



DEVELOPMENT OF AN EDUCATIONAL GAME TO TEACH ITERATION AND CONDITIONAL

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A final year project submitted in partial fulfilment for the degree of
Bachelor's in Computer Science and Mathematics with Honours
University of Bath

April, 2019

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Declaration

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April, 2019

Abstract

To be written.

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Outline of Project

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Acknowledgements

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Chapter 1

Introduction

Chapter 2

Literature Review

2.1 Teaching Programming Fundamentals

In 1978, ACM Computing Curricula used the terms "CS1" and "CS2" to designate the first two courses in the introductory sequence of a computer science undergraduate course. CS1 described introducing students to programming fundamentals and CS2 to teaching data abstraction/data structures. The general principles of CS1 and CS2 have continued, but through the past years, the concepts covered in these courses have changed. The most recent curriculum by ACM-IEEE was created in 2013 (Hertz, 2010). This curriculum notes that the "vast majority of introductory courses are programming-focused, in which students learn about concepts in computer science (e.g., abstraction, decomposition, etc.) through the explicit tasks of learning a given programming language and building software artifacts". The curriculum considers 'conditional and iterative control structures' as fundamental programming concepts (ACM-IEEE, 2013). Thus these concepts are likely be taught as a part of CS1 or introductory programming units.

Koulouri, Lauria and Macredie bring together literature and summarise, that, the complexity of teaching introductory programming, which includes the topics; iteration and conditional statements, is widely acknowledged among educators. Novice programmers have difficulty in tracing (a method of mentally simulating the execution of the code before compiling), reading and understanding pieces of code and fail to grasp basic programming principles and routines. The overhead of learning the syntax and semantics of a language at the same time, and difficulties in combining new and previous knowledge and developing their general problem-solving skills, all add to the complexity of learning how to program (Koulouri, Lauria and Macredie, 2014). Therefore careful consideration will be taken to reduce these problems, with efforts to; introducing programming concepts at a reasonable pace, and making the game fun and enjoyable to keep the user motivated.

Introductory programming courses at University commonly entail, a structured course based on

lectures and practical laboratory work, and a curriculum focused largely on programming knowledge - particularly relating to the features of the programming language being taught and how to use them. Robins, Rountree and Rountree suggest that this approach is popular, due to the important role of such programming knowledge in programming and the sheer volume and detail of language related features that can be covered (Robins, Rountree and Rountree, 2003).

Another method for learning programming fundamentals, which has become increasingly popular, are online resources. These resources include; tutorial websites such as Codecademy and Khan Academy, which have accumulated millions of users; block-based programming environments such as Scratch and Alice, which provide creative visual environments, and educational games (Lee and Ko, 2015).

In comparison, traditional face-to-face classroom learning, centers on instructors who have control over class content and the learning process, whereas, online learning, offers a learner-centered, self-paced learning environment. Online resources are also time and location flexible and provide unlimited access to learners (Zhang et al., 2004). On the other hand, whilst there are many benefits to online learning, there are doubts over its effectiveness (Zhang et al., 2004). Online learning should not replace traditional forms of learning (Zhang et al., 2004; Gunasekaran, McNeil and Shaul, 2002; Agal, Devija and Dave, 2010), however using online learning to complement the learning process in academia, could improve the quality of the learners education (Concannon, Flynn and Campbell, 2005; Zhang et al., 2004).

2.2 Video Games

The video games industry has grown very rapidly in recent years, and is expected to continue to grow. The current value of the market is predicted as \$150 billion USD and is expected to reach \$180 billion by 2022 (Newzoo, 2018). In 2006, video games were considered as one of the most popular forms of entertainment in the United States (Sherry et al., 2006; Ritterfeld and Weber, 2006). Now video games can be considered a popular form of entertainment globally.

A video game can be defined as "a mental contest, played with a computer according to certain rules for amusement, recreation, or winning a stake" (Zyda, 2005).

2.2.1 History

The earliest documented predecessor to video games was observed in 1948, when the "Cathode-Ray Tube Amusement Device" was patented. The amusement device, required players to overlay pictures of targets such as airplanes in front of the screen (The First Video Game?, n.d.).

10 years later, physicist William A. Higinbotham was credited for creating the first video game; attempting to display his research at an exhibition, he anticipated that his display would not

generate any interest, so he conceptualised and created 'Tennis for Two' (Tennis for Two, n.d.). Tennis for Two was created using an analog computer with an oscilloscope for a screen. It was the first game to display motion and allow multiple players to play together (The First Video Game?, n.d.).

The rise of modern generation of video games is credited to the development of 'Spacewar!' in 1962, 'Computer Space' in 1971 and 'Pong' in 1972. Spacewar! was developed for academic purposes to test the limits of new hardware, but shortly after became very popular. Spacewar! was played by Nolan Bushnell, who used the idea of the game to create Computer Space, although, Computer Space did not gain much popular traction. This was partly due to its long winded instructions and complex game controls. Learning from these mistakes, the creators of Computer Space decided to create a simpler game and came up with the idea for Pong, which became very popular. Computer Space and Pong were designed solely for entertainment, and Pongs popularity was credited to the simplicity of its design (Lowood, 2009).

In the late 1980s, video games became a mainstream media industry (Williams, 2003).

2.2.2 Impacts

Initially the majority of research on the effects of playing games focused on the negative impacts; the potential harm related to violence, addiction and depression. But more recently studies have looked into their potential benefits (Granic, Lobel and Engels, 2014; Boyle, Connolly and Hainey, 2011; Ryan, Rigby and Przybylski, 2006).

Games provide a learning environment. Players first learn the rules of the game and the controls, then use this newly acquired knowledge to complete objectives and/or pass levels. In most games, the objectives get harder to reach as you progress, in turn testing the players knowledge and skill, and requiring increasingly complex solutions. Vygotsky claims that in these situations, progress is made when learners are presented with tasks which are just beyond their current level of ability

The research on the impacts of games is vast, so for the purpose of this dissertation, we will look at the benefits and drawbacks of educational games, which will be covered later on.

2.2.3 Uses

Video games now are used for a wide variety reasons, including in the following industries; military, government, education, corporate and healthcare, and also entertainment. The former set of industries for which games are created, that are not simply for entertainment, fall under the term 'Serious Games' (Susi, Johannesson and Backlund, 2007).

2.3 Educational Games

Educational games form a subset of serious games (Michael and Chen, 2005; Zyda, 2005). The market value of serious games industry in 2010, was predicted as 1.5 billion EUR. The study of serious games become an established academic field, evidenced by the founding of The Serious Games Institute at Coventry University in 2007 (Wilkinson, 2016).

2.3.1 Definition

Research into the literature on serious games available online, reveals that there are many definitions for the term 'Serious Game' (Susi, Johannesson and Backlund, 2007).

We start with an early definition by Abt, who is often credited with coining the term (Wilkinson, 2016), in 1970, as follows: "Games that have an explicit and carefully thought-out educational purpose, and are not intended to be played primarily for amusement", but argues that this does not mean that serious games are not, or should not, be entertaining (Abt, 1970). In 2005, Michael and Chen re-interpret this definition to "Games that do not have entertainment, enjoyment or fun as their primary objective" (Michael and Chen, 2005). This makes the definition a lot broader compared to Abts.

On the other hand in 2005, a thorough definition provided by Zyda, "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives". He argues that the story is more important than the pedagogy and that the entertainment component should come first (Zyda, 2005). Thus there is contradiction between the definitions by Michael and Chen and by Zyda. The latter definition also reduces the scope of serious games to just digital games (Djaouti et al., 2011). Although, most agree that serious games are (digital) games used for purposes other than mere entertainment (Susi, Johannesson and Backlund, 2007).

However, for the purpose of this dissertation we will use the definition provided by Abt, and work entertainment into the primary purpose of the game - to teach.

2.3.2 History

Educational games can be digital or non-digital (Djaouti et al., 2011), and have arguably existed since the 7th century. Among the oldest war games is the board game 'Chaturgana', argued by historians to be the precursor to chess. The aim of the game was to allow officers to become better planners for battles. More recently, created at the start of the 20th century was 'Landlord's Game', a precursor to monopoly. It was designed to illustrate the dangers of capitalist approaches to land taxes and property renting (Wilkinson, 2016). Thus games that teach or further knowledge on a specific topic, are not new.

Digital educational games began being developed in the early 1970s. One of the most famous ancestors, 'Oregon's Trail' created in 1971, was created as a text-based game, and is still popular today (Djaouti et al., 2011). 'BASIC Programming' another game, developed in 1979, had the aim of teaching users basic programming concepts (Interview: Warren Robinett, n.d.).

Around this same time, the power and potential of computer games for education and training was beginning to be uncovered (O'Neil, Wainess and Baker, 2005). Computer games were hypothesised to provide multiple benefits, such as:

- Complex and diverse approaches to learning processes and outcomes
- Interactivity
- Ability to address cognitive as well as affective learning issues
- Motivation for learning

Computer games are defined as games that are played on Personal Computers, and video games as games played using a television and a games console (H Cummings, 2007).

In 1958, Tennis for Two was created using an analog computer and oscilloscope for a screen. Four years later, Spacewar was developed using a digital minicomputer and a cathode-ray tube as the display, making it one of the first computer games. In 1972, Computer space and Pong were among the first video games. They were played on televisions placed in upright cabinets, and this paved the look and feel for future arcade games (The First Video Game?, n.d.; Lowood, 2009).

Computer games separated from video games in the early 1990s. Since then, 3D home consoles like the Sony Playstation and the Sega Saturn have been introduced. Some innovations to consoles include; touchscreen and motion control (H Cummings, 2007). Recently, we have seen the development and the use of Virtual Reality consoles for gaming, entertainment and learning (Stone, 2001).

2.3.3 Benefits

There are two sides to discussing the benefits of educational games. On one side, researchers claim that the benefits of video games can be translated to educational games to provide better learning, provided that the game design is good (Granic, Lobel and Engels, 2014). On the other side, researchers argue that educational games do not facilitate better learning when compared to other instructional methods (Clark, 2007).

Analyses show that games promote learning. Games can support the development of a number of different skills; analytical and spatial skills, strategic skills and insight, learning and recollection capabilities, psychomotor skills, visual selective attention.

ELSPA, 2006; Gee, 2005, 2007; Klopfer et al., 2009; Robertson, 2009; Shaffer, 2007

To be written.

To be written.

Kirkpatrick's four levels for evaluating training

Baker and Mayer's CRESST model of learning

To be written.

2.3.4 Examples

Educational games for teaching computer programming (6)

(Not my words) Robocode (2001) is one of the first environments developed as an open source educational game in order to support java programming

2.3.4.1 Gaming Platforms

2.4 Educational Game Design

The design and production of video games involves aspects of cognitive psychology, computer science, environmental design, and storytelling, to name a few (Koster and Wright, 2004).

Designing educational games requires a focus that is different from general game design; otherwise, we may end up designing fun games with little or no learning value (Barnes et al., 2007).

Garris, Ahlers and Driskell describes a "tacit model that is inherent in most studies of instructional games". The model is as follows. Initially, we define a set of learning outcomes and objectives that we wish to achieve. We then design an instructional program which incorporates certain characteristics of games, that delivers the desired learning objectives. Subsequently, the program triggers a cycle that includes user judgments, user behaviours and system feedback. If the pairing of the instructional content with the appropriate game features is successful and effective, the cycle achieves recurring and self-motivated game play. Finally, this engagement in the game leads to the achievement of the learning outcomes (Garris, Ahlers and Driskell, 2002). This model is illustrated in Figure 2.4.1.

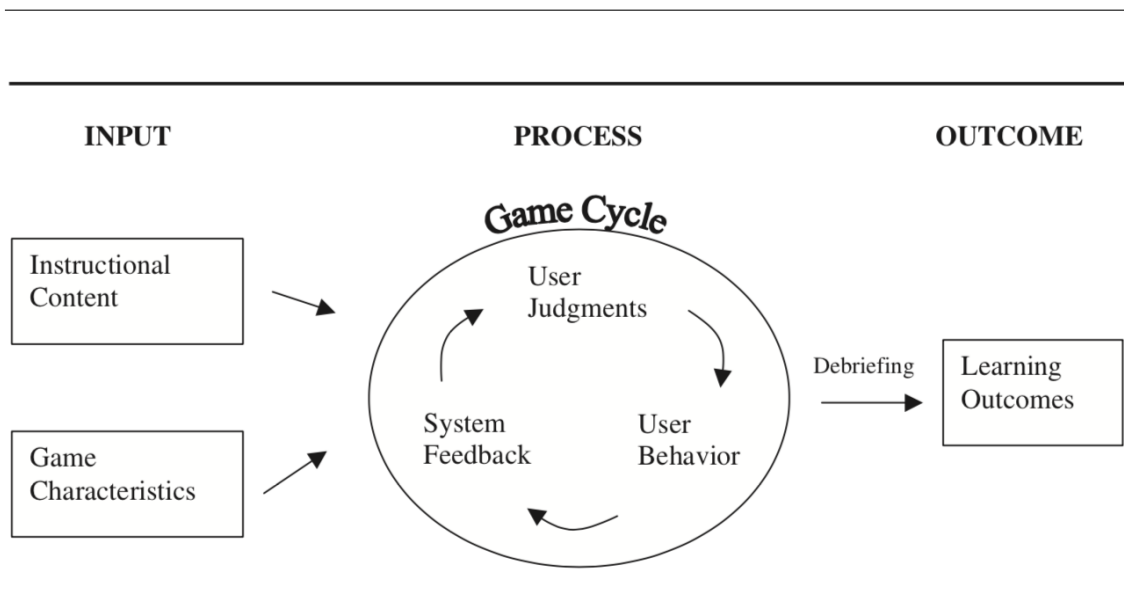


Figure 2.4.1: Input-Process-Outcome Instructional Game Model (Garris, Ahlers and Driskell, 2002)

2.4.1 Frameworks

To be written.

EFM: A Model for Educational Game Design

Game object model version II: a theoretical framework for educational game development (318)

Game, motivation, and effective learning: An integrated model for educational game design (230)

Serious Games: A New Paradigm for Education?

2.4.1.1 Game Genre

To be written.

2.4.2 Game Elements

(CHANGE IT UP) Barnes et al. ran a project that made University Students create games that would teach basic programming. They carried out evaluations to test participant learning from the game, and made some interesting observations as follows: Clear instructions and game goals must be provided and accessible throughout the game, Learning goals must be clearly tied to in-game feedback that motivates the player (through, e.g. experience points, health), and penalizes guessing, Humor can be a motivation for in-game interaction (Barnes et al., 2007).

Chapter 3

Requirements Specification

Chapter 4

Design

Chapter 5

Implementation

Chapter 6

Testing

Chapter 7

Results

Chapter 8

Conclusions

Chapter 9

Future Work

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Appendices

Appendix A

Uncertainty Analysis

Appendix B

Screenshots

Appendix C

Ethics Checklist