias into the focus group session. Moderator bias is claimed to reduce the validity of focus group data (Stewart, Shamdasani & Rook, 2007),
and it could be argued that the host hindered the participants’ ability to learn the different topics in the game by becoming involved in problem solving.

5.2. Communication issues within the game

During the focus group session, there were a number of instances where the game appeared to have failed to communicate certain messages. For example, while teaching about 'if' statements, the game attempted to inform about the use of two 'equal' signs for variable comparison through a message above where the user was to enter code. However, participants seemed to ignore this information, and the host had to inform them directly. In addition, the game provided example code while explaining certain topics, but some participants thought that this was the code they were supposed to enter to pass the relevant obstacle.

While the game attempted to facilitate application of the topics it explained through the obstacles in each of its levels, it could be argued that the communication of the knowledge itself, through boxes that appear on screen with a paragraph of words, relied too much on the use of text. A potentially better idea could have been to explain the topics through animated visualisations demonstrating how they work. By doing this, the game could have taken a more multimodal and therefore potentially more effective (Gee, 2007, p40) approach to educating the user.

5.3. Participant teamwork

Despite the game seemingly failing to sufficiently educate the participants to facilitate its completion, it did seem to instigate a degree of teamwork. On a notable number of occasions, participants asked each other for advice on how to deal with certain obstacles. For instance, one stuck participant went to another and asked “Do you know how to do it?”, and was told to "set this [variable] as false". There were even instances where a participant was able to identify errors in another’s code, inform of the error while pointing at their screen (bluntly in some instances – a participant was told that their error occurred “because that code’s completely wrong”) and help to correct them. In
one example, a participant helped another write an ‘if’ statement, while another watched. In an additional example, a participant noticed when another made spelling errors in their code.

It has been argued that learning is done most effectively through teamwork (Johnson, Suriya, Won Yoon, Berrett & La Fleur, 2002), and the game’s apparent ability to instigate this could be considered as a significant strength. Furthermore, it appears that the game conforms, to an extent, to Gee’s “dispersed principle” of learning (2007, p212), as certain knowledge about the game was shared with others outside it.

5.4. Evidence of entertainment

As well as instigating teamwork between the participants, the game also appeared to provide a degree of entertainment. There appeared to be a number of instances where participants were happy to overcome certain obstacles or obtain certain items – comments such as "I got a key!" were heard during the session. One participant appeared particularly happy to overcome a certain obstacle, shouting the interesting words “In your face! In your face!”. Furthermore, another participant seemed determined to overcome an obstacle they faced, with the comment “I will beat this.”

With respect to Bergeron's definition of serious games (2006, pxvii) it appears that while the game was not as able to “impart [a skill] to the user” as effectively as intended, it was still able to have a “challenging goal” and be “fun to play”. However, it could be argued that the difficulties the game had in achieving its educational goals could have reduced the extent of its entertainment, as some participants were not as entertained by the game as others, with one stuck participant using the comment “it’s a nightmare” when talking with another.
6. CONCLUSIONS

Based on the results of the investigation alone, it appears that the concept of using serious games to teach game programming may not have sufficient merit to be worth professional consideration. However, much like how Claypool and Claypool (2005, p127) recommend further investigation into their proposals, further research should be carried out before making a final judgement on this concept. Many of the issues surrounding the results of this investigation appear to originate from specific errors in this implementation. Issues with the game developed for the study, as well as the conducting of the focus group, appear to have reduced the intuitiveness of the game and prevented the users from successfully developing knowledge of Actionscript 3. However, an investigation conducted by professional serious games developers might not have such errors. Furthermore, from discussions with the advisor about the results of the investigation, it appears that the product developed for this study, rather than being entirely dismissed, could be more suited to intermediate users as a test of their knowledge of Actionscript 3. Many accounts have been produced in favour of the use of games to assist learning and teaching, and as Claypool and Claypool’s research appeared to prove successful with a similar topic, the concept of using serious games to teach game programming should not be dismissed based on the findings of this particular investigation.

7. REFERENCES


**APPENDIX A – GLOSSARY**

2D platform game – A game in which the player moves a character left or right, jumping on different platforms to reach the end of a level.

Actionscript 3 – Scripting language introduced in ‘Adobe Flash CS3’ (replacing Actionscript 2) providing programming functionality to Flash-produced products.

Edutainment – Games developed in the 1990s with intent to educate through entertainment.


Game-based learning – The use of videogames, and the principles underlying them, to assist learning and teaching.

Game engine – The underlying mechanics of a videogame. Licences can be sold for a game engine, allowing use and modification for the production of another game.

Middleware – Software connecting applications or software components in a product. Example middleware products include the ‘DirectX’ framework.

Serious game – A game developed primarily with intent to transfer and communicate knowledge rather than to entertain.

Wargame – A game based on military operations, real or otherwise.
APPENDIX B – GAME SCREENSHOTS

Example problem – Cannot move at start of game

Solution:

Example problem 2 – Cannot jump

Solution: