Games Based Learning

By

Roy Michael Benson

(BSc, PGCE, MSc)

A thesis submitted in partial fulfilment of the requirements for the degree of

Doctor of Philosophy in Education

University of Warwick, Centre for Education Studies

December 2014

Table of Contents

LIST OF FIGURES 9
LIST OF TABLES 10
ACKNOWLEDGEMENTS 11
DECLARATION 12
ABSTRACT 13
ABBREVIATIONS 14
CHAPTER 1: INTRODUCTION 16
1.1 INTRODUCTION 16
1.2 MOTIVATION / RATIONALE FOR THE THESIS 16
1.3 RESEARCH OBJECTIVES 17
1.4 DEFINING THE THESIS RESEARCH QUESTIONS 17
1.5 THESIS HYPOTHESES 18
1.6 FINDINGS SUMMARY 19
1.7 RESEARCH INFLUENCES 20
1.8 THESIS STRUCTURE 23
1.9 CONCLUSION 25
CHAPTER 2: GAMES BASED LEARNING LITERATURE REVIEW 26
2.1 INTRODUCTION 26
2.2 A BRIEF HISTORY OF EDUCATIONAL GAMING 26
2.2.1 Computer Literacy Project 28
2.2.2 Edutainment 30
2.2.3 e-Learning 32
2.3 GAMES BASED LEARNING / SERIOUS GAMES 34
2.4 WHY GAMES BASED LEARNING? 35
2.4.1 Repetition 35
2.4.2 Skills Development 36
2.4.3 Personalised Learning 37
2.4.4 Motivation 38
2.4.4.1 Motivational Theories 42
2.4.5 21st Century Students 46
2.5 WHAT IS A 'GAME'? 48
2.6 WHAT IS AN EDUCATIONAL OR 'SERIOUS' GAME? 49
2.7 SO WHAT IS A 'GAME'? 51
2.8 GAME GENRES 55
2.9 CRITICISM OF GAMES BASED LEARNING 59
2.9.1 General Criticism 59
2.9.2 Education Barriers 60
2.10 CONCLUSION 62
CHAPTER 3: GBL IMPLEMENTATION LITERATURE REVIEW 64
3.1 INTRODUCTION 64
3.2 APPROACHES TO IMPLEMENTING GAMES BASED LEARNING 65
3.3 COMMERCIAL OFF THE SHELF (COTS) GAMES 66
3.3.1 COTS Game Selection 69
3.3.2 Repurposing or 'Modding' a COTS Game 72

3.4 Developing Educational Software 73
3.5 General Design Methodologies 74
3.5.1 User Centred Design 75
3.5.2 Instructional Design (ADDIE) 77
3.6 Designing Games 79
3.7 Games Design Principles 80
3.7.1 Narrative 80
3.7.1.1 The Hero's Journey 82
3.7.2 Challenge 83
3.7.3 Attractive Graphics & Sound 86
3.7.4 Schell's '100 Lenses' 87
3.8 Educational Games Design 89
3.8.1 General Discussion 90
3.8.2 Educational Game Design (Malone and Lepper) 92
3.8.3 Educational Games Design Principles 93
3.8.3.1 Gee's 'Principles of Learning' 96
3.8.4 Learning Theories 97
3.8.4.1 Behaviourism 98
3.8.4.2 Cognitivism 98
3.8.4.3 Constructivism 100
3.8.4.4 Humanism 102
3.8.4.5 Vygotsky's 'Social Development Theory' 103
3.8.4.6 Flow Theory 104
3.8.5 Learning Theory Based Games Design 105
3.8.5.1 Multiple Intelligences 107
3.8.5.2 Gagné's Nine Events of Instruction 109
3.9 Educational Game Implementation 111
3.10 Educational Game Development Tools 112
3.11 Educational Game Design Frameworks 114
3.12 Theoretical EGD Frameworks 115
3.12.1 Four-Dimensional (4D) Framework 115
3.12.2 Game Object Model 117
3.13 Implemented EGD Frameworks ('Proof of Concept') 118
3.13.1 iSpiral Framework 118
3.13.2 JaBInT (Java-based Intelligent Tutoring) 119
3.14 GBL Framework Flaws 120
3.14.1 Technical Practicality 120
3.14.2 Financial Practicality 121
3.14.3 Academic Practicality 121
3.15 Conclusion 122

CHAPTER 4: METHODOLOGY 124

4.1 Introduction 124
4.2 Research Methodology 125
4.2.1 Research Paradigm / Philosophical Position 125
4.2.1.1 Which Paradigm? 126
4.2.1.2 Thesis Paradigm 128
4.2.2 Qualitative and Quantitative Research 129
4.2.3 Ethical Considerations (BERA Guidelines) 130
4.2.3.1 Responsibilities to Research Participants 130
4.2.3.2 Responsibilities to Research Sponsors 133
4.2.3.3 Responsibilities to Educational Researchers 134
4.2.3.4 Responsibilities to the Wider Audience 134
4.2.4 Ethical Considerations (Thesis Specific) 135

4.3 RESEARCH METHODS (BACKGROUND) 138
4.3.1 Sampling *138*
4.3.2 Questionnaire Design *140*
4.3.3 Observations *142*
4.4 QUESTIONNAIRE BASED SURVEY 143
4.5 GAME REVIEW / DESIGN PILOT 144
4.5.1 Game Review *144*
4.5.2 Game Review Considerations *146*
4.5.2.1 Content 147
4.5.2.2 Commercial Availability 147
4.5.3 Final Software Selection *148*
4.5.4 Design Pilot *148*
4.6 GAME DESIGN / DEVELOPMENT 152
4.6.1 Implementation / Development *154*
4.7 PROTOTYPING PILOT / MAIN STUDY 157
4.7.1 Selecting a Primary School *157*
4.7.2 Pilot / Main Study Game Selection *158*
4.7.3 Prototyping Pilot / Main Study *159*
4.7.4 Technical / ICT Usage Issues *160*
4.8 CONCLUSION 161

CHAPTER 5: QUESTIONNAIRE BASED SURVEY / GAME REVIEW 163

5.1 INTRODUCTION 163
5.2 QUESTIONNAIRE BASED SURVEY 163
5.2.1 Sample Groups *164*
5.2.2 Teacher Questionnaire *165*
5.2.3 Parent Questionnaire *166*
5.2.4 Pupil Questionnaire *167*
5.2.4.1 Pupil Questionnaire Results 170
5.2.5 Questionnaire Based Survey Conclusions *171*
5.3 GAME REVIEW 171
5.3.1 Present a Question – Select an Answer *172*
5.3.1.1 Shooting / Target Style Games 173
5.3.1.2 'Whac-A-Mole' Style Games 173
5.3.1.3 Quiz Style Games 174
5.3.1.4 Navigation / Maze Style Games 175
5.3.2 Present a Question – Input an Answer *177*
5.4 CONCLUSION 180

CHAPTER 6: DESIGN PILOT 182

6.1 INTRODUCTION 182
6.2 DESIGN PILOT / SAMPLE GROUP 182
6.2.1 General Observations *183*
6.2.2 Specific Observations / Grading Sheet Feedback *185*
6.2.3 'Unpopular' / Un-played Games *186*
6.2.4 Tran Towers *188*
6.2.5 Donkey Kong Jr Math 2 .... *189*
6.2.6 Math Man *191*
6.2.7 Math Explorer 2 .... *192*
6.2.8 MathsBall *193*
6.2.9 Math Magic *195*
6.2.10 Math Balls *198*
6.3 DESIGN PILOT CONCLUSIONS 199

6.4 CONCLUSION ... 201

CHAPTER 7: PROTOTYPING PILOT / MAIN STUDY ... 202

7.1 INTRODUCTION ... 202
7.2 GAME DESIGN / DEVELOPMENT ... 203
7.3 FINAL GAME SELECTION ... 203
7.3.1 Pyramid Panic ... 204
7.3.1.1 Space Maze Panic / Block Panic ... 205
7.3.2 194X ... 206
7.3.2.1 294X / 1982 ... 207
7.3.3 Moon Maths ... 208
7.3.4 Math Balls ... 208
7.3.5 Math Magic ... 209
7.4 PROTOTYPING PILOT / MAIN STUDY BACKGROUND ... 210
7.4.1 Overview ... 210
7.4.1.1 Sample Group ... 211
7.4.1.2 Pilot / Study Environment ... 211
7.4.1.3 Main Study Scope ... 212
7.4.2 Technical Issues (General) ... 212
7.4.3 ICT Usage Issues ... 213
7.4.4 Development Issues ... 215
7.5 PROTOTYPING PILOT ... 218
7.5.1 Background / Overview ... 218
7.5.2 Observations ... 218
7.5.3 Questionnaire Results ... 219
7.5.4 Prototyping Pilot Summary ... 220
7.6 MAIN STUDY ... 221
7.6.1 Background / Overview ... 221
7.6.2 Observations ... 222
7.6.3 Questionnaire Results ... 224
7.6.4 Main Study Summary ... 235
7.7 CONCLUSION ... 237

CHAPTER 8: ADDRESSING THE RESEARCH QUESTIONS ... 239

8.1 INTRODUCTION ... 239
8.2 RESEARCH QUESTION 1 ... 240
8.2.1 Game Design and Development ... 240
8.2.2 Are the Author's Games Fun? ... 242
8.2.3 Conclusion ... 244
8.3 RESEARCH QUESTION 2 ... 246
8.3.1 Main Study Findings ... 247
8.3.2 Conclusion ... 248
8.4 RESEARCH QUESTION 3 ... 250
8.4.1 Main Study Findings ... 254
8.4.2 Conclusion ... 257
8.5 RESEARCH QUESTION 4 ... 258
8.5.1 Conclusion ... 265
8.6 RESEARCH QUESTION 5 ... 266
8.6.1 Defining the Research Question ... 267
8.6.2 Identifying Gaps within the Literature ... 267
8.6.2.1 Institutional Level Support for Games Based Learning ... 268
8.6.2.2 Practical Implementation Issues ... 268
8.6.3 Lack of Institutional Level Support for GBL ... 269

8.6.4 Addressing the Lack of Institutional support ... 270
8.6.4.1 Creation of a UK Centric GBL Trade Body ... 270
8.6.4.2 Alternative Approaches to Funding ... 272
8.6.5 Practical Implementation Issues ... 274
8.6.5.1 Lack of I.T. Support / Resources ... 274
8.6.5.2 Lack of Centralised GBL Resources ... 275
8.6.5.3 Who Develops Educational Games? ... 276
8.6.6 Addressing Practical Implementation Issues ... 277
8.6.6.1 Hire 'Gaming' Technicians and Eschew 3D Graphics ... 277
8.6.6.2 Creation of an Education 'App Store' ... 280
8.6.6.3 Education/Industrial GBL Collaboration ... 286
8.6.7 Conclusion ... 287
8.7 CONCLUSION ... 289

CHAPTER 9 – CONCLUSIONS AND REFLECTIONS ... 291

9.1 INTRODUCTION ... 291
9.2 THESIS CONTRIBUTIONS ... 291
9.2.1 Redefining the Need for High Fidelity Graphics ... 291
9.2.2 'Real World' GBL Development / Usage ... 293
9.3 THESIS FINDINGS ... 295
9.4 IMPLICATIONS ... 297
9.5 THESIS LIMITATIONS ... 298
9.6 FUTURE RESEARCH ... 299
9.6.1 Perceptions of Games Based Learning ... 300
9.6.2 Learning Theory Research ... 301
9.6.3 Gamification ... 301
9.6.4 Thesis Research ... 302
9.7 THESIS REFLECTIONS ... 303
9.7.1 Research Questions ... 303
9.7.2 The Practicalities of Educational Game Development ... 310
9.7.3 Personal Reflection ... 313
9.8 CONCLUSION ... 314

REFERENCES ... 316

APPENDIX A: QUESTIONNAIRE BASED SURVEY (KSA) ... 350

APPENDIX B: GENERIC ADDIE DESIGN ... 365

APPENDIX C: GAME SPECIFIC ADDIE DESIGNS ... 374

APPENDIX D: PROTOTYPING PILOT / MAIN STUDY - GAME USER GUIDES ... 384

APPENDIX E: PROTOTYPING PILOT / MAIN STUDY - QUESTIONNAIRES ... 389

APPENDIX F: MAIN STUDY - FIELD NOTES ... 398

List of Figures

Figure 2.1: EDSAC Simulator running ‘Noughts and Crosses’ 27
Figure 2.2: Atari 2600 VCS 28
Figure 2.3: Basic Math 28
Figure 2.4: The BBC Micro (Model B) 29
Figure 2.5: Donkey Kong Jr Math 31
Figure 2.6: Math Blaster 31
Figure 2.7: Game Based Learning Model 36
Figure 2.8: Maslow's Hierarchy of Needs 43
Figure 2.9: Trivial Pursuit 54
Figure 3.1: The Prototyping Paradigm 76
Figure 3.2: Schell’s ‘Interest Curve’ 81
Figure 3.3: ‘The Hero’s Journey’ / ‘Three Act Structure’ 83
Figure 3.4: Zone of Proximal Development 103
Figure 3.5: Model of Flow 105
Figure 4.1: Early Prototype of ‘Gauntlet’ 156
Figure 4.2: Educational version of ‘Pyramid Panic’ 156
Figure 4.3: Final version of ‘Pac-Man’ 158
Figure 4.4: Final version of ‘BombJack’ 158
Figure 7.1: Pyramid Panic 204
Figure 7.2: Space Maze Panic 206
Figure 7.3: Block Panic 206
Figure 7.4: 194X 206
Figure 7.5: 294X 208
Figure 7.6: 1982 208
Figure 7.7: Moon Maths 210
Figure 7.8: Math Balls 210
Figure 7.9: Math Magic 210
Figure 8.1: Flappy Birds 251
Figure 8.2: Minecraft Characters 251
Figure 8.3: PEGI Ratings 281
Figure 8.4: Google Play App Store 282
Figure 8.5: Linux Mint Software Manager 282
Figure 8.6: Google Play App Description (Math Workout) 282
Figure 9.1: Bradley Trainer / Military ‘Battlezone’ (1981) 292

List of Tables

Table 2.1: Game Genres. 55
Table 2.2: Commonly available Educational Games by Genre 56
Table 2.3: Game Styles 58
Table 3.1: Schell's 'Interest Curve' 82
Table 3.2: Sample of Schell's (2010) '100 Lenses' 87
Table 3.3: Educational Game Design Principles (Various) 94
Table 3.4: Gee's 'Principles of Learning' (Gee 2007) 97
Table 3.5 Learning theories used within 'game-assisted learning' studies 106
Table 3.6: Most 'popular' learning theories on which to base educational game design 106
Table 3.7: Gardner's 'Multiple Intelligences' 107
Table 3.8: 'Multiple Intelligence' Game Design 108
Table 3.9: Gagné's 'Nine Events of Instruction' 109
Table 3.10: Kellar's ARCS Model of Motivational Design 110
Table 3.11: Gagné / Keller Mapping to 'Common Elements' 110
Table 3.12: Game Engines referenced within the literature 112
Table 3.13: de Freitas's Four Dimensional Framework 116
Table 4.1: Definitions of Epistemology 126
Table 4.2: Game Development Software Comparison Matrix 153
Table 4.3: Initial Game Designs 154
Table 6.1: 'Game Style Grading Sheet' Grades 185
Table 8.1: Author Developed Games 254
Table 8.2: Most 'fun' Games 255
Table 8.3: Quality of Graphics 255
Table 8.4: Suggested 'Typical' EduApp Game Listing 284

Acknowledgements

I would like thank both my supervisors, Assoc Prof Dr Sue Johnston-Wilder and Assoc Fellow Dr Sean Neill for their (long distance) support and guidance over the duration of my research, a task made more challenging due to my overseas work commitments for much of this time period.

I would also like to express my gratitude to the University of Warwick/Centre for Education Studies for granting me the opportunity to undertake my research degree with such a prestigious organisation.

Finally, I would like to thank my family for their support, including my wife, who shares my aspirations for continuous personal development, and my mother who passed away before the completion of my research degree.

Declaration

The work within this thesis was developed and conducted by the author between September 2008 and December 2014. I declare that, apart from work whose authors are explicitly acknowledged, this thesis and the materials contained within the thesis represents original work undertaken solely by the author. None of the work has been previously submitted for any other degree.

Abstract

The aim of this thesis is to investigate whether it is possible for a teacher (as a non-game developer) to create educational computer games that could be considered ‘fun’ to play. The influences of game genre and graphical fidelity on this process are also investigated, along with the practicalities and barriers that constrain the (mainstream) use of computer games within the education system.

A literature review was conducted into the motivations for using educational games, the educational and conventional approaches to games design, and finally the development frameworks/software tools available for the purposes of implementation.

Building upon the literature review, a questionnaire based survey and a games design pilot were conducted in order to establish what constitutes educational games design ‘best practice’. Based on the feedback/results obtained, a small number of educational games were developed (using the package ‘GameMaker’) and piloted for use within the subsequent main study.

The main study consisted of a series of educational game playing sessions (supported by questionnaires) aimed at addressing the thesis research questions. The results of the study (in combination with an additional literature review) suggest the following:

- It is possible for teachers (as non-game developers) to create ‘fun’ educational computer games, although this may not always be the most practical or preferred approach.
- Low fidelity graphics do not negatively impact the successful use of computer games within an educational environment.
- Educational games can be used practically within the education system, but with constraints and barriers preventing their mainstream adoption, unless schools, government and educational game advocates work together towards a shared vision.
- Due to limitations within the study, the influence of genre on the use educational games remains unresolved.

This thesis contributes new knowledge through the discovery that computer games do not require high fidelity graphics in order to be used successfully within an educational environment (at the primary school level), and addresses a gap within the current literature through the documentation of the author’s ‘real world’ experience of developing educational computer games (from a teacher’s point of view).

Abbreviations

2D	Two Dimensional
3D	Three Dimensional
ADDIE	Analysis Design Development Implementation Evaluation
AI	Artificial Intelligence
ANGILS	Alliance for New Generation Interactive Leisure and Simulations
BBC	British Broadcasting Corporation
BECTA	British Educational Communications and Technology Agency
CBM	Commodore Business Machines
CLP	Computer Literacy Project
COTS	Commercial Off The Shelf (Software)
CP/M	Control Program for Microcomputers
CRB	Criminal Records Bureau
CRT	Cathode Ray Tube
DfE	Department for Education
DGBL	Digital Game Based Learning
DOS	Disk Operating System
EDSAC	Electronic Delay Storage Automatic Calculator
ENC	English National Curriculum
FCA	Financial Conduct Authority
GBL	Game Based Learning
GML	Game Maker Language
GOM	Game Object Model
GPS	Global Positioning System
GUI	Graphical User Interface
HCI	Human Computer Interaction
HoS	Head of School
HTML	Hyper Text Markup Language
I.T.	Information Technology
IBM	International Business Machines
ICT	Information Communication Technology
ID	Instructional Design
KSA	Kingdom of Saudi Arabia
LAN	Local Area Network
LMS	Learning Management System
M.I.T	Massachusetts Institute of Technology
MDE	Model Driven Engineering
NES	Nintendo Entertainment System
NPC	Non Player Characters
OOP	Object Oriented Programming
OS	Operating System
OS/2	Operating System/2
PC	Personal Computer
PEGI	Pan European Game Information)
SDT	Social Development Theory
SG	Serious Games
SGA	Serious Games Association
SGDF	Serious Game Development Framework
SGI	Serious Game Institute
SLT	Social Learning Theory
SNES	Super NES
TIGA	The Independent Games Developers Association

Abbreviations (Cont.)

TV	Television
UCD	User Centred Design
URL	Uniform Resource Locator
USB	Universal Serial Bus
WAN	Wireless Area Networks
ZPD	Zone of Proximal Development

Chapter 1: Introduction

1.1 Introduction

Games Based Learning might be considered a broad term, but generally refers to the use of computer games within education. This could be through the use of explicitly educational games or the educational reuse of existing commercial games. The most frequently cited arguments for the use of Games Based Learning, is that it engages and motivates learners in a way that 'traditional' schooling fails to do, and that the current school education system is 'broken' and is in need of repair (in part, through the use of 'Serious Games') (Prensky 2006, Shaffer 2008, Gee 2007).

Within this introductory chapter, the author discusses his motivation/rationale for undertaking research within the area of Games Based Learning. After outlining the thesis objectives, the thesis research questions are presented along with the author's hypotheses for the outcomes to these questions. A summary of the research findings is presented, followed by a discussion on the thesis research influences. The chapter concludes with a description of the thesis structure in terms of the remaining chapters.

1.2 Motivation / Rationale for the Thesis

Having conducted an initial literature review into the area of Games Based Learning (GBL), the author's motivation for the thesis was based on an observation derived from the current literature.

The author's observation was that the research (conducted by academics and experts within the field) was, in the author's opinion, presumptive of the role of the teacher within the area of GBL. While the literature provides examples of GBL theory and the experimental design, implementation and use of educational computer games; there seemed to be little consideration of the greater role of teachers beyond the delivery of the content within a classroom session.

Therefore, the motivation behind the thesis is to contribute to the limited research on how teachers (as non-game developers) can design, develop and deliver educational computer games. This is a broad subject area, and therefore the thesis research has focused on the practical aspects of developing educational (maths) computer games for use within the UK education system.

1.3 Research Objectives

Games Based Learning is an evolving area, and while academic research has focused on the pedagogic aspects of computer game design and selection, there currently appears to be a lack of formal standards or guidelines guiding the implementation and use of GBL within the UK education system.

With this viewpoint in mind, the author has concentrated his area of research (for reasons of practicality) on the following over-arching research question:

> *Is it possible for a teacher to design and implement a computer game based on GBL principles and National Curriculum Objectives?*

1.4 Defining the Thesis Research Questions

Having identified the research objectives (*1.3 Research Objectives*), the author embarked on the first part of the literature review. The literature subsequently helped shape the author's thinking, leading to the refinement of the objectives into a set of formal research questions.

These formalised questions refine the original over-arching research question, and broadly relate to two areas: firstly, the development of educational computer games, and secondly, the broader issue of Games Based Learning and its practical use within the education system.

The early chapters within the thesis lay the groundwork for these questions to be explicitly addressed within the penultimate chapter (*Chapter 8*).

The research questions:

1. Is it possible for a teacher (as a non-game developer) to create 'fun' educational computer games, based on what are (currently) considered good GBL design principles?.

2. Which type, format or genre of game is most suited for use in Games Based Learning?

3. Does the quality of the computer graphics (2D or 3D) have an impact on the successful use of a computer game within an educational environment?

4. How can Games Based Learning be used practically within the education system?

5. How can the current barriers, preventing the mainstream adoption of Games Based Learning, be addressed?

Research questions 4 and 5 proved to be particularly challenging to define, and needed to be re-defined during the course of the literature review. With the benefit of hindsight, both research questions were originally too narrowly focused, and subsequently needed to be broadened in order to allow them to be addressed in sufficient depth.

1.5 Thesis Hypotheses

Reflecting the research questions, the thesis offers the following hypotheses:

Research Hypothesis 1: It should be possible for a teacher (as a non-game developer) to create 'fun' educational computer games. However, the challenge will derive from balancing the elements of 'fun' and education in such a way that one element does not overpower the other (i.e. fun, but not educational or educational, but not fun).

Research Hypothesis 2: Certain formats or genres of computer game are better suited to educational use, in comparison to other format/genre types.

Research Hypothesis 3: The quality, or 'fidelity' of graphics (featured within a computer game) will influence how a given computer game is perceived by players/learners. The hypothesis for this question is that games featuring crude, low-fidelity graphics will be unappealing to play (in comparison to games featuring high-fidelity graphics), and will therefore be less likely to be used successfully within an educational environment

Research Hypothesis 4: While Games Based Learning may have an educational role to play, there will be practical issues (political, technical etc.) that affect *how* this role is implemented within the education system.

Research Hypothesis 5: Based on the previous hypothesis that there will be a role for Games Based Learning (within the education system), the hypothesis for this question is that there will be barriers that prevent this role from being a mainstream one (as advocated by GBL proponents). It may be possible to address some of these barriers, but potentially, not all.

1.6 Findings Summary

The thesis findings are discussed in greater detail within Chapter 9 (*9.3 Thesis Findings*), however, a summary of these findings is included within this chapter, for completeness.

Research Question 1 – It is possible for a teacher (as a non-game developer) to develop ‘fun’ educational computer games. However, expecting (non-game developer) teachers to develop educational games may not be the preferred or the most practical approach to delivering GBL into the classroom.

Research Question 2 – has only been partially addressed, and therefore the author cannot state which type, format or genre is most suited for use in Games Based Learning. However, the literature exhibits a slight bias towards the (3D) simulation genre.

Research Question 3 – Based upon the literature review and the results of the Main Study, the author would state that computer games can utilise low-fidelity graphics and can still be used successfully within an educational environment.

Research Question 4 – the author postulates two alternative views based on the literature: Firstly, Games Based Learning is unlikely to have a practical role to play due to its incompatibility with a ‘locked down’ education system in UK. Secondly, Games Based Learning may have a practical role to play, but not the one as envisaged and advocated by proponents, such as Prensky, Shaffer and Gee.

Research Question 5 – The author has identified a number of gaps within the current literature (relating to barriers preventing the mainstream adoption of GBL), and suggests that they may be addressed (via reference to non-GBL literature) through the following actions:

- The foundation of a UK centric GBL trade body, in order to promote the interests of GBL.
- The eschewing of games with high-fidelity 3D graphics, thereby allowing the reutilisation of existing (older) school computers/
- The creation of an 'Educational App Store' to potentially centralise GBL resources
- Collaboration between the education sector and the games industry, facilitated by the proposed UK centric GBL trade body.

1.7 Research Influences

From the beginning, the thesis research was influenced by the author's commitment to addressing the thesis research questions. Therefore, the discussion within this section broadly follows the outline of the thesis research questions, as identified within the previous section (*1.4 Defining the Thesis Research Questions*).

The first research question asks whether a teacher (as a non-game developer) can develop 'fun' educational computer games. From a theoretical perspective, this could be considered a broad question, crossing several research disciplines.

The overarching research area is that of Games Based Learning, and this forms part of the initial literature review. However, whilst reviewing the literature within this area, it was apparent that an appreciation of educational and conventional game design was also required. The literature on games design was reasonably consistent, with many researchers in agreement on the core 'mechanics' that create 'fun' computer games. The literature within educational game design was much more diverse, and required an investigation into learning theories and then the practical approaches undertaken to create educational games (*Chapter 3*).

While many researchers advocate educational games design based upon recognised learning theories, the author was unable to source many practical examples of this in practice – the majority of the literature being influenced (directly and indirectly) by the work of Malone & Lepper (1987) (*Chapter 3*). Given the commonality between games design principles and the work of Malone & Lepper (which in turn is based on the motivational properties of computer games), the author was influenced to design of a series of educational computer games based on 'classic' games design principles (such as those documented by Habgood & Overmars 2006).

It was the author's hypothesis that, given this commonality, it would be possible to 'blend' educational content into the game mechanics (or 'motivational properties') of a computer game in such a way as to create an evenly balanced game where neither 'fun' nor 'education' overwhelmed the other. As documented within Chapter 8 and Chapter 9, the author was only partially successful in this respect.

Whilst the literature on games design was informative, it was also mostly theoretical. This motivated the author to conduct a Design Pilot (*Chapter 6*) as a mechanism to obtaining practical design guidance (from a target group of learners) on what makes a 'good' educational game.

The basis of the second research question was the author's curiosity as to whether the type or 'genre' of computer game could influence the successful use of that game educationally. Unfortunately, the literature within this area was mostly descriptive or based on researcher opinion, and flaws within the author's implementation (*Chapter 7*) resulted in this question being only partially addressed.

The influence of graphical fidelity on educational gaming was of interest to the author, and this forms the basis of the third research question (*Chapter 7* / *Chapter 8*). Overlapping with the first research question, the author reviewed the literature on games design and games development software (*4.6 Game Design / Development*), ultimately leading to the selection of the application 'GameMaker' as the development tool of choice. The consumer nature of 'GameMaker' was ideally suited to the author as a non-game developer.

The literature on graphic fidelity focused on the development of educational games utilising 3D game engines or gave preference to the use of 3D graphics. Yet this aspect was at odds with one of the literature's criticisms of GBL, namely the lack of '3D capable' I.T. resources (within the education sector) needed to run reasonably modern 3D games. This contradiction influenced the author to create (relatively) higher-fidelity and low-fidelity versions of the games used in the field work for the thesis, in order to establish whether a game's graphical fidelity impacts its successful use as an educational game.

As part of addressing the research questions, the author conducted a Prototyping Pilot, followed by a Main Study (consisting of a series of 'game playing' sessions). The Prototyping Pilot allowed the author to refine/prototype the games, while the Main Study served to provide feedback (via observation and questionnaires) designed to address Research Questions One, Two and Three (*Chapter 7*).

During the review, the author encountered gaps within the current literature, and the process of resolving these gaps formed the basis of addressing Research Questions Four and Five (*Chapter 8*). By their very nature, these gaps required an additional review of the literature, but outside of the area of Games Based Learning. This involved consulting contemporary literature concerned with the 'agents of change' currently filtering through the UK education system, the evolving area of alternative academic funding and the professional side of the (non-educational) games industry. Additionally, the author looked back through educational I.T. of the past (Hammond *et al*. 2009), and this provoked reflection on how the past might influence the development of Games Based Learning in the future.

Finally, the author's 'journey' through the development of the thesis, informs the reflective discussion within Chapter 9. The reflection encompasses the research questions, before logically leading to discussions on the thesis findings, future research and the limitations of the thesis.

1.8 Thesis Structure

The thesis can be broadly split into three parts. The first part discusses the area of Games Based Learning and the methodologies that can be used in order to design educational computer games. The second part discusses the experiences and results of the author's journey to design, develop and then trial run a series of educational computer games, aimed at the primary school level. The final part of the thesis explicitly addresses the identified research questions, through a combination of reference to the literature, the results of trialling the author's games and new contributions to the pool of existing Games Based Learning knowledge.

The thesis is therefore broken down into the following chapters:

Chapter 2

Chapter 2 presents the first half of the literature review and is primarily concerned with setting the background for the thesis research. After a brief review of educational computing (i.e. educational games, e-learning), the literature on Games Based Learning is reviewed. Of note, within the literature, is the difficulty in trying to arrive at a consistent and universally accepted definition of what a computer 'game' actually is.

Chapter 3

The second half of the literature review focuses on the practical approaches to implementing a Games Based Learning strategy. Chapter 3 begins with a discussion on the types of computer game that can be used within the classroom, followed by a substantial review of the literature dedicated to 'classic' and educational games design. The chapter concludes with a discussion on games development software and a review of GBL 'frameworks' – a more recent academic approach to the evaluation and design of educational games.

Chapter 4

Chapter 4 begins with a discussion on the author's chosen research methodology. The author then discusses his research methods for addressing the thesis research questions, which in turn, also serve as an overview of Chapters 5 to 8.

Chapter 5 / Chapter 6

Chapter 5 and Chapter 6 discuss the initial part of the author's methodological approach to addressing the thesis research questions. The author conducted both a Questionnaire Based Survey (*Chapter 5*) and a Design Pilot (*Chapter 6*), the primarily purposes of which were to obtain feedback (from a sample group) on educational game design 'best practice', in turn informing the design of the author's educational games.

Chapter 7

Chapter 7 discusses the latter part of the author's methodological approach to addressing the thesis research questions. Utilising the feedback from the Design Pilot, in combination with the use of games design principles and the ADDIE instructional design methodology, the author designed/developed a series of educational game prototypes for use within a Prototyping Pilot and subsequently, a Main Study. The Main Study was designed to assist in the addressing of thesis Research Questions 1 to 3.

Chapter 8

In the penultimate chapter, the author explicitly addresses the thesis research questions, through a combination of references back to the literature review and discussion of the feedback/results from the Main Study.

Chapter 9

In the final chapter, the author concludes the thesis with both discussion and reflection.

The chapter begins with a discussion on the thesis contributions, limitations and its wider research implications, before concluding with a discussion on future research (in general, and thesis specific). The remainder of this chapter is dedicated to reflecting upon the thesis 'journey', and incorporates both academic and personal reflections.

1.9 Conclusion

After a brief introduction to the subject area of Games Based Learning and its argued benefits for education, this chapter concentrates on describing the thesis in terms of rationale, research influences and thesis structure.

The rationale for the thesis is based on the observation that the literature is presumptive of the role that teachers will play within the development of educational games, and this observation is reflected in the defining of the research objectives, research questions and the thesis hypothesis. Whilst discussed in greater detail within Chapter 9, a summary of the thesis findings is also presented within this chapter, for completeness.

The author discusses the influences for the thesis research, which broadly follows the outline of addressing the research questions. Finally, the chapter concludes with a brief discussion on the thesis structure, followed by an overview of each thesis chapter.

Chapter 2 introduces the first part of the literature review, which concentrates on the subject of Games Based Learning and addressing the absence of an agreed definition for the term 'game'.

Chapter 2: Games Based Learning Literature Review

2.1 Introduction

This chapter begins with a brief review of educational gaming, from the early examples of mainframe computer games, to the more recent marketing of ‘edutainment’ titles. Evolving from this background, the remainder of this chapter is dedicated to reviewing the current literature on Games Based Learning – the educationally focused use of traditional computer games and so-called ‘Serious Games’. As part of the literature review, the difficulties in defining what a ‘game’ is, are discussed, before the author provides his own interpretation based on both the literature and personal experiences. Related to the definition of a game, the type or ‘genre’ of computer game is discussed along with commentary on the preferred genre for use with educational/serious games.

The chapter concludes by examining the criticisms directed towards Games Based Learning, as identified within the literature.

2.2 A Brief History of Educational Gaming

The early days of ‘modern’ computing can be traced back to the early 1950’s when prestigious academic institutions, such as Cambridge University (UK) and the Massachusetts Institute of Technology (US), took possession of the first generation of mainframe computers. Given the subsequent popularity of ‘videogaming’ from the 1970’s onwards, it now seems inevitable (with hindsight) that these early mainframes would be utilised to create the first generation of ‘digital’ games.

The earliest computer-based games are often considered to be ‘Noughts and Crosses’ (1952, Figure 2.1) and ‘Tennis for Two’ (1958) (Goldberg 2012a, Spencer 2004a, Djaouti *et al.* 2011). Ironically, despite being regarded as ‘games’, both were originally written by academics, partly out of academic curiosity and partially as a means of demonstrating the capabilities of these new mainframe computers. It could be argued therefore that these ‘games’ were the first occurrences of ‘educational computer games’, although perhaps not explicitly recognised as such at the time (Cross 2007).

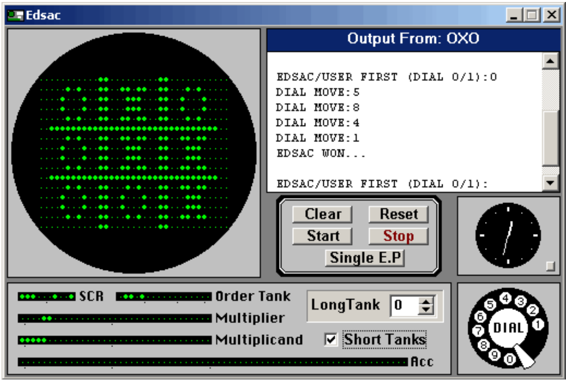


Figure 2.1: EDSAC Simulator running ‘Noughts and Crosses’
(Campbell-Kelly 2006)

By the 1970’s, the falling cost of electronic components led Atari Corporation to develop its ‘Video Console System’ (1977, Figure 2.2), which is credited with creating the home videogame market (Spencer 2004b, Goldberg 2012b, Retro Gamer 2006a). The ‘Video Console System’ (VCS) provided colour graphics and a greater range of games (through interchangeable ‘game cartridges’) for consumers to play with, from within the comfort of their own homes.

Despite its pre-dominating role as a pure gaming console, the VCS also saw a limited number of educational titles released during its lifetime, including ‘Brain Games’ (memory related ‘games’), ‘Math Gran Prix’ (car racing game, where track progress is linked to maths questions) and ‘Basic Math’ (basic arithmetic practice, Figure 2.3) (Cross 2007, AtariAge 2013b, 2013c, 2013d, 2013e).

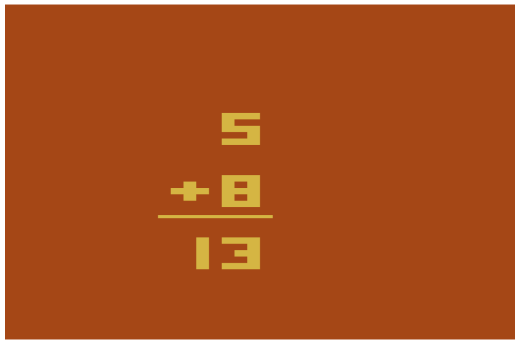


Figure 2.2: Atari 2600 VCS (AtariAge 2013a)   Figure 2.3: Basic Math (AtariAge 2013f)

By the dawn of the 1980's, the era of the games console was beginning to fade (Bevan 2008), giving way to what could be considered the 'home computer revolution'. Compared with their console counterparts, the home computer offered greater power, flexibility and (in addition to the evitable computer gaming usage) the proposal of being 'educational'. These new 'home' computers were marketed as being versatile products (Allen 2006), allowing adult consumers to produce spread sheets, write reports and educate their children. Companies, such as Atari Corporation and Commodore Business Machines (CBM) took the early lead in this burgeoning new market, but would soon be joined by other companies looking for a piece of this new high-tech gold rush (Allen 2008).

2.2.1 Computer Literacy Project

In a move that was unusual for the time (i.e. a publically funded company engaging in commercial practices), the British Broadcasting Corporation (BBC) announced its intention to promote literacy in this new computer technology, through the 'Computer Literacy Project' (BCS 2012, Smith 2011, Blyth 2012, Hammond *et al.* 2009). Running (officially) between 1979 and 1983, the BBC stated:

> "*The aim of the project is to introduce interested adults to the world of computers and computing, and to provide the opportunity for viewers to learn through direct experience how to program and use a microcomputer*." (BBC 1981, p.1).

In order to realise this vision, the BBC planned to produce educational books and a ten-part TV series ('The Computer Programme') revolving around a specially produced 'microcomputer' which would feature a standardised BASIC programming language.

The BBC published a tender for the development, manufacture and distribution of the proposed microcomputer which, with the government's support, would also be used within the UK education system to promote computer literacy. Eventually Acorn Computers would win the tender, and the subsequently produced computer would be known generically as the 'BBC Micro' (Figure 2.4) (Carroll 2008, Crookes 2013, Goodwin 2007).

Figure 2.4: The BBC Micro (Model B)
(Centre for Computing History 2013)

Unsurprisingly, given its educational nature, a considerable amount of maths related software was developed for the BBC Micro, during its lifetime.

During the 1970's the "Secondary Mathematics Individualised Learning Experiment" (SMILE) project was developed as a means of delivering maths education (through practical activities) to the UK secondary school sector. Initially, these practical activities took the form of traditional paper based 'Activity Cards' and worksheets (National STEM Centre 2014a, 2014b), but with the development of the microcomputer, software versions of the original SMILE activities (such as 'Tower' (Fractions), 'Maze' (Logic) and 'Race Game' (Vectors)) were made available for the BBC Micro (SMILE Centre 1984, Johnston-Wilder & Pimm 2005).

Other notable titles developed during this period (typically based upon the adventure game genre) included ‘L - A Mathemagical Adventure’, ‘Granny’s Garden’, ‘Giant Killer’ and (puzzle game) ‘Maths With A Story 1’ (Abbot 2000, Hammond *et al.* 2009, Tan 2010, Acorn Electron World 2013, Topologika 2014).

Today, modern maths-based games are available through a wide variety of outlets, primarily the Internet (Bowland Maths 2014, Manga High 2014, BBC 2014d) and through the ‘app stores’ associated with both Apple and Google Android based mobile phones and Tablet PC’s (Jary 2014). However, in a testament to their historical influence, the pioneering games of the BBC Micro’s era (such as ‘L - A Mathemagical Adventure’ and ‘Granny’s Garden’) are still commercially available in their original formats (for use with software based BBC Micro ‘emulators’, 4Mation 2014a) and have also been redeveloped for use on modern (i.e. Microsoft Windows based) computers (ATM 2014, 4Mation 2014b) – potentially serving the educational needs of a newer generation of learners.

2.2.2 Edutainment

As the 1980’s drew to a close, the ‘8 bit’ generation of microcomputers were gradually replaced with more powerful ’16 bit’ variants, (Commodore Amiga, Atari ST, Acorn Archimedes) and in what would be a recurring theme, the ’16 bit’ market gave way to a new generation of home videogame consoles (Day 2007, Cusick 2004, Reed 2010).

This period of revived video gaming was dominated by two Japanese companies, Sega and Nintendo Corporation (Birch 2004). As with Atari before it, Nintendo also produced a limited number of educational titles, such as ‘Donkey Kong Jr Math’ and ‘Maths Blaster’ (Figure 2.5 / Figure 2.6). Unfortunately, many of Nintendo’s attempts at educational games were deemed to have failed, mainly due to their lack of ‘fun’ or poor design (Cross 2007, X-Entertainment 2003, Panoutsopoulos, Sampson & Mikropoulos 2014).

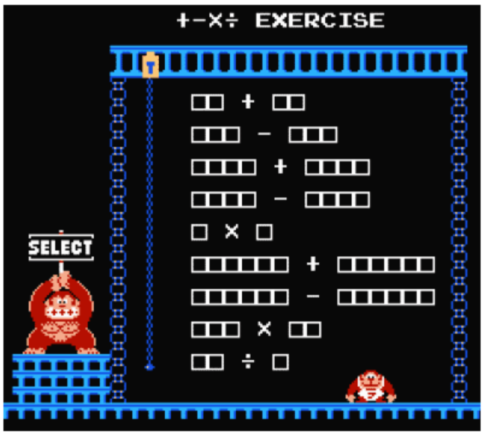


Figure 2.5: Donkey Kong Jr Math
(X-Entertainment 2003)

Figure 2.6: Math Blaster
(Jensen 2012a)

On the more ‘serious’ side of computing, the IBM PC was representing the ‘traditional’, and possibly more ‘educational’ computer system (Milne 2013). As time progressed, and the cost of computer components began to fall, manufacturers began adding Compact Disc (CD) Readers and sound output circuit boards (otherwise known as CD-ROM readers and ‘Sound Cards’) to the increasingly more powerful PC architecture (Milne 2013).

The growing popularity of the home PC, led to the development of so-called ‘edutainment’ (the marriage of ‘education’ and ‘entertainment’) software being produced during the late 1990’s/early 2000’s (Klopfer & Osterweil 2013). ‘Edutainment’ titles married developments in multimedia technology (the aforementioned CD-ROMs and sound cards) with gaming and educational objectives. While these titles were considered successful in the short-term, there is a view that as a whole, ‘edutainment’ failed.

This was due to a number of factors (Klopfer & Osterweil 2013, Cross 2007, Panoutsopoulos, Sampson & Mikropoulos 2014, Dondlinger 2007, Minović, Milovanović & Starcevic 2013, Stowell & Shelton 2008, Hong *et al.* 2009):

- Edutainment titles were considered just regular videogames with educational content 'bolted-on' as an afterthought – resulting in games that were neither (educationally) motivating nor playable. Bruckman (1999) (in Bourgonjon & Van Looy 2012) refers to this concept of edutainment as ''chocolate-covered broccoli''.

- Titles that attempted to be genuinely educational were often poorly designed, with a lack of interactivity and 'simplistic' computer graphics and audio.

- Most titles were considered not particularly well suited to conveying more complex educational material, while at the same time criticised for using a simplistic 'drill and skill' format.

- Later titles fell into the trap of the using 'celebrity' or 'Hollywood movie' tie-in licences in order to increase sales – resulting in what Klopfer & Osterweil (2013) consider to be 'lazy' edutainment products.

- Finally, the rise and development of the (then) fledgling Internet, would eventually provide access to lower cost, and in many cases, free educational games.

2.2.3 e-Learning

At the beginning of the literature review process, early searches concentrated on the most logical (and frequent) terms used to describe the research area, namely 'Games Based Learning' (GBL) and 'Educational Games'.

While using the online academic database 'Athens', it soon became apparent that these search terms also featured in connection with several other subject areas, prompting the author to widen the range of search terms used as part of the initial review process. One key term that frequently appeared within the search results (in connection with GBL and Educational Games) was 'e-learning'.

Although there is some disagreement on what ‘e-learning’ actually is (Pailing 2002, Dublin 2004), the predominant view is that anything involving computers (and more often internet web sites) could be regarded as ‘e-learning’. In recent years, as it has become apparent that e-learning has not replaced more traditional education (i.e. books and teachers), there has been a shift towards so called ‘Blended Learning’ (Stewart 2002, Baldwin-Evans 2006, Bele & Rugelj 2007, Hofmann & Miner 2008).

Blended Learning (sometimes referred to as ‘e-learning 2.0’ or the ‘refuge of e-learning’) is considered by some to be an enhanced version of e-learning, but more often is generally regarded as teaching using a mixture of new and traditional technologies/methods (Canon 2003, Mortera-Gutièrrez 2006, Trasler 2002, Vaughan 2007, Welker & Berardino 2005).

Driscoll (2002) defines blended learning as:

- “*To combine or mix modes of Web-based technology (e.g. live virtual classroom, self-paced instruction, collaborative learning, streaming video, audio, and text) to accomplish an educational goal.*
- *To combine various pedagogical approaches (e.g. constructivism, behaviourism, cognitivism) to produce an optimum learning outcome with or without instructional technology.*
- *To combine any form of instructional technology (e.g. videotape, CD-ROM, Web-based training, film) with face-to-face instructor lead training.*
- *To mix or combine instructional technology with actual job tasks in order to create a harmonious effect of learning and working.*” (Driscoll 2002, p.1).

In addition to this detailed definition, James-Clarke IV (2006) suggests that ‘Blended Learning v2.0’ also uses interactive gaming technology to motivate learners, and is probably why Blended Learning is occasionally referenced in connection with Games Based Learning and Educational Games.

2.3 Games Based Learning / Serious Games

The terms 'Games Based Learning', 'Serious Games' and to a lesser extent 'Educational Games' all seem to be interchangeable and broadly describe games that are designed to be fun/playable and educational at the same time. Michael & Chen (2006) refer to this as '*Stealth Education*', while Prensky (2006) coins the phrase '*unforced learning*'.

Although Ayiter (2008) considers it important that any Serious Game is aligned with a recognised learning theory or pedagogical model, it seems (from the literature) that many Serious Games have not been designed in this way. As a consequence, most literature in this area concentrates on the educational qualities/principles found within computer games, whether they are explicitly designed to be educational or not.

As will be discussed shortly (*2.5 What is a 'Game'?*), defining what a 'game' constitutes (let alone a 'Serious Game') is fraught with difficulty. However, given the broadness afforded by the literature, it could be argued that Serious Games are not a new concept, but a contemporary refining of education, mixed with technology. Early examples of modern 'Serious Games' include military modified versions of Atari's *Battlezone* (1980) arcade game for US Army tank training ('The Bradley Trainer') and id Software's *Doom* (1993) aka *MarineDoom* for US Marine training (Tappeiner & Lyons 2008, Djaouti *et al.* 2011, Jayakanthan 2002).

2.4 Why Games Based Learning?

2.4.1 Repetition

Most researchers in the field (Including Pannese & Carlesi 2007, Annetta 2008 and Gee 2007) agree that one of the most educational aspects of computer games is '*repetition*'.
Most games have a level of difficulty that will require the game player to practice several times, before he/she has mastered the task (this could be a specific task or a 'level' within the game).

For most players, this repetition is almost automatic and without question, if the player fails to complete Level 1 of a game, they will often practice until they can successfully progress to the next level. Gee (2007) argues that this process is fundamental to learning, and that the following sequence actually takes place:

1. The player experiences/explores/plays the game, or as Gee puts it 'probes' the virtual world that the game creates.
2. Having explored the 'game world', the player will reflect on what they have discovered.
3. Having reflected, the player will develop a hypothesis on how the 'game world' operates.
4. With this hypothesis in mind, the player 're-probes' the game world in order to test whether the hypothesis is correct or not.
5. In the event of the hypothesis being incorrect (i.e. the player fails to make progress or complete the current level), the player will then start from the beginning and re-probe, reflect and then re-develop/re-test their hypothesis.

Both Gros (2007) and Annetta (2008) express the view that this process is similar to the 'Drill and Practice' or rote memorisation of traditional teaching. Gee is not alone in proposing this '*probe – re-probe*' view (Martens, Gulikers & Bastiaens 2004, Gros 2007, Wideman *et al.* 2007, Pivec 2007, Tappeiner & Lyons 2008), but is most notably predated by Garris, Ahlers, & Driskell's (2002) 'Game Based Learning model' (Figure 2.7). Gee also argues that the 'probe – reflect – hypothesis – re-probe' process will also lead the player/learner to engage in critical thinking. From this standpoint, the suggestion that players are also developing deductive reasoning skills could also be considered valid (Gros 2007).

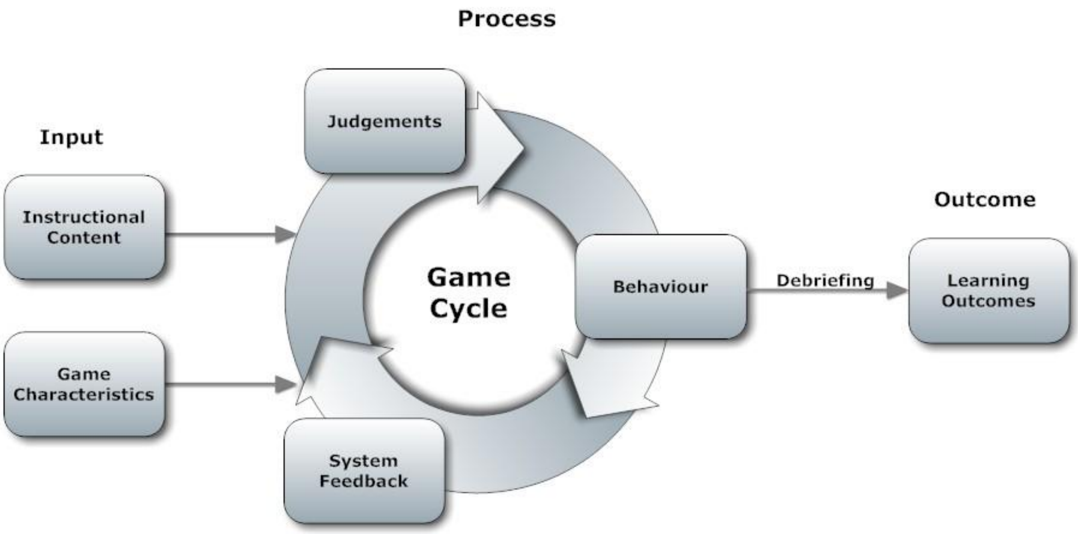


Figure 2.7: Game Based Learning Model (Garris, Ahlers, & Driskell 2002)

2.4.2 Skills Development

Along a similar principle, there are views within the literature that game playing can help develop and improve a range of skills (Gros 2007, Boyle, Connolly & Hainey 2011, Phillips & Popović 2012, Ke 2008, de Freitas & Liarokapis 2011, Connolly, Stansfield & McLellan 2006, Hwang *et al.* 2012, Carolyn Yang & Chang 2013, Dondlinger 2007, Annetta, Folta & Klesath 2010, Boyle, Connolly & Hainey 2011, Tang, Hanneghan & El Rhalibi 2009, Demirbilek & Tamer 2010, Sardone & Devlin-Scherer 2010), including:

- Power of observation.
- Attention span.
- Collaboration.
- Creative thinking.
- Faster processing of information.
- Problem solving.
- Spatial navigation/representation.
- Tracking multiple objects simultaneously.
- Increased retention of information.
- Social and Psychomotor skills.

Both Prensky (2006) and Michael & Chen (2006) list a number of skills/abilities, that they assert, games already teach:

- Hand/Eye co-ordination.
- Curiosity – players learn to test, seek out new information.
- Cognitive Skills.
- Improved 'Visual Selective Attention' (being able to focus/concentrate on a specific object amidst a 'sea' of other objects).
- Improved Visual Memory.
- 'Situational Awareness' (the ability to process information from many sources).
- Multitasking.

Probably the most (recent) prominent example of a 'Serious Game' is *America's Army*, both a recruitment tool and a form of military training developed by the United States Army (Michael & Chen 2006). The game takes recruits through the process of basic training (such as riflemanship, hand-to-hand combat and the use of incendiary devices), and in turn serves to show gamers and would-be recruits what basic army training is actually like. In a military context, Michael & Chen (2006) suggest that *America's Army* allows recruits to develop the required basic skills/abilities *before* they begin the real life basic training:

- Improved ability to multi-task.
- Improved Target differentiation.
- Target Prioritisation.
- Teamwork with limited communication.
- Desensitisation (shooting human targets).
- Willingness to take aggressive action.

2.4.3 Personalised Learning

Closely related to practice and repetition, is the concept of 'personalised learning'.

Gee (2007) argues that most computer games can accommodate individual learning styles by allowing the player to adjust several aspects of a particular game, i.e. the level of game difficulty (easy, normal, hard), the number of villains per level, and the speed at which they are 're-spawn' (re-incarnated). This in turn, Gee argues, allows a game player to customise the game to their own preferred (learning) style of play.

More sophisticated commercial games incorporate a degree of Artificial Intelligence (AI) that can offer ‘dynamic balancing’. Dynamic Balancing involves a game’s internal ‘game engine’ monitoring the player’s progress throughout the game (or game level) and dynamically adjusting the level of difficulty (or challenge) based on an assessment of the player’s current performance (Schell 2010).

From a pedagogic point of view, this design feature is appealing as it theoretically allows for automated ‘personalised learning’ – the dynamic adaption of educational challenge, dependent on the individual player’s current skill – effectively the computer game equivalent of differentiation (Sherry 2013, Faure & Ray 2011, Bourgonjon & Van Looy 2012, Condie *et al.* 2007, Royle 2009, Hwang *et al.* 2012). However, as will be noted in Chapter 3 (*3.7.2 Challenge*), attempting to implement dynamic balancing within computer games can be a challenging (and potentially flawed) process.

2.4.4 Motivation

The other main argument for the educational use of computer games is that they generate high levels of engagement and therefore lead to interested and motivated learners (Vogel, Vogel *et al*. 2006, Paras & Bizzocchi 2005, Tobias, Fletcher & Wind 2014, Chee 2007, Gros 2007, Denis & Jouvelot 2005, Charles, Bustard & Black 2009, Melero, Hernández-Leo & Blat 2011, Gee 2007, Shaffer 2008, Annetta, Folta & Klesath 2010, Ott & Tavella 2009, Ott & Tavella 2010).

Within the literature, the concept of motivation is considered an important aspect for successful learning. Researchers suggest that motivated learners have greater involvement with the process of education, are less likely to ‘drop out’ of the school system and engage more in ‘deep level learning’ (Fang 2012, Hays 2005, Paras & Bizzocchi 2005, Martens, Gulikers & Bastiaens 2004, Gredler 2004).

But how do we define ‘motivation’?

> “*In layman’s terms being motivated is commonly taken to mean being ‘energised’ to work willingly toward some valued goal, and having the desire to put in sufficient effort to succeed.*” (Westwood 2004, p.31).

Or more concisely:

> “*To be motivated means to be moved to do something*” (Ryan & Deci 2000a, p.54).

In this context, games players are willing to spend hours of their own time in order to master a certain game feature, a level (within a game) or the game itself. This could, in part, be due to the fact that players/learners are free to explore the virtual game world in safety, with little worry for their well-being and safe in the belief that any mistakes made will be confined to the (relative) privacy of the virtual world (Gee 2007, Shaffer 2008). Contrast this with the fear or feeling of embarrassment which is frequently associated with a pupil being singled out (within the classroom) in order to answer a teacher’s question in front of the entire class, especially if the pupil does not know the answer.

The virtual worlds that games offer, can sometimes be in themselves educational. For example, World War II themed games (such as the successful *Call of Duty* and *Medal of Honour* series) can be very immersive and historically accurate, allowing the player to experience ‘the world at war’ in a way that traditional movies, such as *Saving Private Ryan*, cannot (Gee 2007).

Gee (2007) suggests that most computer games can accommodate learning styles by allowing the player to ‘control’ the game. In the context of education, the concept of control is considered an important aspect of the learning process, and frequently features within the theories of motivation (*2.4.4.1 Motivational Theories*). Control or ‘Learner Agency’, is the learner’s belief that they have control over, or ‘the capacity to act’ upon, their learning and that this will influence the outcome of the learning process (Mercer 2012, van Lier 2008, Blair 2009, Xiao 2014).

In terms of computer games, this ‘control’ is enabled through the ability to adjust several aspects of a game, and its ‘game play’. For example, many games provide options to adjust the level of game difficulty (easy, normal, hard), the player control mechanisms (keyboard, mouse, joystick) and aspects of the virtual environment (floor/wall texture detail, the amount of lighting). In turn, Gee (2007) argues that these levels of control allow game players to customise a game to reflect their own preferred (learning) style of play.

In the context of the motivational properties of computer games, Malone and Lepper put forward the following properties that they argue can create a motivating environment[1] (Malone & Lepper 1987, Lepper & Malone 1987):

- Challenge.
- Curiosity.
- Control (Learner Agency).
- Fantasy.
- Competition/Co-operation.
- (Peer) Recognition.

Other researchers have expanded upon Malone and Lepper’s original work, suggesting additional computer game based ‘motivational’ properties (Vogel, Greenwood-Ericksen *et al*. 2006, Orvis, Horn & Belanich 2008, Phillips & Popović 2012, Amory *et al*. 1999, Dickey 2005, Dondlinger 2007, Watson, Mong & Harris 2011, Erhel & Jamet 2013, Charles, Bustard & Black 2009), including:

- Flow (*3.8.4.6 Flow Theory*).
- Rewards.
- Scores.
- Fantasy Narrative.
- Good quality sound and graphics.
- Provision of Feedback (positive and negative).
- Elements of ‘surprise’ (Although Sardone & Devlin-Scherer (2010) do not actually define what could be considered a ‘surprise’).
- The pace/speed of a game (which Jennett *et al.* (2008) argue also creates an element of challenge).

[1] Malone & Lepper (1987) will be discussed in greater detail within Chapter 3 (*3.8.2 Educational Game Design (Malone and Lepper)*).

The literature on motivation distinguishes between two types: Intrinsic/Endogenous motivation and Extrinsic/Exogenous motivation.

Intrinsic or endogenous motivation could be considered internal to the individual. A person chooses, (or is motivated) to engage in an activity because they find it inherently interesting and seek to participate due to deriving ‘fun’ and enjoyment from the activity (Deci & Ryan 1985, Ryan & Deci 2000a, Paras & Bizzocchi 2005, Sardone & Devlin-Scherer 2010). Within an educational setting, this is the preferred type of motivation that learners will ideally exhibit towards learning activities, resulting in ‘higher quality learning’ (Ryan & Deci 2000a).

In contrast, extrinsic or exogenous motivation is considered external to the individual. With this type of motivation, a person will participate in an activity (regardless as to whether they find it interesting or not) because they feel obliged or required to do so. For example, few learners are intrinsically motivated to sit an exam, but are extrinsically motivated to do so, because they recognise that it is a requirement for successfully completing their course of education – such as a training programme or a degree course (Ryan & Deci 2000a, Rieber 1996, Erhel & Jamet 2013).

As noted previously, Malone & Lepper and subsequent researchers regard ‘fantasy’ as an important aspect of motivation, with Rieber (1996) regarding ‘endogenous fantasy’ as “*an important first step towards intrinsic motivation*” (Rieber 1996, p.50).

However, Habgood, Ainsworth & Benford (2005a, 2005b) take issue with the emphasis placed (within the literature) on the prominence of fantasy within motivational game design, stating (in connection with the game ‘BreakOut’):

> “*Whether the game uses the fantasy context of a bat and ball or (as in a later interpretation of the game) a space ship and energy bolt, it makes no difference to the fundamental gaming activity*” (Habgood, Ainsworth & Benford 2005a, p. 8)

Habgood, Ainsworth & Benford (2005b) and Habgood & Ainsworth (2011) argue that the integration of ‘flow’ (*3.8.4.6 Flow Theory*) and well designed ‘game mechanics’ (*3.7.4 Game Mechanics*) are more likely to generate successful intrinsic motivation than the use of ‘fantasy’ alone.

Outside the body of their respective work, the author was unable to source additional literature challenging this viewpoint, with the exception of Echeverría *et al*. (2012) who note that this viewpoint does contradict established research on the inclusion of fantasy within computer games i.e. the work of Malone & Lepper (1987) and Rieber (1996).

2.4.4.1 Motivational Theories

While ‘motivation’ can be described in terms of properties (such as challenge, curiosity etc.), theories have been developed to formalise the use of motivation within an educational context. For the purposes of completeness, this section concludes with a brief discussion on the most cited motivation theories, that of Maslow (‘*Hierarchy of Needs*’) and Deci & Ryan (‘*Self Determination Theory*’).

Maslow's Hierarchy of Needs

Abraham Maslow's ‘Hierarchy of Needs’ postulates that human beings have ‘needs’, which when addressed, will lead to satisfaction and well-being (Maslow 1943). Maslow's hierarchy is frequently depicted diagrammatically, composed of five ‘needs’ (Figure 2.8). At the lower end of the hierarchy (Levels 1 and 2), are the ‘basic’ human needs that need to be satisfied before an individual (or a learner, in an educational context) can begin to address the needs at the higher end of the hierarchy (Levels 3 – 5).

Level 1 - Physiological Needs

At the lowest level in Maslow's Hierarchy, are the basic needs that all human beings require to be satisfied in order to live and to be able to function healthily. These needs include the ability to breathe, the need for nourishment (food and water), sleep and shelter.

Level 2 – Safety / Security Needs

Having satisfied the physiological needs, an individual can begin to address the needs of personal safety and security. These needs may only become apparent in situations where they are unexpectedly threatened, such as a health scare, loss of employment or (within the classroom) the sudden fear/embarrassment or anxiety of answering a teacher’s question incorrectly.

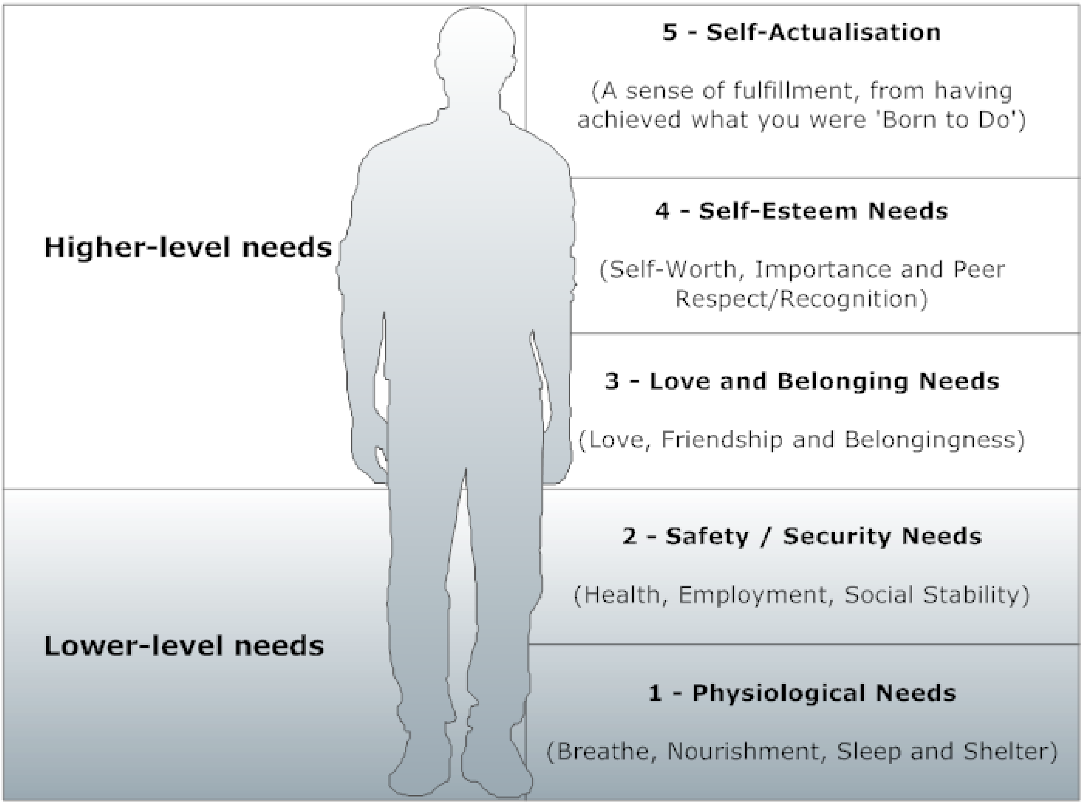


Figure 2.8: Maslow's Hierarchy of Needs (Adapted from Maslow 1943)

Level 3 – Love and Belonging Needs

After the satisfaction of both physiological and safety needs, the next level of needs to be satisfied are those relating to belongingness – the need for love, friendship, fitting into a peer group and a general sense of belonging. As Maslow states:

> "*He will hunger for affectionate relations with people in general, namely, for a place in his group, and he will strive with great intensity to achieve this goal. He will want to attain such a place more than anything else in the world and may even forget that once, when he was hungry, he sneered at love*" (Maslow 1943, p.381).

Level 4 – Self-Esteem Needs

At this level, an individual seeks to satisfy needs relating to their self-esteem, namely a sense of self-worth/importance and respect or recognition from one's peers. This level (along with Level 3) could be said as being reflected within Malone & Lepper's work as the motivational principle of 'peer recognition'. The reverse of this need (e.g. a lack of recognition or respect) can lead to low self-esteem, feelings of inferiority and helplessness.

Level 5 – Self-Actualisation

The final level of Maslow's hierarchy is that of Self-Actualisation – the successful fulfilling of an individual's purpose or meaning in life or as Maslow observes:

> "*A musician must make music, an artist must paint, a poet must write, if he is to be ultimately happy. What a man **can** be, he **must** be. This need we may call self-actualization.*" (Maslow 1943, p.382)

Parallels with Control or Learner Agency could be drawn here, as Self-Actualisation might be considered the desired (or successful) outcome of the control that the learner has asserted over their learning process – they have attained that which they set out to achieve.

As one of the oldest motivation theories, Maslow's Hierarchy has been subjected to several critiques, and as a consequence has drawn several criticisms. The most significant criticism is that Maslow's theory is just that – a theory, with little or no empirical evidence to support the existence of the hierarchy, nor the specific ordering of the needs within the hierarchy (Wahba & Bridwell 1976, Kaur 2013, Kremer & Hammond 2013).

Neher (1991) and Trigg (2004) both argue that the hierarchy focuses too much on the individual's needs, and therefore downplays the role of social interaction (Level 4) and cultural influences on people's 'needs' in general. Reflecting both these criticisms, Denning 2012 argues that:

> "*Needs are not hierarchical. Life is messier than that. Needs are, like most other things in nature, an interactive, dynamic system, but they are anchored in our ability to make social connections*." (Denning 2012).

Finally, Neher (1991) criticises the hierarchy by claiming that Maslow originally overstated his theory in order to make it more 'distinctive' from other motivation theories of the time, and that therefore the theory has been afforded greater importance than it really deserves.

Self Determination Theory (SDT)

As with Maslow's Hierarchy of Needs, Self Determination Theory (Deci & Ryan 1985, Ryan & Deci 2000b, Deci & Ryan 2000, Deci & Ryan 2013) postulates that human beings have psychological needs, which need to be addressed in order to ensure satisfaction and well-being. Deci & Ryan identified these needs as:

- Competence – The desire and confidence to develop and master new skills.
- Relatedness – A sense of belonging, within a supportive environment.
- Autonomy – Freedom of choice for the individual to engage in activities within their control.

Upon examining these needs, a degree of commonality can be seen with the previously discussed literature. For example, it could be suggested that *Relatedness* reflects Maslow's needs of Belongingness (Level 3) and Self-Esteem (Level 4), while *Autonomy* reflects the principle of Control or Learner Agency (i.e. in the context of Malone & Lepper's motivational principles or Gee's views on 'preferred (learning) style of play'). While not a motivational theory per se, it might be argued that Deci & Ryan's *Competence* also touches upon Vygotsky's *Zone of Proximal Development* and the mastery of new skills (*3.8.4.4 Vygotsky's 'Social Development Theory'*).

Self Determination Theory itself actually consists of five 'sub-theories' (Deci & Ryan 1985, Deci & Ryan 2000):

1. Basic Psychological Needs Theory (BPNT) – describes the psychological needs that are required for intrinsic motivation and psychological well-being.

2. Cognitive Evaluation Theory (CET) – describes *intrinsic* motivation.

3. Organismic Integration Theory (OIT) – describes several types of *extrinsic* motivation, such as the motivation for rewards or out of self-esteem.

4. Causality Orientations Theory (COT) – describes the differences in what motivates individuals (i.e. driven by self-interest, for rewards, or out of anxiety).

5. Goal Contents Theory (GCT) – distinguishes between intrinsic and extrinsic goals. Intrinsic goals may be altruistic (i.e. for the wider community), whereas extrinsic goals may be egoistic, such as the pursuit of 'power' or fame.

In contrast to Maslow's hierarchy, the author experienced difficulty in locating literature critiquing SDT, with the literature (which was discovered) focusing on specific aspects of the theory, rather than on SDT as a whole.

Referring to the CET sub-theory, Deci & Ryan (2000) postulate that environments or tasks that are perceived (negatively) as ‘controlling’ will undermine an individual’s self-determined motivation. McLellan (2009) and McCally (2010) argue that this view is at odds with current education systems, where the use of formal testing and (extrinsic) rewards (both of which might be perceived as ‘controlling’ by learners) are common practice.

If subscribing to Deci & Ryan’s view, then in theory, education systems (through the use of ‘controlling’ exams or tests) should be de-motivating learners en masse, which McLellan (2009) disputes due to a lack of supporting evidence.

2.4.5 21st Century Students

One of Prensky’s (2001, 2006) most commonly quoted arguments for Games Based Learning, is that of the ‘Digital Native’. Prensky argues that today’s 21st century learner has grown up in a considerably different environment to that of the pre-21st century learner. These so-called ‘Digital Natives’ have grown up surrounded by all pervasive technology – mobile phones, MP3 players, digital cameras, Personal Computers, laptops, games consoles and more recently the Tablet Computer (e.g. the iPad).

It is Prensky’s contention that such a digital upbringing, has in turn, created a new generation of learners that think and learn differently from their pre-21st century counterparts (so-called ‘Digital Immigrants’) and therefore they need to be educated differently.
As learners, Digital Natives are more naturally inclined to learn from web blogs or ‘consume’ from social media (accessed through their iPad or iPhone), rather than from the ancient art of ‘reading books’. They have the ability to ‘parallel process’ several sources of input simultaneously, rather than the ‘serial processing’ that is the hallmark of ‘classical’ classroom teaching – and it is in this context – that computer games are promoted as being the ideal teacher (or at least, teaching assistant) for the 21st century and its pupils (Eseryel, Ifenthaler & Ge 2011, Rapeepisarn *et al.* 2008, Abrams 2011, Tang, Hanneghan & El Rhalibi 2009, Admiraal *et al.* 2011, Wideman *et al.* 2007, Annetta, Folta & Klesath 2010, Von der Heiden *et al.* 2011).

The concept of this ‘gamer’ or ‘net’ generation (Furió *et al.* 2013) does not go unchallenged though. Bennett, Maton & Kervin (2008) argue that Prensky’s work is often uncritically referenced within the literature and describe the ‘grand claims’, made by ‘Digital Native’ advocates, as a form of academic ‘moral panic’.

Studies conducted since Prensky’s early work (Prensky 2001) suggest that today’s ‘digital natives’ do not differ significantly from previous generations (i.e. digital immigrants) in terms of their IT / ICT usage (Smith 2012, Thang *et al*. 2014). Where there are differences, these can be attributed to the social-economic status of the ‘native’ or their level of IT access at school or college (Bennett, Maton & Kervin 2008, Smith 2013, Gu, Zhu & Guo 2013, Eynon 2010, Demirbilek 2014, Dietrich & Balli 2014).

Bekebrede, Warmelink & Mayer (2011) argue that the extensive use of different media and technology does not automatically make today’s learners ‘different’ and that they have witnessed (in the context of Higher Education) “*no fundamental change in learning style preferences*” (Bekebrede, Warmelink & Mayer 2011, p.1522).

Bekebrede, Warmelink & Mayer also make the point that:

> “*Interestingly, Prensky recently introduced some amendments to his original theory of digital natives and immigrants (2009), suggesting that the distinction between the two was losing ground.*” (Bekebrede, Warmelink & Mayer 2011, p.1523).

In terms of digital natives being able to ‘parallel process’, Bennett, Maton & Kervin (2008) argue that there is no evidence to suggest that this is a ‘new’ skill, citing digital immigrants completing their homework in front of the television, as a ‘traditional’ example of multi-tasking. While digital natives are regarded as being ‘tech savvy’ social media consumers (Smith 2012), a number of studies contradict this view (Bennett, Maton & Kervin 2008). The main findings would suggest that young learners actually make limited use of social media (Somyürek & Coşkun 2013, Thang *et al*. 2014, Gu, Zhu & Guo 2013), giving preference to more ‘traditional’ IT (i.e. static web pages and e-mail) for learning purposes (Thang *et al*. 2014, Smith 2012, Somyürek & Coşkun 2013, Kennedy & Fox 2013).

At the time of writing, while there is disagreement (within the literature) around Prensky's definition of the 'Digital Native', there is a consensus that the concept warrants additional academic research (Bennett, Maton & Kervin 2008, Eynon 2010, Smith 2012, Smith 2013, Gu, Zhu & Guo 2013, Thang *et al*. 2014, Demirbilek 2014).

2.5 What is a 'Game'?

What do we mean by the term 'game'?

The author regarded this as a somewhat simple term, in the context of computers, i.e. computer games. However, during subsequent literature reviews (into Games Based Learning, and related areas), it became apparent that there is little agreement on what might constitute a (computer) 'game' (Wilson *et al.* 2009, Hwang *et al.* 2012, Mislevy *et al.* 2012, Dempsey *et al.* 2002, Shute & Ke 2012). It is the opinion of this author, that this lack of agreed definitions is a recurring theme throughout the area of Games Based Learning.

Starting with pure (non-educational) definitions of a 'game', Perry & DeMaria (2009) define a 'game' as offering a "*series of choices – or decisions*" (Perry & DeMaria 2009, p. xxvi), whereas Schell (2010) takes a more pragmatic approach, arguing that many have tried to define what a 'game' is, but that most have failed to successfully do so. He offers 12 definitions of what a game actually 'is', before finally settling on: "*A game is a problem-solving activity, approached with a playful attitude.*" (Schell 2010, p.37). Koster (2005) shares Schell's view that defining what a 'game' is, is not straightforward, but in the context of having 'fun', Koster offers the following definition of a good game as: *"one that teaches everything it has to offer before the player stops playing*" (Koster 2005, p.46).

2.6 What is an Educational or 'Serious' Game?

While the majority of definitions (found within the literature) are concerned with defining 'traditional' (digital) games, some researchers have attempted to expand upon these definitions in order to define educational and 'Serious' games. However, as with the definition of a 'game' itself, there seems to be little agreement on what exactly constitutes either an educational or a 'Serious' game (Djaouti, *et al.* 2011, Hainey *et al.* 2013, Panoutsopoulos, Sampson & Mikropoulos 2014, Tang, Hanneghan & El Rhalibi 2009, Tappeiner & Lyons 2008, Erhel & Jamet 2013, Arnab *et al.* 2012).

Marsh (2011) proposes the following definition of a (digital) Serious Game:

> "*Serious games are digital games, simulations, virtual environments and mixed reality/media that provide opportunities to engage in activities through responsive narrative/story, gameplay or encounters to inform, influence, for well-being, and/or experience to convey meaning. The quality or success of serious games is characterized by the degree to which purpose has been fulfilled. Serious games are identified along a continuum from games for purpose at one end, through to experiential environments with minimal or no gaming characteristics for experience at the other end.*" (Marsh 2011, p.63).

While Rice (2007), in reference to educational videogames, offers the following definition:

> "*Gredler (1996) defined educational games as unique opportunities for children to experience activities within a cognitive domain in which new knowledge can be introduced. For the sake of this article, the term computer video game simply extends Gredler's definition of games to computing environments. Computing environments involve the use of personal computers, and in the case of this article we are concerned with personal computers used specifically within classroom settings.*" (Rice 2007, p.250).

Burgos, Tattersall & Koper (2007) distinguish between 'digital games' and 'educational games', as such:

> "*A digital game is a game played in an electronic platform fulfilling the following features: (a) it is a voluntary action, started and completed by the user as he wants; (b) it is also imaginary, parallel to the real world, replicating a universe or an activity without any consequence in the real life; (c) it is limited, in time and space; (d) it follows a set of rules, a specific and private framework; and (e) it provides an uncertain solution since every run, every play, is different and depends on unpredictable user behaviour.*" (Burgos, Tattersall & Koper 2007, p.2657).

> "*Beyond these generic features, educational games exhibit additional characteristics: (a) an educational game starts with a premise to be solved; (b) being unproductive, it does not generate any property or wealth; (c) the main drive is the gaming activity itself; (d) there is at least one right solution; and (e) the user/player learns a skill or attains a competence, introducing new knowledge, fixing previous acquired knowledge, training skills, sharing experiences, discovering new concepts, developing outcomes*." (Burgos, Tattersall & Koper 2007, p.2657).

As with defining the term 'game', a universally agreed definition for either 'Educational' or 'Serious' games seems elusive. However, having reviewed the literature for both definitions, the author has a personal preference for the definitions of Burgos, Tattersall & Koper (2007).

The author regards their definition of a 'digital game' to be practical (e.g. '*it is limited, in time and space*') and conveys a sense of fun and enjoyment (e.g. '*voluntary action*', '*completed by the user as he wants*', '*imaginary*'...). Similarly, their definition of an 'educational game' is broad enough to apply to reasonably any educational environment (be it schooling or corporate training) while also retaining the same sense of fun and enjoyment ('*the main drive is the gaming activity itself*') of their 'digital game' definition.

In the following section the author intends to take the definitions of Burgos, Tattersall & Koper (2007), and use them as a starting influence for defining what a 'game' actually represents.

2.7 So what is a 'Game'?

Given that experts and researchers, more knowledgeable than this author, have failed to arrive at a consistent and agreed term, this author does not presume that he can produce the definitive definition of the term 'game' (where others have failed).

However, influenced by the definitions of Burgos, Tattersall & Koper (2007), and the author's limited game playing experience during his childhood (some of which still applies during his subsequent adulthood), the author would define a 'game' as an 'experience'.

So what is a 'game'?

Within the literature, many researchers refer to 'games', 'educational games' or 'Serious Games'. For consistency, the author will refer to digital based games as simply 'games' – the author is not concerned with which platform they are based upon (i.e. video console, mobile phone, home computer) but that they are digital in nature and offer the prospect of fun and enjoyment.

In terms of education, the author prefers the term 'educational games' – this term is unambiguous, it is a 'game' which will contain some form of educational content. The author regards this term as being more appropriate than that of 'Serious Games'.
The reasoning behind this view is that Serious Games are designed with education in mind, and therefore could also be regarded as 'educational games'. Additionally, in the author's mind, the term 'Serious' carries connotations of not being fun (i.e. a bit serious), whereas the term 'educational' allows for interpretation (i.e. depending on the individual learner/player, educational games might or might not be fun).

Rather than define a game in mechanical terms (as with most ‘game’ definitions), the author prefers to define a game as an ‘experience’.

First and foremost, a game needs to be ‘fun’. As with the definition of a ‘game’, fun is also open to interpretation. When the author was of school age, playing computer games was fun, but for the author’s friend Ashley, listening to music was more fun than computer games. Meanwhile Michael preferred riding his BMX bike around the local playground, having been inspired by the movie ‘BMX Bandits’ (IMDB 2013a).

If an activity is not fun, then chances are the participant is not going to want to engage in it. Hence the author never rode around on a BMX bike while listening to music, instead preferring the relative comfort of a warm living room and an Atari computer. But why is playing games, ‘fun’? This is a difficult question to answer, aside from being the author’s preferred choice of ‘fun’, the author is of the personal opinion that fun is specific to the individual.

At one time, the author’s friend Ashley enjoyed the music of a particular American rock band, which had featured in the movie ‘Back to the Future’ (IMDB 2013b). It seemed (to the author’s eyes) that Ashley enjoyed this particular band’s music due to enjoying the movie, which in turn was due to its fantasy time-travelling storyline – that appealed immensely to Ashley’s interest in science fiction.

Michael in contrast, enjoyed outdoor activities, hence he derived his fun and enjoyment from riding his BMX bike – even when it was raining (as was typical during the school summer holidays).

The author enjoyed playing computer games, it's hard to define exactly why, as each game had a slightly different appeal:

- The sound of a game was important, the music and the sound effects would help create an atmosphere, whether it was the sound of a Lockheed Lightening performing a roll (in the game 'Screaming Wings') or 'Jet Boot Jack' hovering across the screen in his Hover-Boots.

- Equally, the graphics, although crude by today's standards, were colourful and imaginative, and any gaps in realism were filled in by the player's imagination.

- Elements of challenge added to the appeal of the games, but even then, different games offered different challenges. Part of this was down to a game's individual game mechanics, but also on how the player controlled the game, via a computer joystick or paddle. Whether it was moving the joystick in eight different directions (while playing 'International Karate') or frantically moving the joystick from side to side (in the sports game 'Decathlon') – as a player, you enjoyed the challenge, even if your hands were blistered as a consequence.

- Anticipation also played a part – as the owner of a computer disk drive, games could be loaded into a computer fairly quickly. However, for most game players, games had to be loaded via slow loading cassette tape. Despite this, the highly visual 'Loading Screen' along with the anticipation of playing the game (once loaded), seemed to add to the appeal of the eventual game – in fact one of the reasons for playing a specific game for a prolonged period of time was the knowledge that it would take a long time to load the next game.

- Motivation – Fun is often linked with motivation, and it is the author's opinion that whether playing games, listening to music or riding a BMX bike, intrinsic motivation plays a large part in why we voluntarily commit time to these activities.

Having 'defined' a game as an experience, how do you define an 'Educational' game? In a personal opinion, the author would argue that explicitly educational games are at odds with the game 'experience' described above and that ideally learning through games comes about subtly, non-invasively and ideally (but perhaps most difficult to achieve) subconsciously.

While playing the computer version of 'Trivial Pursuit' (Figure 2.9), it did not occur to the author at the time that this exercise might be educational; it was merely a general knowledge quiz with the added excitement of the sound effects, graphically rendered old style living room and the challenge of trying to beat the computer with (admittedly limited) knowledge.

Figure 2.9: Trivial Pursuit (AtariMania 2012)

The author cannot recall if he actually learnt anything from ‘Trivial Pursuit’ (aside from facts and figures). However, the process of playing ‘Trivial Pursuit’ on the computer was not off-putting, the overtly knowledge testing nature of the game did not detract from its enjoyment – it did not seem explicitly educational.

More subtly, the author learnt that Second World War planes, were propeller-based and could have two engines (via ‘Screaming Wings’) and that to drive a car around a corner (of a race track) required moving into the correct lane and either slowing the car’s speed or gently applying the brakes (‘Pole Position’), while the name ‘Robin Hood’ is often associated with stealing, it can also be associated with charitable giving to those less fortunate than yourself and that the weapon of choice during this era was the bow and arrow (English Software’s ‘Adventures of Robin Hood’).

More recently, it occurred to the author that he had learnt more about the Second World War from ‘The History Channel’ documentaries, than he had at school. This aspect was reinforced through the playing of the game ‘Call of Duty II’ which placed you (as the player) in strangely familiar situations, such as the ‘Battle for the Reichstag’. Having watched this battle through grainy monochrome documentary footage, the author was now transported there, storming the front entrance and engaging in room to room combat with the enemy. Maybe, due to the presence of ‘being there’, the author began to appreciate the danger and sacrifices that the Soviet troops had made to eventually place the Soviet flag upon the Reichstag. So while more of a monologue, than a definition, this is the author’s view of what games and educational games can be.

2.8 Game Genres

Closely related to the definition of a computer game, is the game ‘type’ or ‘genre’. A survey of the relevant literature revealed the following game genres, as summarised within Table 2.1 (Shaffer 2008, DeVary 2008, Allery 2004, Gros 2007, Annetta 2008, Annetta 2010, Dempsey *et al.* 2002, Clearwater 2011, Hong *et al.* 2009, Prensky 2001, Clyde & Thomas 2008, Ahmad & Jaafar 2012, Libin *et al.* 2010, Mislevy *et al.* 2012, Shute & Ke 2012, Liu & Lin 2009, Apperley 2006, Elliott *et al*. 2012, de Freitas *et al.* 2012, Faure & Ray 2011, Dickey 2007, Linden Research 2014).

Genre	Description
Action	Typically involves an element of jumping, running and shooting.
Adventure / RPG (Role Playing Games)	Cerebral, puzzle-based tasks within an evolving storyline.
Driving	Simulate a vehicle (e.g. motor cars or bikes), typically in the context of racing
Epistemic	Games (possibly serious games) played in a casual context (Shaffer 2008).
Exergame	Games controlled by physical movement, e.g. Nintendo’s Wii game console.
Flying	Simulates (to varying degrees of authenticity) flying a plane or spaceship.
Fighting	Simulate sports, such as karate or boxing
MMORPG (Massively Multiplayer Online Role Playing Games)	An RPG, involving travel around a ‘virtual world’ e.g. *World of Warcraft*, *Second Life*.
Puzzle	Often incorporated into other genres, but can also be a standalone game, e.g. *Tetris*.
Sports	Involve simulating a specific sport, e.g. Football, Golf.
Simulations / Simulation Games	Designed to train individuals in scenarios or the use of equipment, e.g. managerial trainers, combat simulators.
‘Strategy’	Typically involve simulating historical battles within a military conflict (e.g. Second World War).

Table 2.1: Game Genres.

In terms of game development, Research Question 2 is concerned with which genre is the most appropriate to develop educational games around, i.e. is there a preferred or 'best' game genre? A review of the literature revealed a lack of empirical research in the area of game genre, with the literature consisting mainly of the opinions and/or preferences of the researchers themselves.

A number of journal articles gave preference to the Simulation genre of computer game, but this was frequently without detailed explanation or was presented as the stated choice without further elaboration (Tang, Hanneghan & El Rhalibi 2009, Kiili & Lainema 2008, Obikwelu & Read 2012, Melero, Hernández-Leo & Blat 2011, Connolly, Stansfield & McLellan 2006, Bekebrede, Warmelink & Mayer 2011, Vogel, Vogel *et al*. 2006).
For example, Tang, Hanneghan & Carter (2012) boldly claim that both Role Playing and Simulation game genres are "*the most suitable for utilisation within the context of education and training compared to other game genres*" (Tang, Hanneghan & Carter 2012, p.64), while Maciuszek *et al*. (2010) express a preference for the Role Playing genre. In both instances, neither researcher elaborates on the empirical basis for their choices.

Similarly, through their research, Liu & Lin (2009) have produced a table (Table 2.2) highlighting the most commonly available educational games (by genre). This does not in itself suggest which is the 'best' genre, but does highlight that the most widely available educational games (by a large margin) are based on Puzzle and Simulation genres.

Genre	Number of games	Ranking
Puzzle	60	1
Simulation	40	2
Sports	24	3
Action adventure	21	4
Shooting	20	5
Role playing	17	6
Strategy	14	7

Table 2.2: Commonly available Educational Games by Genre (Liu & Lin 2009)

A number of researchers suggest that the Adventure genre lends itself well to mapped instructional content, supports scaffolding and allows for interactive and flexible narrative storylines (Waraich & Wilson 2005, Hu, J. 2010, Dickey 2006, Sisarica & Maiden 2013). Marchiori *et al*. (2011) suggest the following genres as noteworthy, due in part to their view that games based on these genres can be re-used in different educational contexts:

- Puzzles.
- 'Word' games.
- Fill-in-the-Blanks exercises.
- Simulations.

However, they subsequently propose a framework (eAdventure 2.0) based on the ('Point and Click') Adventure game genre. Amory (2007) shares the views of Marchiori *et al*., stating that "*challenges, puzzles, and quests are not only important educationally but are an essential part of a computer game*" (Amory 2007, p.68).

Clyde & Thomas (2008) and Minović, Milovanović & Starcevic (2013) suggest the use of First Person Shooter (FPS) games, arguing that they present a realistic immersive virtual world for players to navigate through. This could also be interpreted as support for the Simulation or MMORPG genres. Charles *et al*. (2012) conclude (based on experience gained through their iSpiral framework) that genre was not seen as important to students, who instead placed greater emphasis on the inclusion of social aspects within the iSpiral ('space shooter') game.

Finally, both Prensky (2001) and Rapeepisarn *et al.* (2008) offer guidance as to how to use Commercial Off The Shelf (COTS) games (*3.3 Commercial Off The Shelf (COTS) Games*) within an educational environment.

They assert that certain genres lend themselves to certain types of activities, i.e. Game Show or Puzzle games can be used to teach facts or help develop reasoning skills, whereas Strategy and Role Playing Games can be used in 'Learning by doing' or 'Learning by mistake' exercises. However, neither Prensky nor Rapeepisarn *et al* offer any empirical evidence to support their assertions, beyond suggestions for 'Possible Game Genres' to use (Table 2.3).

Learning Techniques	Learning Activities	Possible Game Genres
Practice & feedback	Questions, memorization, association, drill, imitation	Game show competition, flashcard type game, mnemonics, action, sports game
Learning by doing	Interact, practice, drill, imitation	Strategy game, action game, role playing game
Learning from Mistake	Feedback, problem	Role-play game, puzzle game
Discovery learning & guided discovery	Feedback, problem, creativity play	Adventure game, puzzle game
Task-based learning	Understand principle, graduated tasks	Simulation game, puzzle game
Question-led learning	Question / questioning, problem	Quiz or trivia game, game show competition, construction game
Situated learning	Immersion	Immersive style game such as role-playing game, flashcard game
Role playing	Imitation, practice, coaching	Role-playing game, strategy game, reflex game, adventure game
Constructivist learning	Experimentation, questioning	Building game, constructing game
Multisensory learning	Imitation, continuous practice, immersion	Games which introduce new technologies, such as locatable sound or force feedback, reflex game
Learning object	Logic, questioning	"*Games which are becoming object-oriented*"
Coaching	Coaching, feedback, questioning	Strategy game, adventure game, reality testing game
Intelligent tutors	Feedback, problem, continuous practice	Strategy game, adventure game, puzzle game, reflex game

Table 2.3: Game Styles - "Relationship between learning techniques, learning activities and possible game styles" (Adapted from Rapeepisarn et al. 2008)

2.9 Criticism of Games Based Learning

While a number of researchers advocate Games Based Learning and the use of Educational/Serious Games within education, there are those who argue otherwise.

2.9.1 General Criticism

Surveying the literature in this area, general criticism of Games Based Learning includes the view that increasing a learner's motivation (through the playing of computer games) does not necessarily lead to improvements in understanding and attainment in the longer term, furthermore some researchers also regard (educational) game playing as only producing superficial learning (Bourgonjon *et al.* 2010, Orvis, Horn & Belanich 2008, Wilson *et al.* 2009).

While research has been geared towards the premise that Serious Games have educational benefits (such as increasing cognitive skills), several researchers argue that there has been little solid research to assert these claims (Kearney 2007, Gunter, Kenny & Vick 2008, Annetta 2008). Pivec (2009) even goes as far as to state:

> "*Prensky's theories get quoted often when references are needed to support the introduction of a game into the classroom, even when Prensky himself has offered no empirical evidence.*" (Pivec 2009, p.5).

Where research has been completed, the results suggest that Serious Games offer no educational benefit or the results have been contradictory (Bourgonjon *et al.* 2010, Ke 2008, Wu, Hsiao *et al.* 2012, O'Neil, Wainess & Baker 2005, Pivec 2009, Hainey, Connolly & Boyle 2010, Vogel, Greenwood-Ericksen *et al*. 2006, Erhel & Jamet 2013).

Additionally, there has been limited research on formal frameworks or assessment systems designed explicitly for use with Games Based Learning, although this may be as a result of the area's relative newness (Gros 2007, Kearney 2007, Chee 2007, Dondi & Moretti 2007, Michael & Chen 2006). Ifenthaler, Eseryel & Ge (2012) and Kickmeier-Rust, Hillemann & Albert (2011) suggest that Games Based Learning has been hyped as the 'next big thing' and at best, could be just a passing fad.

As discussed earlier (*2.4.5 21st Century Students*), not all researchers agree with the concept of the 'Digital Native' and contest the premise that western education systems are failing and are therefore in need of desperate change through the use of computer games. Even if accepting this premise, Games Based Learning and Serious Games are not necessarily the solution to the (perceived) problems (Squire 2005, Bourgonjon *et al.* 2010, Pivec 2009, Gros 2007). Even Games Based Learning advocate James Paul Gee states that he is not actually promoting the use of games in schools as a 'solution', just that Serious Games can incorporate good educational principles and it is these principles that should be used in today's schools (Gee 2007).

2.9.2 Education Barriers

Beyond the general criticism, there are specific criticisms around the practical use and development of Games Based Learning within the education system.

A lack of institutional level support (academic and political) is cited as a cause for concern (Demirbilek & Tamer 2010, Watson, Mong & Harris 2011, Gros 2007), as is the lack of consistent or coherent policies on the introduction and use of new technologies in the classroom (Bourgonjon *et al.* 2013, Ketelhut & Schifter 2011). Unfortunately, the educational use of technology is often decided at a government policy level, with schools and colleges subsequently having 'technology initiatives' inflexibly imposed upon them (Cellan-Jones 2010a, Curtis 2010).

Ironically, this problem is not new and as Hammond *et al*. (2009) note, dates back to the earliest days of educational I.T. with the introduction of the BBC Micro into schools via the Computer Literacy Project. While the BBC Micro may have ushered in an era of I.T., it seems that government policies concentrated on providing schools with computers, and less so on how teachers could utilize them.

Assuming the adoption of Games Based Learning within the classroom, there are still additional issues that need to be resolved.

As with traditional teaching, the use of computer games requires time for preparation and practice before they can be used effectively within the classroom. Given their already heavy workloads, will teachers cope with the increased duties and (technically) complicated issues associated with the implementation and use of computer games on the academic network? (Che Pee 2011, Ketelhut & Schifter 2011, Wernbacher *et al.* 2012, Whitton 2012, Rice 2007, Gunter, Kenny & Vick 2008, Lean *et al.* 2006, Ney, Emin & Earp 2012).

Researchers also argue that the ‘inflexibility’ of the standardised school curriculum does not allow for the natural use of computer games in the classroom, and on the rare occasions where it does, educational games (or COTs) do not always lend themselves to teaching specific learning outcomes (Bourgonjon *et al.* 2010, Demirbilek & Tamer 2010, Whitton 2012, Watson, Mong & Harris 2011, Lim, Nonis & Hedberg 2006, Ney, Emin & Earp 2012).

As a consequence, there are those who suggest that the ‘standardised curriculum’ should be re-designed in order to accommodate the use of Games Based Learning (Whitton 2012, Royle 2009). This includes extending the average time of a classroom session (> 60 minutes) or selecting/designing games that can be used within the ‘standard’ classroom session (45-60 minutes) (Gros 2007, Tang, Hanneghan & El Rhalibi 2009, Rice 2007, Watson, Mong & Harris 2011, Hammond, Reynolds & Ingram 2011).

A prominent issue that recurs (within the literature) is that of the technical issues associated with deploying Games Based Learning into a school environment (Bourgonjon *et al.* 2010, Demirbilek & Tamer 2010, Novak & Nackerud 2011, Whitton 2012, Wideman *et al.* 2007, Watson, Mong & Harris 2011, Tang, Hanneghan & El Rhalibi 2009, McAlpine, Van derZanden & Harris 2010, Scalise & Wilson 2012, Rice 2007, del Blanco *et al.* 2012, Eastwood & Sadler 2013).

These issues include:

- A limited availability of hardware or other ‘resources’ – not enough Personal Computers/Laptops on which to play computer games or availability of staff to host game sessions.
- A lack of ‘Games Capable’ computers – modern computers capable of displaying/handling modern 3D/Virtual World computer games.
- Network Security – will security restrictions interfere with the installation and use of computer games on the school network?
- Within time limited classroom sessions (45-60mins), valuable time can be lost waiting for pupils to successfully log into the school network (in order to launch and play a game), a situation exacerbated if the school network is wirelessly connected (i.e. limited bandwidth compared to cabled Ethernet connections).
- Do teachers have the technical skills required to deliver a Games Based Curriculum? – Ideally, teachers will have both technical and computer-gaming knowledge, in addition to specific subject knowledge (e.g. physics, geography, history).

2.10 Conclusion

Since the introduction of the mainframe computer, there have been several attempts at creating appealing computer-based educational games. From the introduction of ‘edutainment’ in the 1990’s, and ‘e-learning’ in the early 21st century, the concept of Games Based Learning has evolved.

Many advocates promote the benefit of using the motivational properties of computer games within the education system, citing educational benefits such as repetition, personalised learning and increased motivation. The concept of the ‘Digital Native’ is discussed, but is equally disputed by others who cite the lack of empirical evidence.

One of the difficulties within Games Based Learning is defining what a ‘game’ actually is. As researchers acknowledge, the literature cannot agree on a universal definition for the term ‘game’, let alone a ‘Serious Game’. While the author does not claim to resolve this difficulty, he does argue that a ‘game’ should be thought of as an ‘experience’, which is unique to the individual. The number of ‘game’ definitions is nearly matched by the variety of types or ‘genres’ of computer game that are available, and a review of the literature within this area reveals a preference (in the context of educational games) for Simulation, Role Playing, Puzzle and Adventure games.

Finally, this chapter concludes by examining the criticisms directed towards Games Based Learning, as identified within the literature. These include the questioning of Prensky’s ‘Digital Native’ concept, and the educational barriers facing GBL, such as the lack of coherent institutional policies (both academic and political) and the practical difficulties of implementing GBL within the school education system

Chapter 3 continues the literature review, but concentrates on the approaches that can be taken in order to implement Games Based Learning within the classroom

Chapter 3: GBL Implementation Literature Review

3.1 Introduction

Following on from Chapter 2, this chapter focuses on the practical implementation of Games Based Learning (GBL) within the classroom. Broadly, there are two approaches that can be followed:

- The educational use of Commercial Off The Shelf (COTS) computer games, and
- The custom development of educational computer games.

There are advantages and disadvantages associated with both approaches, but given the flexibility of custom game development, the majority of this chapter is dedicated to the various game design methodologies that can be followed:

- Designing games using an Instructional Design methodology, such as ADDIE.
- Designing games using ‘classic’ games design principles.
- Designing games based on the work of Malone & Lepper.
- Designing games based on a set of educational game design principles (which in turn have been influenced by the work of Malone & Lepper).
- Designing games, based on alignment with an established learning theory.

In addition to games design, the practical development and implementation of computer games is discussed with reference to the use of game development software. Concluding this chapter is a review of the literature on Educational Game Design Frameworks, which are designed to bring formal academic standards to educational game development and implementation.

3.2 Approaches to Implementing Games Based Learning

The literature review conducted for Chapter 2, focused on defining the area of Games Based Learning. This chapter builds upon this foundation and reviews the literature on the implementation of Games Based Learning within an educational environment. Broadly, two main themes were identified within the literature, which represent different approaches to the use of computer games within education.

The first approach is to use an existing commercial computer game and integrate it into classroom delivery, in such a way that it can successfully deliver certain learning outcomes. Computer games in this context are often referred to as Commercial Of The Shelf (COTS) games. An extension to the use of COTS games is that of 'modding'. Should a specific COTS game not be suitable for educational use, it may be possible to modify or 'mod' the game in such a way that does allow it to be used more pedagogically within the classroom. While the use of COTS games has its advantages, it may not always be the most suitable or practical approach to use.

Therefore the second theme (within the literature) is concerned with the custom development of educational computer games. A discussion on the different approaches to educational game development will form a substantial part of this chapter and is broken down into three areas:

- Designing games using instructional design methodologies or user centred design approaches – These are generic design methodologies, which can be used in the context of game development.
- Designing games using 'classic' computer game design principles and then blending educational content into the games retrospectively (Game First, Education Second).
- Designing games by aligning them with a recognised learning theory, and then adding game-like elements retrospectively (Education First, Game Second).

Finally, the literature review draws to a close with a discussion on theoretical and 'Proof of Concept' game design 'frameworks' for developing educational games.

3.3 Commercial Off The Shelf (COTS) Games

The term COTS commonly refers to any standardised commercially available software product, traditionally available for purchase within a retail outlet. Therefore, because of this association with retail outlets, this type of software is typically referred to as a ‘boxed product’ or just plainly as an ‘off the shelf’ product (Sandford *et al*. 2006). Historically, this has included office software suites (such as earlier versions of Microsoft Office), edutainment products or utility software designed to perform specific tasks (such as for producing greeting cards).

In the context of education, this approach involves a teacher taking a commercially available computer game and using it within a classroom, in order to teach a specific objective or learning outcome. As an example of the COTS game approach, Walker & Shelton (2008) use the game ‘Sim City’. ‘Sim City’ places the player in charge of developing and managing a fictional city, complete with all the legal, administrative and civic issues that one might associate with the process. Walker and Shelton argue that several subjects can be taught through the classroom use of this game, including the principles of local taxation, the importance of local government and community responsibility. They also suggest that traditional art classes can utilise ‘Sim City’ (i.e. pupils can design and paint city banners as part of an art project).

Some researchers argue that the use of appropriately chosen COTS games is the most effective approach to introducing Games Based Learning into the classroom environment (MacKenty 2008). Compared to writing and developing computer games, the purchase of a ready-made commercial game is both (relatively) low cost and will be more professionally produced than self-written or even commercially produced educational games. (Van Eck 2006, MacKenty 2006a, MacKenty 2008, Moreno-Ger *et al.* 2008, Minović, Milovanović & Starcevic 2013, Arnab *et al.* 2012, Jong *et al.* 2008).

There are, however, disadvantages associated with the use of COTS games.

In general, there seems to be an acceptance within the literature that pupils like to play games, and therefore they will want to play games within an educational environment. But as Clyde & Thomas (2008) and Auman (2011) suggest, this is a presumption on the part of the researcher. As with other aspects of education, the profile of the target learner, their learning styles and preferences need to be considered as part of a Games Based Learning approach. For example, not all school pupils are natural computer game players (i.e. non-gamers) and therefore these pupils might find the playing of games unappealing. In this scenario, an alternative approach would be needed in order to successfully deliver the same educational content (Clyde & Thomas 2008, Auman 2011).

There are also practical issues related to the use of COTS games within the classroom. Games (purchased or developed) typically demand faster/newer computer processors and modern graphics cards than those typically available within older school computers. Software compatibility may also be an issue, with modern games requiring the latest versions of Microsoft graphics software (DirectX) and associated software patches and 'hot fixes' (Clyde & Thomas 2008, Auman 2011).

Within a time limited classroom session (45-60mins), valuable time can be lost waiting for pupils to log into the school network and then have to go through the process of launching a COTS game (Eastwood & Sadler 2013). This process can be further delayed depending on the speed of the school network (network bandwidth – Wi-Fi or cabled network). Network bandwidth issues can also be exacerbated if using a multiplayer COTS game, as typically multiplayer games tend to transmit larger amounts of data across the network (Eastwood & Sadler 2013).

Given the relatively open-ended nature of COTS games (especially strategy games, such as 'Sim City'), it may be difficult constraining pupils to playing the desired (or educationally relevant) part of the chosen game i.e. pupils might find it more 'fun' repealing the law, increasing taxes and watching the resulting destruction of their 'sim' city (Walker & Shelton 2008). Many commercial games can also contain lengthy introductions (or 'cut-scenes') or other educationally 'irrelevant' content that will need to be skipped (assuming it can be skipped) if a teacher is expected to successfully deliver the required learning objectives within the time limits of the classroom session (Gros 2007, Tan 2010, Bourgonjon & Van Looy 2012, Bourgonjon *et al.* 2013, Kim & Lee 2013, Abrams 2011, Moreno-Ger, Burgos & Torrente 2009, Dempsey *et al.* 2002, Gunter, Kenny & Vick 2008, Van Eck 2006).

Choosing a COTS game for educational use will be explored in the next section (*3.3.1 COTS Game Selection*), but regardless of the actual game selected, COTS games are usually not designed for education. Therefore, any Games Based Learning strategy needs to take into account how COTS games will be integrated and used within the classroom environment (Pivec 2007, Gunter, Kenny & Vick 2008).

A starting point to this process would be ensuring that teachers are familiar with the chosen COTS games (i.e. by playing the games themselves) and are trained in how to introduce and use the games as educational tools. Ideally, this training will be supplemented with support material, such as customisable lesson plans (Abrams 2011, Watson, Mong & Harris 2011, Eastwood & Sadler 2013, Becker 2007, Dempsey *et al.* (2002), Arnab *et al.* 2012, Hirumi *et al.* 2010, Van Eck 2006).

In terms of integration, teachers attempting to use COTS games within the classroom will face many questions:

- How much of a (time limited) classroom session should be dedicated to game use?
- How much of a specific game should be used within a session? Should pupils be allowed to play the game in its entirety? (such as a biology simulator allowing many activities) or only play only a certain point/stage within the game, in order to teach a specific objective?
- Should a game be used actively or passively? (letting pupils play the game, versus showing pupils a pre-recorded video clip of a specific scene within the game).
- How can/should certain aspects of a game be related or tied into the objectives that the teacher needs to deliver ('this concept is the same as that test you performed within the biology simulator').
- How do you structure a classroom session in order to allow the use of a game, but also ensure time for adequate reflection and reinforcement?

The literature within this area is currently considered limited (Arnab *et al.* 2012), but the importance of COTS game integration and appropriate support is recognised (Bourgonjon *et al*. 2010, Demirbilek & Tamer 2010, Whitton 2012, Watson, Mong & Harris 2011, Lim, Nonis & Hedberg 2006, Ney, Emin & Earp 2012).

3.3.1 COTS Game Selection

Another issue related to the use of COTS games within the classroom, is that of *suitability*. We define suitability, as addressing issues such as:

- Is the chosen game designed for the age level of the intended pupil group?
- Can the game be adapted for use within the set time limits of a typical classroom session (45-60 minutes)?
- Is the content (or genre) of the game appropriate for use within a school environment? (e.g. First Person Zombie Shooter).

The author found the majority of the literature within this area to be focused on providing common sense guidance as to how to select a COTS game appropriately (Van Eck 2006, Eastwood & Sadler 2013, Schrader & McCreery 2012, Overmars 2004a).

MacKenty (2006b) suggests that in order to be used within the classroom, COTS games should ideally have the following features:

- Allow the saving of a ‘gaming session’ so that the game can be played/resumed within class time (45-60 minutes).
- Support networked/multiplayer play in order to facilitate group work exercises.
- Have various difficulty levels (pupil differentiation).
- Contain educationally accessible context (What does/can it teach?).
- Include multiple levels (in order to create variety).

As with MacKenty, Dempsey *et al.* (2002) recommend that games should be selected for their potential educational content or ease of use (educationally), be simple to play (low pupil learning curve) and support ‘modding’ (*3.3.2 Repurposing or ‘Modding’ a COTS Game*) for maximum flexibility.

Novak & Nackerud (2011) advise that selecting a COTS game is dependent on it meeting the technical requirements of a school’s computers (are the computers powerful enough to run the game?) and that the content of the game should be appropriate for the school environment (no violence or adult content). They also propose a formal COTs selection model, which they refer to as the ‘RCIPR Model’.

The RCIPR Model consists of five steps or ‘aspects’, which when applied to a specific COTS game, will allow a teacher to methodologically determine whether the game is appropriate for use within the classroom. The five steps are as follows:

- **Research** – Which COTS games are suitable for delivering your objectives? (i.e. what are the learning outcomes?).

- **Choose** – Select a COTS game based on the research (above) and the intended use.

- **Investigate** – Can the COTS game be used within the school environment (i.e. are there any technical barriers to using the game? Flexible school licence agreements?).

- **Pilot** – How will/can the game(s) be integrated into the classroom?

- **Reflect** – Reflect upon the Pilot step (above) and use the data/experience gained to improve the process of implementing the RCIPR Model.

The author was unable to source additional examples of formal COTS selection methodologies within the literature. Therefore, although the author takes the view that it may be time consuming for teachers to implement the RCIPR model in its entirety, it does represent an attempt to bring a formalised approach to an area dominated by 'common sense' guidelines.

In terms of suitability for use, not all researchers agree that COTS games should be used within the classroom in the first place, with suggestions that game playing can lead to addiction, anti-social or aggressive behaviour, obesity and poorer academic performance in general (Eastwood & Sadler 2013, Schrader & McCreery 2012, Hou *et al.* 2012).

According to Krcmar, Farrar & McGloin (2011), the 'realism' of a computer game's graphics can contribute to player aggression. In their research, members of a sample group played iD Software's 'Doom' and the sequel 'Doom 3'. 'Doom' (referred to as 'Doom 1' within the journal article) was originally released in 1993 and could be considered to have low fidelity graphics by today's standards, whereas 'Doom 3' is still considered a milestone in computer graphic realism upon its original release in 2004 (Krcmar, Farrar & McGloin 2011). After the sample group had played both games, Krcmar, Farrar & McGloin concluded that "*Physically aggressive intentions were also higher among those who played Doom 3 as compared to those who played Doom 1*" (Krcmar, Farrar & McGloin 2011, p.437).

The counter arguments to negative criticisms of game playing, are that many research findings are weak due to being traditional media-based rather than explicitly relating to computer games (Tang, Hanneghan & El Rhalibi 2009), suffer from 'publication bias' (Boyle, Connolly & Hainey 2011) or 'methodological problems' (Griffiths 1999).

While not promoting the depiction of violence within computer games, Cross (2009) suggests that it can be considered acceptable in the context that the violence is only being committed against 'bad guys' (as with other media, such as books and movies). Clyde & Thomas (2008) also argue that the depiction of violence (within their 'information literacy first-person shooter', 'Benevolent Blue') is required on the grounds that it contributes to the 'flow experience' (*3.8.4.6 Flow Theory*), which they regard as an important principle within educational game design.

3.3.2 Repurposing or 'Modding' a COTS Game

'Out of the Box', most COTS games are designed to be played the way that the designers originally intended them to be played. However, ever since the release of the game 'Doom' in the early 1990's (Lambie 2009), most games released commercially have been developed with 'modding' in mind. 'Modding' (a gaming abbreviation) involves altering or 'modifying' an existing computer game in some manner. In the early days of modding, this meant allowing game players to change the cosmetics of the game (such as changing the wall colours or the look/style of game characters) and to create their own game levels (Minović, Milovanović & Starcevic 2013, Rice 2007, Moreno-Ger *et al.* 2008, Walker & Shelton 2008, Pivec 2007, Tang, Hanneghan & Carter 2012, Whitton 2012, Tang, Hanneghan & El Rhalibi 2009).

In recent years, the process of modding has advanced, allowing game players and designers alike to completely alter a game's look and feel, and ultimately how the game is played (Clyde & Thomas 2008). If a given COTS game is unsuitable for use in an educational environment, perhaps it can be 'modded' or 'repurposed' so that it can be used? Although favoured by a few (Pivec 2007, Moreno-Ger *et al.* 2008), there is still the issue as to whether the underlying game is still suitable for educational use or not. For example, no matter how modifiable a First Person Shooter game is (e.g. 'Doom 3'), the violent nature of these types of games may prohibit their use within the classroom, regardless as to how they have been 'modded' (Moreno-Ger *et al.* 2008).

Given the limitations of using COTS games within education, the alternative would be to use educational games that have been designed for this purpose. The fundamental problem with this approach is that most educational games can be 'too educational' and therefore may not be as (relatively) 'fun' to play as commercial games (Walker & Shelton 2008). Even modifying an existing (commercially successful) game, so that it appears more 'educational', may cause the playability/fun factor of the game to suffer (Kiili 2005a, Moreno-Ger *et al.* 2008, Overmars 2004a).

3.4 Developing Educational Software

As briefly discussed at the beginning of the chapter, a literature review was conducted into the implementation of Games Based Learning within an educational environment. The review revealed two themes: Using commercial games within the classroom, and the alternative approach of custom development of educational games.

COTS games may be considered a relatively expedient, low cost and accessible approach to introducing games into the classroom. However, such games are not without issues, including unsuitable (e.g. mature) content and the requirement for higher specified computer hardware (faster processor or more computer memory). Therefore, if a COTS game is unsuited to use within the classroom, the alternative is for interested parties to develop their own educational games.

Reviewing the literature within this area reveals three complementary approaches to (educational) game development:

- Designing games using instructional design methodologies or user centred design approaches – These are generic design methodologies, which can be used in the context of game development.
- Designing games using 'classic' computer game design principles and then blending educational content into the games retrospectively (Game First, Education Second).
- Designing games by aligning them with a recognised learning theory, and then adding game-like elements retrospectively (Education First, Game Second).

The proceeding sections will discuss these three approaches in turn.

3.5 General Design Methodologies

The proceeding sections broadly describe the subject of ‘design’. In a similar vein to defining what constitutes a ‘game’, the meaning of ‘design’ is dependent on context.

From a traditional software design point of view, ‘design’ refers to the process of designing (and then writing) a software program. This design process would focus on the software as an ‘end product’ and would give preference to the required functionality (i.e. does it perform the tasks as specified) and testing that the completed software was fault free. Over time, dedicated models, such as the ‘Water Fall’ or ‘Top Down’ models, were developed in order to address the (historical) lack of formalisation within this software development process (Sommerville 2007).

In later years, Personal Computers moved from using command line operating systems (CP/M, DOS) to those featuring a Graphical User Interface or ‘GUI’ (Microsoft Windows, IBM OS/2). In this context, to ‘design’ a computer program could describe the process of GUI design, which in turn would draw upon human psychology. This led to design methodologies such as HCI (Human Computer Interface) which concentrated on how the ‘end user’ would ‘experience’ the software (Sharp, Rogers & Preece 2007).

Reviewing the literature, the most prominent modern design methodologies seem to be (in the author’s opinion) a mixture of both traditional and newer ‘design’ approaches. These design methodologies focus on the design of generic ‘products’, which can include physical products (such as computer hardware or consumer electronics), knowledge products (such as education or training) or products in-between (such as computer software or a movie streaming service). Regardless of the ‘product’ type, these design methodologies place the emphasis on both how the product (generically) works and how the user will interact with it.

In terms of design methodologies that are most prominent within the literature, User Centred Design (UCD) and Instructional Design (ADDIE) will be discussed within the proceeding sections.

3.5.1 User Centred Design

User Centred Design (UCD) could be regarded as a more holistic approach to design and is described within the literature as a ‘philosophy’ or a set of principles that summarise ‘best practice’. Although an international standard exists (ISO 9241-210:2010), it does not specify the exact methods for implementing a UCD approach (Moschini 2006, UsabilityNet 2006, Usability Professionals' Association 2011). UCD consists of a number of stages, which if followed, should lead to the successful analysis, design and implementation of the given ‘product’ – which could be a physical product, software or a training solution (Usability Professionals' Association 2011, Monk 2000, Gulliksen *et al.* 2003, Waraich & Wilson 2005, Hu 2010). The UCD stages are as follows:

Research / Analysis

Before actually designing a given ‘product’, the designers need to identify:

- The type of people (‘users’), who will ultimately use the product (i.e. their level of education, age, motivations for using the product).
- The tasks that the product will need to perform, from the user’s point of view (Task Analysis).
- The environment/conditions under which the product will be used.

Iterative Design

Taking the requirements from the Research/Analysis stage, the process of design begins.

Generally, the designer will use some form of Rapid Prototyping to produce a visible ‘mockup’ of the final product. Rapid Prototyping (Figure 3.1) is an iterative process where a prototype version of the ‘product’ is quickly developed and then demonstrated to the prospective user (this could be a focus group, beta testers or the product client/user). The collected feedback will then be incorporated into further (increasingly more refined) prototypes until such a time as the prospective user is satisfied with the prototype, at which point the prototype is considered finalised (Sommerville 2007, Pressman 2001, Hu 2010).

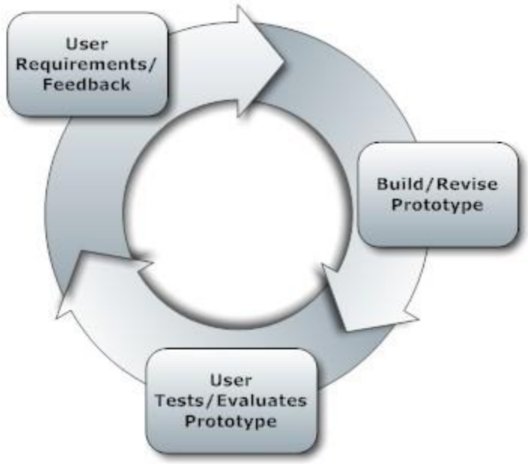


Figure 3.1: The Prototyping Paradigm (Adapted from Pressman 2001)

By the end of the Iterative Design stage, a high level design will have been produced and (assuming the use of Rapid Prototyping) a refined final prototype.

Implementation

Depending on the actual product, the prototype may be optimised (if software) or actually built and then implemented (i.e. hardware or a training solution). At this stage, various types of testing will be performed, this could be user/usability testing (does it work as the user expected?) or defect testing (does the product work correctly, and if not, does it fail in a 'graceful' controlled manner?).

Deployment

This final stage involves obtaining user feedback (on the finished product) and collecting information on how the product is *actually* used by the users within their environment. This feedback will potentially be fed back into subsequent versions of the product.

3.5.2 Instructional Design (ADDIE)

Whereas User Centred Design is regarded as holistic, Instructional Design (ID) is considered a more systematic approach to identifying users/learners needs and devising appropriate training material (University of Adelaide 2011, Business Performance 2003).

The heart of Instructional Design is the use of a design model. While there are a variety of different design models available (i.e. Dick & Carey, Kemp ISD), most are variations on the 'ADDIE' model (Instructional Design 2011, Castagnolo 2002). The variant of the ADDIE model that will be discussed within this section is geared towards the design/development of educational ICT (Information Communication Technology), most commonly e-learning and Internet web pages, although it can be equally applied to the development of educational games (Squire 2013, McMahon 2009).

The ADDIE model consists of five stages:

Analysis

The analysis stage is concerned with:

- Identifying the 'user' (or learner) – their education, experience, special needs.
- Constraints on the ADDIE process – access to users, time restrictions.
- The environment where any training will be performed or software tested (e.g. a classroom or computer lab and its environment, such as the type/level of lighting used).
- Identifying tasks that need to be performed by the training/software and the objectives/outcomes that need to be achieved by the user/learner.
- Timescale/Project Outline – how long will the ADDIE process take to complete?

Design

Building on the previous analysis stage, if the 'product' is software, it will be designed with the following considerations:

- How will the identified tasks/objectives be implemented within the software?
- The User Interface will need to be designed (i.e. layout of icons, controls and graphical design).
- Evaluation Methods – What user feedback will be given and how will it be collected?

Although not part of the original ADDIE model, the model has been adapted to incorporate Rapid Prototyping (Figure 3.1) as part of the design process. As with UCD, by the end of the ADDIE Design stage, a high level design will have been produced and (assuming the use of Rapid Prototyping) a refined prototype.

Development

In terms of software, this stage will have considerable overlap with the Rapid Prototyping of the Design stage. Typically, there will be a final prototype which may only require minor adjustment, such as final sound/graphical effects added to the software or late usability feedback incorporated. Traditionally, if prototyping has not been used, the software would be written at this stage. Testing (i.e. is the software free of technical faults?) will also be performed at this stage. The level of testing required will be dependent on whether prototyping has been used and how refined the 'final' prototype is. Unfortunately, it is not uncommon for commercial software to be officially released with undetected faults, which subsequently require additional development work and further testing.

Documentation will also need to be produced and this may include a printed user manual/trainers' guide or inline documentation (Online Help or On-Screen Game Instructions).

Implementation

By this stage, the final prototype will be ready to go 'live'.

- This stage may involve booking rooms and appropriate facilities in order to demonstrate/make available the final prototype to the end users/learners.
- With software, the prototype will need to be installed on computers and then configured appropriately.
- It is at this stage that users/learners get the opportunity to use/learn from the software as its designers intended. If necessary, a trainer/teacher will be on hand to provide guidance on how to use the software.

Evaluation

In theory, Evaluation will take place throughout all of the stages of the ADDIE model (Formative Evaluation), but will also take place after the Implementation Stage (Summative Evaluation). The purpose of Evaluation will be to assess the level of understanding (cognitive, affective and behavioural) displayed by a user/learner, when using the (final) prototype. Typically, this can involve the use of a number of techniques:

- Assessing user/learner knowledge and comprehension (cognitive), through the use of questionnaires or formal testing.
- Observation of user/learner reactions (affective) whilst using the prototype i.e. displays of enthusiasm or positive feedback would suggest that the prototype has been designed/implemented correctly according to the users/learners needs (as identified at the Analysis stage).
- Observation of user/learner behaviour (behavioural) whilst using the prototype i.e. do they interact with the prototype in the way that the designers anticipated or do they use it in an unforeseen manner? (e.g. the user pulls the power cord out, rather than pressing the 'Power Off' button).

The results of the evaluation stage will be used to further improve the prototype/final product and related documentation.

3.6 Designing Games

While general design methodologies offer a systematic approach to the design of 'generic' products, they do not specifically offer guidance in 'best practice' when designing computer games. A survey of the relevant literature reveals two approaches to developing computer games. The first approach focuses on designing 'fun' games, first and foremost, with the possibility of educational content being added at a later stage, whereas the second approach emphasises the importance of the educational aspects first, followed by the 'gaming' aspects.

3.7 Games Design Principles

The first approach to games design could be considered the 'classical' approach. In this approach, computer games are designed to be 'fun' and enjoyable, but are typically not educational. As with COTS games, games developed using the 'classical' approach can still be used in an educational context, or developed in such a way as to incorporate educational content, i.e. they become educational games. However, as MacKenty (2008) states "*A game has to be a good game before it can be a good educational game*".

Therefore, before discussing the second approach (designing and developing educational games), a thorough understanding of computer games design (as a foundation) is required.
A survey of the relevant literature revealed that there are very few formal or academic methodologies for designing computer games (leisure or educational). Habgood & Overmars (2006) go as far as to state that there is no simple formula for creating a 'great game', but they do (along with others) put forward a series of 'Game Design Principles' or 'Best Practice' for the design and development of computer games.

3.7.1 Narrative

Before actually developing a computer game, it is considered best practice to design the game beforehand. This includes defining the story (often referred to as the 'narrative') behind the game, along with the characters that the player will control or interact with (Overmars 2004a, Habgood & Overmars 2006, Dondlinger 2007, Scatteia 2005, Annetta, Lamb & Stone 2011).

It has been suggested that having a fantasy-themed narrative makes a game more appealing to a potential player and will therefore increase their motivation, in comparison to using a more conventional, perhaps 'boring', narrative (Van Eck 2006, Habgood & Overmars 2006, Gunter, Kenny & Vick 2008).

The game narrative (especially if it is to be educational) should have a clear set of goals/objectives that the player must achieve in order to win the game. Depending on the size of the game, these goals might be split up into short, medium and long term goals (Dondlinger 2007, Habgood & Overmars 2006, MacKenty 2006b, Prensky 2006, Rothschild 2008). The narrative will also cover the characters themselves, offering a background history as to who they are, what they do and what motivates them to undertake their respective tasks (Perry & DeMaria 2009).

Schell (2010) promotes the use of an 'Interest Curve' (Figure 3.2 / Table 3.1) when designing computer games. This can be used to map out the narrative (along with a rough overall design) which depicts the level of interest that a player (or 'guest' as Schell refers to them) has in an 'experience'. An 'experience' in this scenario could be a movie, a play, a book or a game. Typically, the narrative will start with an opening scene involving the game character tasked with achieving some form of goal. In order to achieve this goal, the character will undergo a series of challenges or obstacles (represented by the peaks and troughs of the 'Interest Curve'), before finally reaching and achieving said goal.

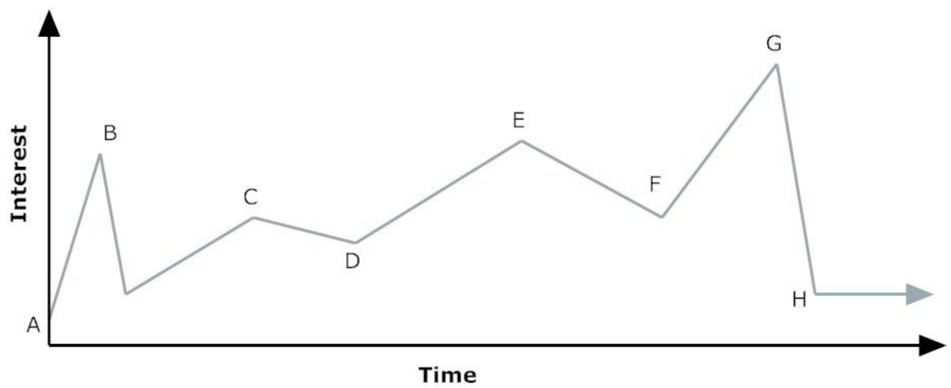


Figure 3.2: Schell's 'Interest Curve' (Adapted from Schell 2010)

Point	Description
A	At the start of the interest curve, there is initial interest in what the 'experience' has to offer.
B	The 'guest' likes what they see ('The Hook') – and becomes excited about the upcoming experience (The 'Hook' could be the opening sequence of the movie or the screenshots/narrative on the game packaging).
C, D, E, F	As the guest watches the movie or plays the game, interest in the experience gradually increases (with slight dips and peaks).
G	The Interest Curve peaks when the climax/conclusion of the movie or game is finally reached.
H	Finally, the Interest Curve subsides, now that the 'experience' is over.

Table 3.1: Schell's 'Interest Curve' (Legend) (Adapted from Schell 2010)

3.7.1.1 The Hero's Journey

In terms of narrative, Perry & DeMaria (2009) and Schell (2010) both refer to the work of Christopher Vogler (a 'Hollywood Story Consultant'), which in turn might be considered a modernisation of Joseph Campbell's book 'The Hero with a Thousand Faces' (originally published in 1949). In his book, Campbell (2008) examines the stories and myths embedded within many cultures (over several eras) and arrives at the conclusion that they all share a commonality in terms of storytelling, which Campbell refers to as 'The Hero's Journey'.

Vogler (2007) summarises and adapts 'The Hero's Journey' into a 'Three Act Structure' – the structure of storytelling most commonly found within Hollywood movies (Figure 3.3):

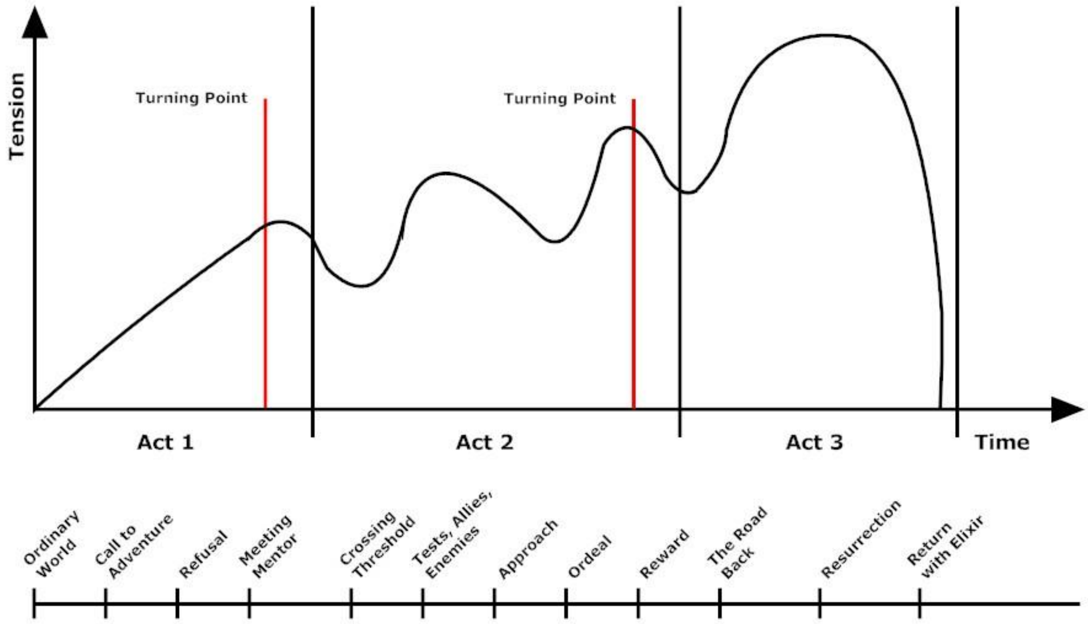


Figure 3.3: 'The Hero's Journey' / 'Three Act Structure' (Adapted from Vogler 2007, Campbell 2008, Perry & DeMaria 2009 and Schell 2010)

The 'Hero's Journey' may seem familiar, and is credited by Perry & DeMaria (2009) and Schell (2010) as being the blueprint for many of Hollywood's movie blockbusters as well as serving as the storytelling basis for many modern computer games, such as 'Halo (Combat Evolved)', 'Far Cry' and the 'Call of Duty' series of games.

3.7.2 Challenge

A successful computer game keeps its players interested and motivated to play the game (Kiili 2005a, Song & Zhang 2008, MacKenty 2006b). This involves a mixture of ingredients; Dondlinger (2007), Habgood & Overmars (2006) and Harteveld *et al.* (2007) suggest that interactivity is important, while Squire (2005) suggests that motivation can be created through the use of a fantasy based narrative combined with a degree of curiosity and an element of competition. However, all agree that for a game to be motivating there needs to be challenge. The level of challenge should be evenly balanced so that the game is not too hard to complete, nor too easy. Additionally this challenge needs to be introduced within the game at the right time – not too late, nor too early (Van Eck 2006, Habgood & Overmars 2006).

It is suggested that the game engine itself should be able to dynamically detect and adjust the level of challenge in response to the player's performance within the game (Prensky 2006, Habgood & Overmars 2006, Orvis, Horn & Belanich 2008, Tan 2010, Kickmeier-Rust, Hillemann & Albert 2011, Aponte, Levieux & Natkin 2011, Vogel, Greenwood-Ericksen *et al*. 2006) i.e. if the player is struggling to complete the current task, the level of difficulty should be eased, if the player is completing the current task too quickly, then the level of difficulty should be increased.

Schell (2010) counters this concept of 'dynamic game balance' with the philosophy that "*(this) is a beautiful dream. But it is a dream that is rife with some surprising problems*" (Schell 2010, p. 205).

- Players could manipulate the situation (by deliberately playing badly) in order to cause the game engine to lower the level of challenge, therefore making the game easier to play and win.
- Players will naturally improve as time progresses, making the concept of 'Dynamic Game Balancing' more difficult to implement.

There is also the consideration that 'Dynamic Game Balancing' is not a development task to be undertaken lightly. While games companies may have the time, money and resources to develop similar systems, smaller companies producing educational software, do not (Kickmeier-Rust *et al.* 2007, Moreno-Ger, Burgos & Torrente 2009, Csapó, Lörincz & Molnár 2012, Kiili 2005a).

As a result, it is suggested that a range of techniques are used in order to balance and adjust the level of challenge within a game. These techniques include the following (Schell 2010, Perry & DeMaria 2009, Habgood & Overmars 2006):

Variable Difficulty Levels

Most modern computer games will give the player the option of selecting a difficulty level (e.g. Easy, Medium or Hard) at the beginning of the game and then adjust the level of game difficulty based on the selected option.

Type of challenge

How much of the game should involve pure physical challenge (moving a character over an obstacle) and how much should involve more cerebral (thinking) challenges? (solving a puzzle).

Length of Game

A game needs to be of the 'right' length. If the game is too short, the players may not have enough time to practice or develop. If the game is too long, the players may get bored and stop playing the game.

Rewards \ Penalties

Offering a reward when the player overcomes an obstacle, or penalising for failure, can increase the element of challenge, in turn spurring the player on to continue playing the game. Rewards can take on different forms, including praising the player on their success or offering additional bonuses: such as unlocking secret levels of play or prolonging the game play (i.e. allowing progression onto the next lap within a racing game). Extra lives or special powers can also be used as an incentive. Penalties can also contribute to the element of challenge, as taking risks (with the fear of punishment) could be considered 'exciting', and therefore encouraging continued play. Classic penalties include shortened play (loss of life), 'Setback' (having to restart the current level) or terminated play ("Game Over").

As with challenge in general, the giving of rewards/penalties should be balanced in order to encourage the right amount of caution and risk-taking within the game.

Feedback

Feedback is considered important within a game and can be implemented in different ways.

Creating an atmosphere through the use of sound/music and lighting effects can set the tone of the narrative or current scene. It can also be used to communicate impending danger/action or suggest a brief respite in the game (allowing the player to take a breather).

3.7.3 Attractive Graphics & Sound

There is a general consensus that attractive computer graphics improve the gaming experience and have a positive effect on the motivation of learners.

The literature places an emphasis on the use of Three-Dimensional (3D) graphics, which researchers argue are highly immersive and promote ‘presence’ (the sense of ‘being there’ within the game), in turn generating a greater level of motivation (Dondlinger 2007, Ibáñez, Crespo & Kloos 2010, Admiraal *et al.* 2011). It is suggested that this motivational effect might be additionally enhanced, if the 3D graphics are of a higher (i.e. realistic) fidelity (Rice 2007, Krcmar, Farrar & McGloin 2011, Jeong, Biocca & Bohil 2012).

The counter argument to the use of high-fidelity 3D graphics, is that they are unnecessary, as long as the ‘ingredients’ that constitute a good game design (e.g. narrative, challenge) are present (Papert 1980, Pivec 2009, Shute, Masduki & Donmez 2010, Cross 2009, Annetta, Folta & Klesath 2010, Michael & Chen 2006, Habgood & Overmars 2006). The author is of the opinion that the relative popularity of ‘Retro Games’[2] available on mobile phones, tablet devices and the Internet (BBC 2013b), reinforce the argument that modern 3D graphics, while being able to enhance a game, are not always necessary in order to create a genuinely ‘good’ game. Whichever approach is taken, the combination of graphics, sound effects and in-game music should try to engage the player to play the game (Habgood & Overmars 2006). Designing a computer game’s graphics is not just about how they look – the design of the user interface and how the player interacts can also be important considerations (Barendregt & Bekker 2004, Kiili 2005a, Kiili & Lainema 2008, Schell 2010).

[2] ‘Retro Games’ are games that were originally released in the ‘golden age’ of video games (the 1970’s/1980’s) that have since been transferred/updated to be played on modern mobile phones or embedded within Internet web pages.

3.7.4 Schell's '100 Lenses'

While most literature on games design could be regarded as prescribing a list of qualities or ingredients that a 'good' computer game should consist of, Schell (2010) puts forward his concept of game design 'Lenses'. Schell argues that 'good game design' occurs through viewing a given design from several different perspectives, or 'Lenses' as Schell refers to them. These Lenses are essentially a checklist of best-practice questions (Table 3.2) that a designer can compare their game design against, in turn improving the design and the subsequently implemented game(s).

Lens 3: 'The Lens of Fun'
• "*What parts of my game are fun? Why?*" • "*What parts need to be more fun?*" (Schell 2010, p.*27)*
Lens 25: 'The Lens of Goals'
• "*What is the ultimate goal of my game?*" • "*Is that goal clear to players?*" (Schell 2010, p.149)
Lens 70: 'The Lens of Story'
• *"Does my game really need a story? Why?"* • *"Why will players be interested in this story?"* (Schell 2010, p.280)

Table 3.2: Sample of Schell's (2010) '100 Lenses'

While Schell's 'Lenses' may differ in approach to the general games design principles found elsewhere within the literature, the 'Lenses' broadly describe the same areas of game design (*Narrative*, *User Experience (or Design)*, *Game Mechanics*, *Technical/Development*).

Narrative

As previously discussed, the narrative is considered to be the background story or theme of the game. This may include the characterisation of both the player's and enemy's characters.

User Experience (or Design)

Schell dedicates several ‘Lenses’ to the area of general game design, and particularly to that of the user’s experience while playing the final implemented game. Design ‘Lenses’ focus on the control mechanisms (such as keyboard or joystick) of the final game, the Graphical User Interface and the audio/visual feedback given to the user. In regards to user or player experience, some of Schell’s Lenses could be considered as reflecting the User Centred Design methodology (*3.5.1 User Centred Design*), in terms of identifying the end user/player of a given game design.

Game Mechanics

In the context of Schell’s Lenses, game mechanics could be considered as ‘ingredients’ that contribute to the playability of a given game. These ingredients include identifying the goals/rewards/penalties of the game, the level of challenge given to the player and the various mechanisms employed (puzzles, surprises) that make the game ‘enjoyable’.

Technical / Development

One area frequently neglected by other sets of design principles, is the development process that is undertaken in order to create a successful computer game. While it could be argued that ‘development’ is not actually ‘design’ itself, it is clearly an important part of the design process. By development, Schell is referring to the importance of communication (documenting what needs to be remembered or communicated about a game), teamwork (amongst game designers or programmers) and the technical aspects of game development itself (programming/testing the game).

While regarding Schell’s ‘Lenses’ to be one of the more methodological approaches to game design, the author found it difficult to locate independent references to its use in designing games. Where additional literature was discovered, the literature would typically take the form of a descriptive review of Schell’s book (Schell 2010) or act as a reference list for the 100 lenses.

The author would argue that Schell's '100 lenses' encompass the same principles (e.g. Narrative, Target User) as other, less methodological, game design approaches. However, given the volume of lenses that potentially need to be applied during the design process, the author would also argue that Schell's approach is probably better suited to larger scale, perhaps commercial, game development (rather than as a basis of (typically smaller scale) educational game design).

3.8 Educational Games Design

A survey of the relevant literature reveals two approaches to developing games. The first approach to games design, discussed in the previous section, could be considered the 'classical' approach. In this approach, computer games are designed to be 'fun' and enjoyable, but are typically not educational. Therefore, educational content is 'retro-fitted' or 'blended' into the game as a secondary consideration.

In the second approach, the literature argues that the development of educational games should be based on, or aligned with, recognised learning theories, with elements of 'gaming' blended into the resulting educational games

The results of the literature review into 'pedagogic games design', fall broadly into four areas:

- A general discussion relating to designing computer games, with a pedagogical foundation (*3.8.1 General Discussion*).
- Designing computer games, based on the work of Malone and Lepper (*3.8.2 Educational Game Design (Malone and Lepper)*).
- Designing computer games, based on 'educational games design' principles (*3.8.3 Educational Games Design Principles*).
- Designing computer games, based on some form of pedagogical theory i.e. learning, instructional or motivational (*3.8.4 Learning Theories / 3.8.5 Learning Theory Based Games Design*).

3.8.1 General Discussion

If the author could summarise the literature on developing (educational) computer games, it would reflect Moore & Price's (2009) view that there is, as of yet, no standard or recognised theory on how to design computer games. The importance of basing educational game design on a 'pedagogical foundation' is recognised within the literature (Tang, Hanneghan & El Rhalibi 2009, Ke & Grabowski 2007, Arnab *et al.* 2012, Wu, Chiou *et al.* 2012a, Wu, Hsiao *et al.* 2012b, Furió *et al.* 2013, Hirumi & Stapleton 2009, Wei & Li 2010), with Gunter, Kenny & Vick (2006) stating:

> *"A failure to base serious game design on well-established learning theories as proposed by well-respected educators like Robert Gagne and James Keller, increases the risk of the game failing to meet its intended educational goals."*
>
> (Gunter, Kenny & Vick 2006, p.2).

However, in spite of this, the reality is that even the literature within this area fails to address this issue. Some researchers (Arnab *et al.* 2012, Kiili & Lainema 2008, Harteveld *et al.* 2007) acknowledge that the majority of educational games available are not based on established learning theories.

In their study of learning theory use within Games Based Learning, Wu, Hsiao *et al.* (2012) state:

> "*They* (Kebritchi and Hirumi 2008) *reviewed 50 studies and 55 educational games to examine the pedagogical foundations behind modern educational computer games. Their results showed that 24 games were based on established learning theories (e.g. experiential learning) or their corresponding instructional strategies, whereas 31 games provided no explicit information concerning their pedagogical foundations.*"
>
> (Wu, Hsiao *et al.* 2012, p.266).

"*Additionally, Pivec and Dziabenko (2004) indicated that pedagogy was one of the major components of successful game-based learning. However, the connection between learning theories and game-based learning is still vague.*"

(Wu, Hsiao *et al.* 2012, p.268).

"*Our results revealed that 567 studies failed to use learning-theory foundations in their analyses, as opposed to only 91 studies, which were founded on learning theory. The results were similar to those of an exploratory study by Ke (2009), which explored game-based learning activities with or without a learning-theory foundation using qualitative and quantitative meta-analysis and found little research concerning the learning-theory foundations of game-based learning.*"

(Wu, Hsiao *et al.* 2012, p.275).

While the author's literature review within this specific area cannot claim to be as comprehensive as that of Wu, Hsiao *et al.* (2012), it does reflect their findings in the fact that very little literature on Games Based Learning and educational computer game design is strongly linked with established learning theories. Instead the literature falls into the aforementioned areas, which will be discussed in subsequent sections of this chapter:

- Designing computer games based on the work of Malone and Lepper.
- Designing computer games based on 'educational games design' principles.
- Designing computer games based on some form of pedagogical theory (learning, instructional or motivational).

3.8.2 Educational Game Design (Malone and Lepper)

A number of researchers directly cite the seminal work of Malone & Lepper (1987) as the basis on which to design educational computer games (Che Pee 2011, Shute & Ke 2012, Boyle, Connolly & Hainey 2011, Minović, Milovanović, & Starcevic 2013, Bufe & Krömker 2010, Rothschild 2008, Belanich, Orvis & Sibley 2013, Preston & Morrison 2010).

In their 'Taxonomy of Intrinsic Motivations for Learning', Malone & Lepper describe the features within computer games that can be used in the "*design of intrinsically motivating instructional environments*" (Malone & Lepper 1987, p.247). To some extent, the question might be asked as to whether the design of computer games influenced Malone & Lepper, or whether Malone & Lepper have influenced modern (educational) game design? Irrespective of this point, Malone & Lepper's taxonomy consists of 'individual' and 'interpersonal' motivations:

Individual Motivations

Challenge

As previously discussed (*3.7.2 Challenge*), challenge can be a mixture of ingredients, such as variable difficulty levels, the use of rewards/penalties and giving the player appropriate feedback (through the use of sound and the graphical user interface).

Control

A player must feel (or perceive) that they are in control of their environment. They will 'know' that the results and outcomes of the game will be shaped (to varying degrees) by their actions within the game.

Curiosity

Ideally, a game should elicit the player's curiosity in some manner, perhaps through exploration of the game environment (such as a scrolling maze game) or having to collect certain objects scattered around the playing area, in order to complete a specific task.

Fantasy

Utilising a fantasy based narrative or other mechanisms that encourage immersion within a game (such as the use of 3D graphics), can also potentially aid a player's motivation.

Interpersonal Motivations

Malone & Lepper describe 'interpersonal motivations' as being dependent on the individual learner, and therefore they may not necessarily be present within the learning environment.

Cooperation – collaborating with other players (within a group) can be seen as motivating. In modern gaming terms this motivation might be derived from playing multi-player games.

Competition – In a similar vein, competition between players (potentially within the same team, or on an opposing team) can be regarded as a powerful motivator.

Recognition – It could be suggested that recognition is related to feedback, but is more personalised to the individual, such as recognising a specific player's contribution to a particular goal or an achievement.

3.8.3 Educational Games Design Principles

Moving away from the work of Malone & Lepper, researchers have suggested that certain 'qualities' or 'principles' should be incorporated into educational game design. However, while not directly citing Malone & Lepper, it is the opinion of this author, that these suggested 'principles' have been influenced by their seminal work. Reviewing and categorising these 'principles' (Table 3.3), reveals a degree of commonality with Malone & Lepper's (1987) 'Taxonomy of Intrinsic Motivations for Learning'.

Design 'principle' (Malone & Lepper 1987)	Reference
Challenge	Vogel, Greenwood-Ericksen *et al*. (2006), Lieberman, Fisk & Biely (2009), Charles, Bustard & Black (2009), Hsu, Tsai & Wang (2012), Wilson *et al.* (2009)
Curiosity (Also referred to within the literature as 'Uncertainty' and 'Mystery')	Rothschild (2008), Ozcelik, Cagiltay & Ozcelik (2013), Belanich, Orvis & Sibley (2013), Shute & Ke (2012), Wilson *et al.* (2009)
Fantasy (Narrative and Characterisation)	Wideman *et al.* (2007), Cheng *et al.* (2012), Scatteia (2005), Dondlinger (2007), Habgood, Ainsworth & Benford (2005), Westera *et al.* (2008), Waraich & Wilson (2005), Clearwater (2011), Lieberman, Fisk & Biely (2009), Tragazikis *et al.* (2011), Hsu, Tsai & Wang (2012), Wilson *et al.* (2009)
Fantasy (Narrative and Characterisation, but also citing Campbell's 'The Hero's Journey')	Dickey (2006b), Clyde & Thomas (2008), Busch, Conrad & Steinicke (2011), Kiili (2005a)
Cooperation (Also referred to within the literature as 'Collaboration' and 'Social Interaction')	Lieberman, Fisk & Biely (2009), Charles, Bustard & Black (2009), Hsu, Tsai & Wang (2012)
Recognition (Feedback)	de Freitas & Liarokapis (2011), Mislevy *et al.* (2012), Ibáñez, Crespo & Kloos (2010), Charles, Bustard & Black (2009), Ifenthaler, Eseryel & Ge (2012), Belland (2012), Melero, Hernández-Leo & Blat (2011), Schrader & McCreery (2012), Erhel & Jamet (2013), Ekanayake *et al.* (2011), Eseryel, Ifenthaler & Ge (2011), Lieberman, Fisk & Biely (2009), Dempsey *et al.* (2002), Charles, Bustard & Black (2009), Hsu, Tsai & Wang (2012)

Table 3.3: Educational Game Design Principles (Various)

Beyond the influence of Malone & Lepper, the literature might be considered more fragmented in its arguments for which 'principles' should be incorporated into educational games/games design. As a consequence, the following educational game principles appear more disjointed, but are discussed here due to being considered of relevance within the literature.

MacKenty (2006a, 2008) offers advice on what he feels makes a game educational, in MacKenty's opinion, a game should:

- Contain educationally accessible and relevant content (historical and contemporary).
- Ensure that success within the game depends on the (intelligent) choices made by the player during the game.
- Allows failure – teaching that it is possible to get things 'wrong'.
- Allow multiple ways for the player to successfully complete the given game ('victory conditions').
- Give short and concise feedback, allowing players to see the results of their decisions expediently.
- Offer increasing levels of difficultly/challenge.
- Be Fun - "*if it's not fun, why do it?*".

Beyond the games themselves, MacKenty argues that lessons need to be well organised and that class time should be sufficiently long enough to accommodate the use of games. Additionally, as with other researchers, MacKenty stresses the importance of technical support in order to practically (and successfully) implement Games Based Learning.

Prensky (2001) offers a series of 'principles' that he feels should be followed by games designers in order to create "*good games*", including:

- The game should be player centred, providing variable levels of difficulty (Easy, Medium, Hard) so that the player can adjust the game to their individual skill level.
- The game should be easy to learn, but hard to master.
- Allow the player to stay within a 'flow' state (*3.8.4.6 Flow Theory*).
- Provide frequent rewards, rather than penalties i.e. even after failure, restart the player from a nearby set point within the current level, rather than forcing them to restart from the very beginning.
- Allow for explorations and discovery.
- Provide a user friendly Graphical User Interface (GUI).
- Feature support for saving game progress.

3.8.3.1 Gee's 'Principles of Learning'

Gee (2007) advocates the use of video games (within education) as a tool for learning, arguing that they inherently contain sound learning principles (such as encouraging repetition, reflection and fostering curiosity). Gee's arguments are distilled into his 'Principles of Learning' (Table 3.4), which he argues can be found built into 'good computer games', which will ideally be played within environments that encourage 'overt reflection'.

Initially Gee's 'Principles' appear to be a COTS game selection list, for promoting the use of COTS games within education. However, in this author's opinion, Gee's principles could be compared to Schell's (2010) '100 Lenses' game design checklist (*3.7.4 Schell's '100 Lenses'*), but with a greater emphasis on designing educational games.

Gee’s ’Principles of Learning’ can be broadly grouped into the following game design areas:

Design Area	Principle
User Centred Design	Principle 1: Active, Critical Learning Principle
General Game Design	Principle 2: Design Principle
Challenge / Skill Development	Principle 12: Practice Principle Principle 13: Ongoing Learning Principle Principle 14: “Regime of Competence” Principle
Subconscious Training Mode (Aspects needed to play the game, are introduced to the player gradually)	Principle 24: Incremental Principle Principle 26: Bottom-up Basic Skills Principle Principle 28: Discovery Principle
Narrative / Characterisation / Promotion of Flow	Principle 7: Committed Learning Principle Principle 8: Identity Principle
Rewards / Attainment	Principle 10: Amplification of Input Principle Principle 11: Achievement Principle
Exploration	Principle 15: Probing Principle Principle 16: Multiple Routes Principle
User Information / Feedback (Textual / Visual / Audible)	Principle 17: Situated Meaning Principle Principle 20: Multimodal Principle
Promotion of Reflection (User, subject area and in general)	Principle 9: Self-Knowledge Principle Principle 30: Cultural Models about the World Principle Principle 31: Cultural Models about Learning Principle
Social	Principle 35: Affinity Group Principle
Knowledge (Storage & Retrieval)	Principle 33: Distributed Principle Principle 34: Dispersed Principle

Table 3.4: Gee’s ‘Principles of Learning’ (Gee 2007)

3.8.4 Learning Theories

As a prelude to the discussion on learning theory based games design (*3.8.5 Learning Theory Based Games Design*), this section summarises the theories most commonly referenced in the context of Games Based Learning. While the majority of these theories centre on the learning process, Flow theory (*3.8.4.6 Flow Theory*) has its foundations in psychology.

3.8.4.1 Behaviourism

Behaviourism is one of the oldest established learning theories, the origins of which can be traced back to the beginning of the 20th century (Pavlov 1902, Watson 1913, Skinner 1938).

Referred to as the 'acquisition of new behaviour' (Nagowah & Nagowah 2009), behaviourism theory views the human mind as a 'Black Box' which can be 'stimulated' in order to generate a 'response' ('Classical Conditioning')[3]. Depending on the desired response, an observable change in the learner's behaviour can either be positively reinforced through some form of reward, or actively discouraged through some form of punishment ('Operant Conditioning') (Johnson 2007, Pritchard 2009, Coulter 1990, Jordan, Carlile & Stack 2009).

Nagowah & Nagowah (2009) regard this theory's strength as being the relative ease with which successful learning can be detected through an observable change in the learner's behaviour, but counters that learners typically do not react well when presented with unexpected or abnormal learning situations. Ullrich (2008) refers to behaviourism as having similarities to 'Programmed Instruction' (Glaser 1962), but expresses the view that the academic results from Programmed Instruction (PI) curriculums have been mixed, with the added disadvantage that PI curriculums have historically been time-consuming to develop.

Finally, Pritchard (2009) is of the opinion that behaviourism (maybe due to its age) has 'fallen out of fashion' as a learning theory, in preference to Cognitivism.

3.8.4.2 Cognitivism

Behaviourism regards the mind as a 'Black Box', concentrating on the external inputs and outputs for evidence of learning. In contrast, cognitivist theory (or cognitivism) is concerned with the mental processes that take place within this 'Black Box'. Historically, the most prominent exponent of cognitivism was Jean Piaget, who developed the 'Stages of Cognitive Development'.

[3] Due to the stimulus / response nature of Behaviourism, it is sometimes referred to as 'Stimulus-Response' theory (Ullrich 2008, Pritchard 2009).

Stages of Cognitive Development

Piaget's theory describes the development of human intelligence (through a series of stages) from childhood to adulthood (Piaget 1972, Piaget 2007).

Sensorimotor Stage (0 – 2 years)

In this initial phase of Piaget's theory, a child will develop and explore the world through their senses (i.e. sight, sound, touch and smell) and become aware that objects will still continue to exist even when out of range of their senses (i.e. an object can still be 'present', even if you cannot momentarily see it).

Preoperational Stage (2 – 7 years)

In the preoperational stage, a child will continue to develop their language skills, but their thinking will still be regarded as 'egocentric' i.e. they cannot see the world from other points of view.

Concrete Operational (7 – 12 years)

By this stage, a child will become less 'egocentric' (beginning to 'see' other viewpoints) and will develop both logical thinking and higher mathematical skills (such as division or volumes)

Formal Operation (12 – Adulthood)

This final stage concentrates on the transition from childhood to adulthood. This transition is marked by further development of logical thinking and the development of conceptual or generalised (abstract) thinking. Piaget views this stage as continuing throughout an adult's life, where thought processes will constantly change, influenced by 'life' experiences.

In a modern interpretation of Piaget's original theory, Buckleitner (2008) describes the stages of cognitive development in terms of modern digital devices.

- At the Sensorimotor Stage, 'digital toys' are designed to allow babies/toddlers to explore with their senses, e.g. toys which can play sounds or flash lights in response to a toddler's touch.
- In the years preceding/starting primary school (the Preoperational stage), children will be exposed to common digital devices, such as mobile phones and tablet PC's. Buckleitner suggests that the use of 'toy' phones and cameras will aid children in their development of 'play'.
- At the Concrete Operational stage, exposure to the Internet (through search engines such as 'Google' or 'YouTube') will allow children to develop their logical thinking skills and contribute to making them less 'egocentric' in their view of the world.
- Finally, upon reaching adolescence (Formal Operation stage), teenagers' thought processes are influenced or shaped by living in the modern digital world. Buckleitner suggests that through the ownership of multiple digital devices (mobile phones, MP3 players, laptop computers), teenagers develop the ability to process 'synchronous streams of information'. While an interesting analogy, the author notes that the ability of a teenager (or 'Digital Native') to 'multi-process' is not strictly what Piaget proposes at this stage i.e. conceptual or abstract thinking.

3.8.4.3 Constructivism

Constructivism theorises that learners absorb or process new knowledge by relating it to their own existing knowledge, effectively constructing (or 'scaffolding') their own mental structures (or models) of this new knowledge (Bruner 1966, Bruner 1974).

From the author's personal experience, one analogy that could be used for describing constructivism, is that of learning a computer programming language. With computer programming, there are two important stages that must be mastered.

The first stage is learning the fundamentals of computer programming. These fundamentals will include the theory of designing a computer program (procedural or object-oriented), followed by the practicalities of writing and testing the final program.

Having mastered the fundamentals, the second stage is the learning of a specific computer programming language. Although programming languages generically perform the same tasks, they differ in syntax. For example, some languages end an instruction with a full stop (.), others with a semi-colon (;), some languages enclose a series of instructions within a 'BEGIN' and 'END', while others use opening/closing 'braces' ({ }).

Having mastered both stages, the learning of additional computer languages should (in theory) be straightforward, as any new language can be related back to the computer program writer's existing programming knowledge i.e. while the new language might differ in terms of syntax, the fundamentals of writing programs (with this new language) will still apply.

In addition to 'classical' constructivism (Harris & Graham 1994), there are two related theories – that of 'Social Constructivism' and 'Cognitive Constructivism' (Wang 2007, Pritchard 2009).

Social Constructivism places an emphasis on the social interaction between learners, with Vygotsky's theories (*3.8.4.4 Vygotsky's 'Social Development Theory'*) being frequently cited as an example (Pritchard 2009, Jordan, Carlile & Stack 2009, Nagowah & Nagowah 2009, Ullrich 2008). Vygotsky theorises that knowledge is constructed or 'scaffolded' through social and cultural interaction with friends, teachers and through practices specific to the individual's culture.

While associated with his work on cognitivist theories, Piaget has also contributed to the area of Cognitive Constructivism (Piaget 2007). Piaget refers to the mental organising of knowledge through the use of 'schemas', which learners adapt (i.e. scaffold) through two processes - Assimilation and Accommodation. With Assimilation, a learner assimilates new knowledge, by relating and organising it with existing schema (knowledge). However, when encountering new knowledge that cannot be 'assimilated', the learner must now 'accommodate' this knowledge through modifying an existing schema, or through the creation of a new schema.

3.8.4.4 Humanism

Contrasting with the theories of Behaviourism and Cognitivism, which focus on the outputs or processing of ‘information’ (Ashworth *et al*. 2004), Humanism takes the view that learners have a natural desire and willingness to learn, and therefore, learning should centre on the person, rather than the process (Huitt 2009, Gage & Berliner 1998). Key to this view is that the learner perceives that they have control (or learner agency) over the learning process and that they should be allowed to choose what they desire to learn (Rogers 1969). It is argued that this in turn leads to higher levels of learner motivation and self-actualisation (the realisation of one’s talent or abilities) (Huitt 2009, Kurtz 2000). Part of this learning process involves the teacher becoming a ‘facilitator’, who (instead of ‘teaching’), actually ‘facilitates’ the learner’s natural curiosity and desire to learn, within a safe and secure environment (Rogers 1969, Dunn 2002).

Humanism is not without its critics, who argue that its view of human nature is both subjective and naïvely optimistic (Heffner 2011). The criticism of naïvety stems from the positive view that Humanism adopts towards the learner, and its presumption that all learners are inherently ‘good’ with a natural desire/willingness to learn (Huitt 2009) This view is challenged by Heffner (2011) who argues that the theory only focuses on “healthy” learners, in turn neglecting those with personality or mental health issues. As Abraham Maslow (Maslow 1968) is cited as one of the strongest influences in Humanism (Huitt 2009, Ashworth *et al*. 2004, Dunn 2002), the theory also suffers from the same criticisms as directed towards Maslow’s ‘Hierarchy of Needs’ (*2.4.4.1 Motivational Theories*) – namely that Humanism lacks an empirical foundation on which to base its views, and that it focuses too much on the individual learner’s needs (Pearson & Podeschi 1999, Heffner 2011).

3.8.4.5 Vygotsky's 'Social Development Theory'

Lev Vygotsky developed a number of theories that are generically referred to as Vygotsky's 'Social Development Theory' (SDT) (Vygotsky 1978, 1986).

Probably the most relevant aspects of Vygotsky's SDT are 'Social Interaction' and, often discussed within GBL literature, 'The Zone of Proximal Development' (ZPD) (Bodrova 1997 and Chew, Jones & Turner 2008).

'Social Interaction' permeates throughout Vygotsky's theories, including the so-called 'Higher and Lower Mental Functions' of the human brain. While 'Lower Mental Functions' are basic to all humans (such as the ability to feel sensations or react to sudden events, such as flashing lights), 'Higher Mental Functions' are formed over time through learning, experience and culture. In his 'Cultural-Historical Theory', Vygotsky theorises that knowledge is built up or constructed through social and cultural interaction i.e. interacting with friends, teachers and through practices/circumstances specific to the individual's culture (Pritchard 2009, Chew, Jones & Turner 2008).

In 'The Zone of Proximal Development', the learner starts with a certain level (or 'Zone') of knowledge, which they have successfully mastered. As learning takes place, the learner will progress to the next level/zone of knowledge where (initially) they will need the guidance and support from a teacher. Eventually the learner will master this new level/zone of knowledge, as they did the previous level (Figure 3.4).

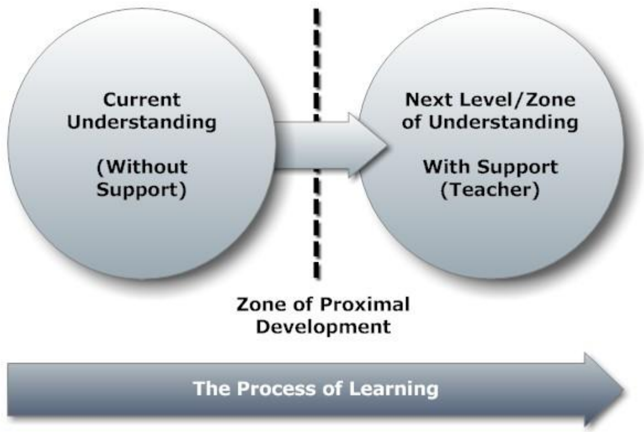


Figure 3.4: Zone of Proximal Development (Adapted from Pritchard 2009)

3.8.4.6 Flow Theory

Originally proposed by Mihaly Csikszentmihalyi, Flow Theory (sometimes referred to as 'Optimal Experience') is a set of conditions, which if experienced simultaneously, can cause the learner to enter and exist in a 'Flow' state (Csikszentmihalyi 1975, Donner & Csikszentmihalyi 1992). When learners are induced into this Flow state, they will find themselves intensely engaged with their current activity, to the exclusion of everything else.

This proposed level of engagement is very appealing within the education sector and is regarded by Gee (2007) as one of the most persuasive reasons for the use of games within the education system.

A learner is said to be in a 'Flow'-like state when the following (although not necessarily all) conditions occur during a learning activity: (Csikszentmihalyi 1975, Csikszentmihalyi 1997, Shernoff *et al*. 2003, Dietz 2004, Procci *et al*. 2012, Faiola *et al*. 2012, Hsieh, Lin, Hou 2013, Smith 2005):

- **Clear Goals:** The activity should have clear outcomes or goals to be achieved.
- **Immediate Feedback:** Throughout the activity, the learner should be aware of their progress (good or bad).
- **No Distractions:** The learner's environment should be distraction free, allowing the learner to concentrate on the activity in hand.
- **Total Absorption:** The learner should be so engaged in the current activity that the outside world (including the fear of failure) fades into the background.
- **Time Loss:** The activity should be so engaging that the learner loses track of time, and to some extent, time has no meaning.
- **Control / Autonomy:** The learner should feel they have a degree of personal control / autonomy over the current activity.
- **Challenge / Skills Balance:** an activity should not be too challenging or too easy, but within the learner's current skill level.

The ideal balance is represented by a 'Flow Channel' (Figure 3.5), which shows that a balanced mix of challenge and skills are required in order to enter a flow state. As a learner's skill increases, the level of challenge will also need to be increased if the learner is to remain in the 'flow' channel. If the right mix is not maintained, then the learner may become bored with the activity (learner has high skills, and finds the 'challenge' easy) or may find it too daunting (low skills and an impossibly high challenge).

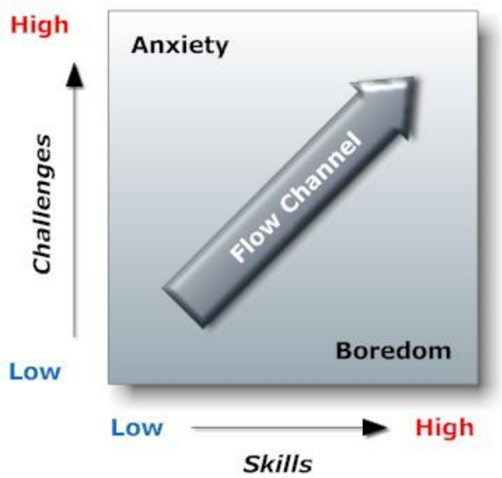


Figure 3.5: Model of Flow (Adapted from Csikszentmihalyi 1975, Kiili 2005b, Nelson 2008, Kiili *et al*. 2012)

3.8.5 Learning Theory Based Games Design

Many researchers argue that the design of educational computer games should be based explicitly on recognised learning theories. However, during the literature review, the author discovered limited examples to support this argument. Reflecting this situation are the literature reviews conducted by Wu. Hsiao *et al.* (2012) and Wu, Chiou *et al.* (2012). In their review of 567 'game-assisted learning' studies, Wu, Chiou *et al.* (2012) suggest that only a few (91) are based on the use of an established learning theory, with most of these studies favouring the use of constructivism and humanism in preference to other theories (Table 3.5).

Learning Theory	Total References (Out of 91 studies)	Notes
Constructivism	58	Situated learning theory (17 references), Problem-based learning (13 references), Activity theory (8 references), Discovery theory (7 references), Social development theory (5 references), Cognitive apprenticeship (4 references), Case-based learning (3 references), Actor–network theory (1 reference).
Humanism	25	Included references to Experiential learning.
Cognitivism	16	Elaboration theory (7 references), Cognitive development (4 references), Theory of conditions of learning (3 references), Attribution theory (2 references)
Behaviourism	15	Direct instruction (9 references), Programmed instruction (3 references), Social learning theory (3 references)

Table 3.5 Learning theories used within ‘game-assisted learning’ studies
(Adapted from Wu, Chiou et al. 2012)

Similarly, in their meta-analysis of 658 ‘Games Based Learning’ studies, Wu, Hsiao *et al.* (2012) conclude that the most ‘popular’ learning theories (upon which to base educational game design) followed a similar pattern (Table 3.6), but noting that the majority of these studies (567) described the use of GBL with no underlying pedagogic foundation.

Learning Theory	References (Out of 658 studies)
Constructivism	48
Humanism	25
Cognitivism	17
Behaviourism	12

Table 3.6: Most ‘popular’ learning theories on which to
base educational game design (Wu, Hsiao *et al.* 2012)

Reflecting Wu, Chiou *et al*.’s (2012) and Wu, Hsiao *et al*.’s (2012) findings, the literature review conducted (by the author) within this area revealed very few *explicit* examples of educational game design based on an established learning theory. Therefore what follows is a description of the examples that were found.

3.8.5.1 Multiple Intelligences

Two references to the use of Gardner's Multiple Intelligences (Gardner 1993) were found within the literature (Minović, Milovanović & Starcevic 2013, Furió *et al.* 2013), but only one (Furió *et al.* 2013) makes the explicit reference between game design and the theory itself.

Similar to the concept of 'differentiation', Multiple Intelligences hypothesises that learners have a number of different 'intelligences'. These 'intelligences' reflect the different abilities of the learner (i.e. linguistic, musical, logical/mathematic, interpersonal) and therefore have an influence on how the learner actually learns (Table 3.7).

'Intelligence'	Description
Linguistic	The capacity to use language effectively.
Logical-mathematical	The ability to analyse and manipulate abstract relations.
Spatial	The ability to perceive and receive visual and spatial patterns/images.
Bodily-Kinaesthetic	The ability to use the body expressively or skilfully.
Musical	The ability to create, communicate and understand music.
Interpersonal	The ability to empathise and interact socially with others, typically as part of a group environment.
Intrapersonal	The ability to interpret personal feelings and build accurate self-representations.
Naturalistic	The ability to classify and use features of the environment.

Table 3.7: Gardner's 'Multiple Intelligences' (Adapted from Gardner 1993)

By identifying a learner's 'intelligences', it is argued that learning can be tailored to that individual learner, with an emphasis on their specific intelligences – leading to a more personalised learning experience (Pritchard 2009, Hopper & Hurry 2000).

Critics argue, however, that there is no empirical evidence to support the existence of Gardner's 'intelligences' (Armstrong 2009, White 2005, Smith 2008, Dana Foundation 1999, Mathews 2004, Klein 1997, Peariso 2008) and that his approach is not particularly original i.e. the 'intelligences' that he promotes are nothing more than talents, abilities or learning styles, which have already been acknowledged by experts in the field (Willingham 2004, Education Scotland 2014).

Despite this criticism, Furió *et al.* (2013) document the development of their (unnamed) iPhone game, based on Multiple Intelligence theory, which is designed to teach "*multiculturalism, tolerance, and solidarity*" (Furió *et al.* 2013, p.9) (Table 3.8). Unfortunately, Furió *et al.* fail to elaborate on their reasoning for the use of Gardner's theory (as a basis for games design), beyond stating that "*Gardner's theory of Multiple Intelligences suggests that individuals have different preferences and aptitudes for different types of learning*" (Furió *et al.* 2013, p.9).

'Intelligence'	As implemented within iPhone Game (Furió *et al.* 2013)
Linguistic	N/A.
Logical-mathematical	N/A.
Spatial	*"The game is mostly visual and also allows players to look at objects from different points of view (not only from the front, but also from the back)."* (Furió *et al.* 2013, p.13).
Bodily-Kinaesthetic	*"The children have to explore a room to find the element requested by the guide character."* (Furió *et al.* 2013, p.13).
Musical	*"The game transfers the information through musical patterns (e.g. the typical sounds of different animals)."* (Furió *et al.* 2013, p.13).
Interpersonal	*"The game is played in pairs. Since the game is played in pairs and players have to find the same element, they must compete to be the first one to find the element."* (Furió *et al.* 2013, p.13).
Intrapersonal	N/A.
Naturalistic	N/A.

Table 3.8: 'Multiple Intelligence' Game Design (Adapted from Furió *et al.* 2013).

3.8.5.2 Gagné's Nine Events of Instruction

Roodt & Joubert (2009), Gunter, Kenny & Vick (2006) and McAlpine, Van derZanden & Harris (2010) suggest that Robert Gagné's 'Nine Events of Instruction' (Gagné 1985) can act as a basic foundation for the design of educational computer games. Gagné's 'Nine Events of Instruction' is regarded as an Instructional Design Model (rather than a learning theory) that describes the 'conditions' or steps required for learning to take place (Table 3.9).

'Events Of Instruction'	Description
1. Gain the learner's attention	Gain the attention and interest of the learner.
2. Inform the learners of the objectives	Inform the learner of what they will learn, i.e. the learning the goals/objectives and potential outcomes.
3. Stimulate recall of prior learning	Relate current learning to relevant prior learning, allowing learner to build upon their previous knowledge.
4. Present stimulus or lesson	Present the learning material (lecture or presentation).
5. Provide learning guidance and instruction	Guidance, in addition to the learning material itself.
6. Elicit performance	Allow learner to practice or apply their newly learnt knowledge.
7. Provide feedback	Provide feedback designed to correct understanding/reaffirm understanding.
8. Assess performance	Assess learning (through assignments, exams, quizzes).
9. Enhance retention and transfer	Provide opportunities for the learner to reflect, or relate knowledge (to be learnt) to the leaner's own experiences.

Table 3.9: Gagné's 'Nine Events of Instruction'
(Adapted from Gagné 1985, Roodt & Joubert 2009)

Both Gunter, Kenny & Vick (2006) and McAlpine, Van derZanden & Harris (2010) argue that Gagné's 'Nine Events' can be used as the basis for designing the various stages of an educational computer game, with Gunter, Kenny & Vick (2006) mapping both Gagné's 'Events' and Keller's 'ARCS Model of Motivational Design' (Table 3.10) to 'Common Game Elements' found within computer games design (Table 3.11).

ARCS Model of Motivational Design	
Attention	Gain and sustain the learner's attention through the element of surprise or through provoking learner's curiosity (e.g. by asking thought provoking questions).
Relevance	Delivering instruction in such a way that it appears relevant or 'authentic' to the learner (by understanding their interests and what motivates them).
Confidence	As with Bandura's concept of self-efficacy (Bandura 1997), this step involves creating an environment where the learner has the confidence that there is an achievable outcome from the instructional process, and is therefore motivated to pursue it.
Satisfaction / Success	At the end of the instructional process, the learner should be able to take satisfaction in their accomplishments, which ideally they should perceive as having been achieved through their own contribution and hard work.

Table 3.10: Kellar's ARCS Model of Motivational Design (Adapted from Keller 2010).

Gagné's Nine Events of Instruction	Keller's ARCS Model	Common Game Elements
Gain Attention	Attention	Scenario exposition
Inform of Objectives		Problem Setup
Stimulate Recall	Relevance	*No existing game analogy*
Present Stimulus / Lesson		Offer Challenge / Choice
Provide Learner Guidance	Confidence / Challenge	Provide Direction
Elicit Performance		Elicit Action / Decision
Provide Feedback	Satisfaction / Success	Discernible Outcome
Assess Performance		Success / Failure screens
Retention and Transfer		*No existing game analogy*

Table 3.11: Gagné / Keller Mapping to 'Common Elements'
(Adapted from Gunter, Kenny & Vick 2006)

Unlike Gardner's Multiple Intelligence theory (*3.8.5.1 Multiple Intelligences*), the literature's promotion of Gagné's instructional model (as a basis for educational games design) seems to be only theoretical – the author was unable to locate any documented examples of actual computer game implementation. Additionally, beyond the descriptions of both Gagné's and Kellar's work, the author was unable to locate literature independently critiquing both models, especially their validity for use as the basis of educational games design.

3.9 Educational Game Implementation

So far within this chapter, the literature review has broadly described:

- The use of computer games within the classroom (COTS games), and
- Game Design Methodologies (UCD/ADDIE, Classic and Educational Game Design Principles).

The concluding part of this chapter concentrates on the practical implementation of educational games – through the use of software development tools and educational game design 'frameworks'. As will be discussed within subsequent sections, the author experienced difficulty sourcing literature within these areas, with much of it being descriptive in nature. The author would therefore advise that these difficulties be kept in mind for the remainder of the chapter. The literature review within this area is organised accordingly:

- Educational Game Development Tools.
- Educational Game Design Frameworks.

3.10 Educational Game Development Tools

A review of the relevant literature identified two approaches to games development: Game Engines and Game Development Packages.

'Game Engines' can either be found incorporated into commercial games or obtained on a standalone basis. Typically a game engine provides all of the tools required to create commercial quality computer games and will offer the game developer a high degree of technical control over the game creation process. This can include controlling the fidelity of the graphics (realistic shadowing and lighting effects), network/multiplayer functionality and support for sophisticated Artificial Intelligence (AI) (Tang, Hanneghan & Carter 2012, Petridis *et al*. 2012, Friese, Herrlich & Wolter 2008).

In terms of the educational use of game engines, the author experienced difficulty in sourcing appropriate literature, with many of the journal articles discovered merely citing the use of a particular game engine with little or no explanation as to their selection criteria (Table 3.12).

Game Engine	Reference
Shiva3D (http://www.stonetrip.com/)	Charles *et al.* (2012) (Considered for game development, but ultimately not used)
Unity3D (http://unity3d.com/)	Charles *et al.* (2012) (Considered for game development, but ultimately not used), Champsas *et al.* (2012)
Delta3D (http://www.delta3d.org/)	Tang, Hanneghan & Carter (2012)
OpenSim (open source Second Life) (http://opensimulator.org/)	Champsas *et al.* (2012) (Considered for game development, but ultimately not used), Maciuszek *et al*. (2010)
Emergo Toolkit (http://emergo.ou.nl/)	Westera *et al.* (2008), Nadolski *et al.* (2008)
XNA Game Engine (http://www.microsoft.com/)	Blanchfield (2009) (Considered for game development, but ultimately not used)
Quake III (now ioquake3 - http://ioquake3.org/)	Stowell & Shelton (2008)

Table 3.12: Game Engines referenced within the literature

However, where criteria was stated, a recurring theme for selection was the availability of the game engine as open source (or low cost) software and support for creating 3D virtual world environments. The one exception within this theme is the review of ‘high-fidelity’ game engines conducted by Petridis *et al*. (2012). Petridis *et al* argue that for game engines to be successfully used within education, they should ideally include the following features:

- Game Level Editors.
- Support for computer networking.
- Artificial Intelligence (AI), and
- Be (relatively) straightforward to use by teaching staff with limited technical knowledge.

Due to the highly technical nature of game engines, they can exclude the less technically proficient developer from the game development process (Charles *et al.* 2012, Westera *et al.* 2008, Blanchfield 2009). Therefore as an alternative approach, more complete ‘game development’ packages are available. Game development packages are typically aimed at ‘novice’ developers and are designed to make game development more ‘accessible’. In real terms this means that less computer programming experience is required in order to develop games (Whitton 2012). Game development packages will also frequently include simplified versions of graphics or sound editors, thereby reducing the need for the novice game developer to seek out and learn (more complicated) dedicated software tools.

Reviewing the literature on game development packages reveals a number of low priced commercially available products (*4.6 Game Design / Development*) that are designed to allow different genres of computer games to be created with varying levels of ease (and difficulty). Most of these products perform the same range of tasks (with some exceptions) and to some extent succumb to the same criticisms. Reviewing comments posted to community websites/forums reveals that almost all of these products are criticised for poor documentation, instabilities, and the use of aging computer graphics technology.

Within the literature, the author discovered a limited number of references to the use of game development packages within education, with the package ‘GameMaker’ cited the most frequently (Charles *et al*. 2012, Khalili *et al*. 2011, Blanchfield 2009, Overmars 2004a , Overmars 2004b, Claypool & Claypool 2005).

3.11 Educational Game Design Frameworks

An alternative approach to the development of educational games is through the use of a formal educational game design (EGD) framework. While an educational design framework may still use a game engine or game development package as part of its underlying architecture, its primary purpose is to bring a more formal (academic) approach to the development and implementation of educational games. As with defining the meaning of the term ‘game’, the literature reveals differing interpretations over what exactly an educational game design framework is, and what it is supposed to do. A ‘framework’ within the literature could be classified in the following ways:

- Frameworks designed to evaluate computer games for educational use within an educational environment.
- *Theoretical* frameworks aimed at the development of educational games.
- *Implemented* frameworks aimed at the development of educational games.

These interpretations overlap to varying degrees, making classification difficult. Therefore for the purposes of discussion, the frameworks have been grouped into theoretical (evaluation/implementation) and implemented (‘proof of concept’) frameworks.

The author experienced difficulty sourcing literature within this area, with many of the proposed frameworks lacking additional literature beyond that of the framework originator’s initial journal articles. Where additional literature was discovered, typically it would be descriptive in nature, merely reciting the original work of the framework originator.

The author would advise that these difficulties be kept in mind during the subsequent discussions within this section.

3.12 Theoretical EGD Frameworks

3.12.1 Four-Dimensional (4D) Framework

Probably one of the most prominent GBL Frameworks is de Freitas's Four-Dimensional Framework, which can be used for "designing and evaluating immersive learning experiences in a virtual world" (de Freitas *et al.* 2010, p.69). In terms of 'virtual worlds', the framework can be applied to virtual world environments, such as Second Life (or the open source equivalent, OpenSim) and computer games in the context of Games Based Learning (de Freitas & Liarokapis 2011, Arnab *et al.* 2012, Tragazikis *et al.* 2011).

The framework consists of four 'dimensions' (Table 3.13):

Learner Specifics

The first dimension of the framework is concerned with profiling the learners or 'users' of the virtual world/game, with the intention of closely matching the learner to appropriate learning activities and desired learning outcomes. Analogies could be drawn between this first dimension and the 'Analysis' phases of both UCD and ADDIE design methodologies.

Pedagogy

The second dimension considers the pedagogic approaches that should be supported by the virtual world/game. de Freitas *et al*. (2010) suggest that this may include instructional design models, such as Gagné's 'Nine Events of Instruction' or constructivist theories such as Vygotsky's 'Social Learning Theory'.

Representation

The third dimension concentrates on the graphical fidelity, interactivity and levels of immersion found within a virtual world/game. This dimension might be interpreted as representing the process of design i.e. the elements of narrative, challenge, graphical fidelity etc., all of which contribute to making the virtual world/game, 'fun' and immersive.

Context

The fourth and final dimension relates to the environment within which the virtual world/game will be used (i.e. the classroom), the type of lighting, the availability of technical support and whether the available equipment is technically compatible with the virtual world/game. As with the first dimension (Learner Specifics), analogies could be drawn between this dimension and the 'Analysis' phases of both UCD and ADDIE design methodologies.

Learner Specifics	Pedagogy
Profile Role Competencies	Associative Cognitive Social / Situative
Representation	**Context**
Fidelity Interactivity Immersion	Environment Access to learning Supporting Resources

Table 3.13: de Freitas's Four Dimensional Framework (Adapted from de Freitas *et al*. 2010, de Freitas & Liarokapis 2011, Arnab *et al*. 2012)

While de Freitas (and colleagues) have subsequently cited the use of the 4D Framework in software-related development projects (de Freitas & Routledge 2013, Arnab *et al.* 2013, de Freitas *et al.* 2010, Dunwell, de Freitas & Jarvis 2011), the author had difficulty sourcing independent references to the framework's use outside of the body of de Freitas's work.

Where independent references were discovered, they were descriptive in nature (Molka-Danielsen, Deutschmann & Panichi 2009, Miller, Dawood & Kassem 2012), or merely citing the use of the framework without further elaboration (Yap *et al*. 2013).

3.12.2 Game Object Model

Amory (Amory 2007, Amory, Molomo & Blignaut 2011) promotes the use of his Game Object Model (GOM) for evaluating existing games (for pedagogical value) as well as for the design of educational games. The model consists of three ‘spaces’:

Game Space – This is concerned with evaluating/designing the core elements of a game, which Amory regards as ‘Play’, ‘Exploration’, ‘Challenges’ and ‘Engagement’. The Game Space also consists of the following ‘sub-spaces’:

- **Visualization Space** is concerned with the game ‘experience’, i.e. the promotion of critical thinking, competition and the use of a story narrative.
- **Elements Space** poses the following questions - Is the game ‘fun’? Does the game utilise attractive graphics and sound?
- **Actors Space** is concerned with how the players interact with the game and/or their fellow players.

Problem Space concentrates on the communication aspects of game design, such as how do players communicate? How does the game communicate with the player? Within this space are the ‘sub-spaces’ of **Literacy** (educational content to be learnt), **Memory** (long/short term memory storage/retrieval) and **Motor** (the physical movements of the player, such as visual/hand coordination).

Social Space – focuses on the development of social interaction and support for what Amory refers to as ‘on-line communities’.

As with de Freitas’s 4D Framework, the author had difficulty sourcing independent references to the use of GOM outside of the body of Amory‘s work, and when references were discovered, they tended to be descriptive in nature (Sommeregger & Kellner 2012, Arnab *et al*. 2014, Kurzel 2010, Chen, Hsu & Chan 2010).

Aside from being a theoretical ‘model’, GOM is very technical in nature, being based on Object Oriented Programming (OOP). This OOP approach in turn makes the model conceptually challenging to understand (and use) for practitioners outside of the field of software development (Westera *et al.* 2008). Additionally, the model is criticised for being a reflection of Amory’s own ‘ideology’ and that it does not take into account either ‘gameplay’ or flow theory (van Staalduinen & de Freitas 2010).

3.13 Implemented EGD Frameworks (‘Proof of Concept’)

3.13.1 iSpiral Framework

Charles *et al*. (2012) describe the development of the iSpiral (**I**nteractive Stellar Platform **I**ntegrating Reflection and Learning) system for the creation and rapid deployment of educational games using the Moodle LMS (Learning Management System) and the games development package ‘GameMaker’. Part of the reasoning behind the selection of ‘GameMaker’ (as the development tool of choice) was the project requirement for iSpiral to be developed and deployed within a short time scale (according to Charles *et al*., seven weeks). Hence, ‘GameMaker’ was chosen due to its relative ease of use and simplicity.

The academic goal of the iSpiral system was to improve students’ motivation through active participation. For students using iSpiral, attainment was linked to their level of participation in various blogs, wilki’s and online quizzes (provided by Moodle). This ‘attainment data’ was then fed into a ‘GameMaker’ produced ‘space shooter’ game. While superficially a shooting game, the game mechanics (rewards, weapon availability, health levels) were linked to the aforementioned attainment data – therefore, the greater the student’s academic participation, the greater number of in-game options/rewards would became available (for that particular student).

Students' performance within the game was therefore a combination of both academic participation and genuine gaming skill. However, while Charles *et al*. express the view that "*levels of engagement were generally better than expected*" (Charles *et al*. 2012, p.100), they also point out the system was not without its flaws. The main flaw encountered was the tendency of some students to deliberately 'click on links' (to 'register' their participation in a blog or wilki) in order to improve their in-game rewards or health.

3.13.2 JaBInT (Java-based Intelligent Tutoring)

Maciuszek *et al*. (2010) describe the implementation of their JaBInT framework, which is orientated towards a software engineering view of Games Based Learning. Described as a 'component-based educational game framework', JaBInT is designed to act as a skeleton (or '*Plug 'n Train*') framework allowing software developers to construct educational games through the swapping in (and out) of re-usable software components. On the theoretical side, JaBInT consists of four (customisable) components for changing the genre of the educational game ('User Interface'), storing information about the users/players ('User'), subject matter material ('Expert') and the game mechanics ('Process Steering').

While Maciuszek *et al*. provide an example of how 'new games' can be created by replacing the 'User Interface' component, they concede that for more complex game development, a new architecture would need to be developed. Additionally they detail compatibility issues that they encountered while trying to adapt JaBInT to communicate with third party software and the Game Engine 'OpenSim' (Champsas *et al*. 2012).

3.14 GBL Framework Flaws

While the surveyed GBL frameworks offer positive approaches to educational game development, they are not without their flaws. Given their evolving nature, there are at present no formally agreed standards for either GBL frameworks, or the framework produced games. Additionally, there is little official standardised guidance on the building of educational games or how they can be integrated within the (UK) curriculum (Gros 2007, Becker 2007, Tan 2010). There is also the issue of the 'practicalities' of the proposed frameworks. These practicalities fall broadly into three areas – Technical, Financial and Academic.

3.14.1 Technical Practicality

Westera *et al*. (2008) argue that many educational game frameworks are too complex – resulting in a difficulty in developing educational games. Westera's *et al*. solution to this problem is to attempt to reduce the complexity of game development through their use of the 'Emergo' toolkit (Table 3.12). However, in the author's opinion, their documented solution appears to be complicated and ideally still requires dedicated academic resources for game development.

Where frameworks have been implemented (*3.13 Implemented EGD Frameworks ('Proof of Concept')*), the academics involved have demonstrated technical expertise, however many of the target users (teachers) for these frameworks may be less technically inclined. What seems to be lacking, within the literature at least, are high-end development tools which would realistically aid less technical would-be games designers in the production of high-quality educational games (Tan 2010, Tang *et al*. 2012). One possible solution to this absence of high-end tools would be the formal collaboration of academia with the games industry.

Given their expert knowledge, games designers are best placed to design the mechanics of educational games, while academics are left to design the pedagogical aspects through the use of Instructional Design methodologies, such as ADDIE (Bellotti *et al*. 2011, Hirumi *et al*. 2010, Marne *et al*. 2012, Tan 2010). As part of their development of the iSpiral framework, Charles *et al*. (2012) advocate the use of such collaborations, offering the opinion that their 'space shooter' game performed more effectively and 'looked better' as a consequence of industrial input. Ideally, teachers and pupils should also be involved in this process, as they will effectively be the 'end users' and can provide valuable feedback on the final game(s) (Hirumi *et al*. 2010, Waraich & Wilson 2005).

3.14.2 Financial Practicality

Many of the documented frameworks have been produced with little or no financial budget, typically with (financially unsupported) open source software. As Tran, George & Marfisi-Schottman (2010) and DeVary (2008) point out, commercial educational games can cost a considerable amount of money to produce and a development cycle of months to years. For the games industry, the major incentive to develop (or co-develop) educational games, is if they will subsequently make a profit through either selling the final games to interested schools, or if the games can be released commercially.

Equally, if educational games are to find a meaningful role and use within the education system, there will need to be some form of long term educational funding (Charles *et al*. 2012). However, as the United Kingdom (at the time of writing) is still currently undergoing a period of austerity, that funding would seem to be unlikely at the present time (Whitton 2012).

3.14.3 Academic Practicality

While there are examples (within the literature) of gaming being used as part of the teaching process, these examples are largely un-formalised and conducted on a limited academic scale (Blanchfield 2009, Ibáñez, Marne & Labat 2011, Charles *et al*. 2012).

It is generally acknowledged that teachers often have to contend with heavy teaching/administrative workloads, yet advocates of GBL frameworks seem to suggest that it will be the teachers who are best placed to develop educational games. Teachers may be the best placed, but if they have no time to physically spare, or have greater (work-related) priorities, then this could be considered a arguable point (Conole *et al*. 2004, Morris 2009, Ice *et al*. 2012).

In their defence, a number of researchers acknowledge that the amount of preparation required, and then the use of the games themselves (within a teaching session) can be time-consuming, and may actually preclude them from use within the classroom (Gros 2007, Tan 2010, Whitton 2012, Tran, George & Marfisi-Schottman 2010, Melero, Hernández-Leo & Blat 2011). Finally, Annetta (2008) asks the question about who will actually design and build educational games? Assuming that this task falls to teachers, do they have the appropriate technical skills to actually write games based software? (Let alone the time amidst teaching and related administration).

3.15 Conclusion

This chapter builds upon Chapter 2, but focuses on the practical implementation of Games Based Learning (GBL) within the classroom. Broadly, there are two approaches that can be followed:

- The educational use of Commercial Off The Shelf (COTS) computer games, and
- The custom development of educational computer games.

The appropriate use of COTS games within the classroom can result in the delivery of a range of subjects, from taxation to world history. Compared to custom game development, the use of COTS games can be cost effective and offer a high quality (educational) gaming experience. However, there are a number of barriers to COTS adoption, including the suitability of their use within the classroom and practical/technical limitations. Repurposing COTS games (‘modding’) may address some of these issues, but not necessarily all.

The majority of this chapter is dedicated to the second GBL approach, that of developing educational games. A review of the literature reveals several approaches to educational game development:

- The use of an instructional design methodology, such as ADDIE.
- Designing games based on ‘classic’ game design principles, such as narrative, elements of challenge and the use of attractive graphics/sound etc.
- Designing games based directly on or influenced by the work of Malone & Lepper (which shares a degree of commonality with the ‘classic’ game design approach).
- Designing games, based on alignment with established learning theories or motivational design models.

Beyond the work of Malone & Lepper, support for pedagogic game design is limited. While many researchers argue the importance of basing educational game design on a formal learning theory, there are limited examples of this actually in practice.

The practical approaches to game development are explored through the use of Educational Game Development Tools, namely game engines and game development packages. Game engines offer greater technical control and the possibility of high fidelity graphics, whereas game development packages are more often aimed at the novice game developer.

Concluding this chapter is a review of the literature on Educational Game Design (EGD) Frameworks, which are designed to bring formal academic standards to educational game development and implementation. The EGD Frameworks have been classified (by the author) into two areas: Theoretical and Implemented. Theoretical frameworks are designed to allow non-educational games to be evaluated for pedagogic value, although the framework designers also suggest that they can be used for designing educational games as well. Implemented frameworks allow for the production of games designed to deliver academic material. As ‘proof of concept’ frameworks, they should be considered at a prototype stage of development. Regardless of type, the author is of the view that EGD Frameworks still require further research, funding and standardisation in the long term.

Chapter 4 follows on from the literature review, and documents the author’s methodological approach to addressing the thesis research questions.

Chapter 4: Methodology

4.1 Introduction

The purpose of this chapter is to discuss the author's methodological approach to addressing the thesis research questions.

The chapter begins with a discussion on the thesis research methodology, including the author's philosophical position, qualitative/quantitative research and ethical considerations. Following on from this, the author discusses the considerations that influenced the implementation of his chosen research methods (sampling, questionnaire design, observations), leading to the main discussion on the implementation of the methods themselves:

1. The use of a Questionnaire-based Survey, designed to elicit the views of parents, teachers and pupils on the subject of Games Based Learning
2. A review of maths related educational games currently available on the market (Game Review)
3. The running of a Design Pilot in order to elicit 'best practice' feedback on the design of educational games
4. The design and development of a series of educational games
5. The running of a Prototyping Pilot designed to trial the author's developed educational games.
6. The implementation of a Main Study, designed to collect (research question) relevant feedback through observation and questionnaires.

Finally, before concluding, the author discusses the technical and usage issues associated with the running of the Prototyping Pilot and the Main Study.

4.2 Research Methodology

At the beginning (and throughout) the 'thesis 'journey', the author reflected upon the issues associated with researching and developing the thesis. Therefore, this section aims to discuss the background to the author's chosen methodology, prior to the main discussion on the chosen research methods that form the remainder of this chapter.

4.2.1 Research Paradigm / Philosophical Position

It is argued that the way in which researchers view 'the world', and the values which they hold, can in turn influence their methodological approach to conducting research (Pring 2004, Cohen, Manion & Morrison 2008, Saunders, Lewis & Thornhill 2012). Given that views and values can be unique to the individual researcher, a number of 'research paradigms' have been developed in order to represent these differing views/values.

When publishing research, it is considered good practice for researchers to state their preferred paradigm or 'philosophical position' as part of any discussions on their chosen methodology. This in turn, allows the reader (of the published research) to form a view on the researcher's viewpoint (or research influences), as well has helping the reader to identify any potential biases within the published research (Scotland 2012).

Connected to the general concept of the research paradigm, is what might be considered as its attributes – Ontology, Epistemology and Methodology.

Ontology is described as the 'study of being'. The researcher is encouraged to reflect on the world, and specifically on what constitutes 'reality' (Scotland 2012) i.e. Does an object actually exist? Or is it based on our views or perception? E.g. an upturned wooden box is a box, or is it actually a rudimentary chair for sitting on? Or is it both?

Epistemology broadly refers to the 'study of knowledge' (Table 4.1), and similarly to a researcher's ontological view, can be influenced by their chosen paradigm (Saunders, Lewis & Thornhill 2012, Krauss 2005, Ponterotto 2005).

Methodology is the "*strategy or plan of action*" (Scotland 2012, p.9) or the "*process and procedures of research*" (Ponterotto 2005, p.127) which influence the choice of research methods (questionnaire, interviews, surveys etc.), for the purposes of data collection.

Definition	Reference
"*Epistemology concerns what constitutes acceptable knowledge in a field of study*"	(Saunders, Lewis & Thornhill 2012, p. 126)
"*Epistemology is concerned with the relationship between the "knower" (the research participant) and the "would-be knower" (the researcher)*"	(Ponterotto 2005, p.131)
"*In simple terms, epistemology is the philosophy of knowledge or how we come to know*"	(Krauss 2005, p.758)
(Epistemological assumptions) "*concern the very bases of knowledge – its nature and forms, how it can be acquired, and how communicated to other human beings*"	(Cohen, Manion & Morrison 2008, p.7)

Table 4.1: Definitions of Epistemology

4.2.1.1 Which Paradigm?

As briefly touched upon earlier, research paradigms have been designed to accommodate the differing views and values of researchers. This section will discuss the main paradigms available, as a prelude to a discussion on the author's own philosophical position/preferred research paradigm.

The following paradigm definitions draw upon the work of Pring (2004), Cohen, Manion & Morrison (2008), Scotland (2012), Krauss (2005), Ponterotto (2005) and Saunders, Lewis & Thornhill (2012), Wahyuni (2012).

Positivist

The positivist paradigm might be considered that of the ‘natural scientist’ (Saunders, Lewis & Thornhill 2012) – the researcher who wishes to work with what is known and can be proven empirically through the use of scientific methods (i.e. experiments, statistics) in order to test a hypothesis. In this paradigm, the researcher will typically hold the view that the ‘science’ should be independent of what is actually being studied, and will be concerned with establishing the ‘facts’ objectively.

Realist

The realist (or ‘post positivist’) paradigm is similar to the positivist paradigm, in the sense that it also supports scientific-based inquiry. However, ‘realism’ recognises that not every aspect of ‘reality’ can be measured empirically, and that some aspects of ‘reality’ might be influenced by the researcher’s perception of that aspect. Within this paradigm, there are two types of ‘realism’. ‘Direct Realism’ assumes that what researchers perceive through their senses, is accurate – i.e. “*what you see is what you get*” (Saunders, Lewis & Thornhill 2012, p.129). In contrast ‘Critical Realism’ takes the view that human senses can be deceptive or can be tricked, and that not every aspect of ‘reality’ actually exists in the way that the researcher might perceive it.

Interpretivist

Interpretivism could be regarded as the polar opposite of positivism. Whereas positivism places importance on empirically measureable ‘facts’, interpretivists argue that knowledge cannot always be neatly classified or measured as ‘facts and figures’. The interpretivist paradigm is suited to those researchers who engage in more naturalistic or ethnographic research, where the views, emotions and feelings of the research participants are the main source of data. Researchers adopting the interpretivist paradigm will typically engage in deep or self reflection (Ponterotto 2005).

4.2.1.2 Thesis Paradigm

There is inevitably some debate on which is the 'best' or the most appropriate paradigm that researchers should adopt as part of their research methodology (Pring 2004, Cohen, Manion & Morrison 2008). In this respect, the author found the guidance of Saunders, Lewis & Thornhill (2012) to be most helpful when deciding on his preferred paradigm/philosophical position.

Saunders, Lewis & Thornhill (2012) put forward the argument for the 'pragmatist paradigm', on the basis that "*choosing between one position or the other is somewhat unrealistic in practice*" (Saunders, Lewis & Thornhill 2012, p.134). They argue that pragmatists regard the most important aspect of a research philosophy, to be the addressing of the research question. Therefore, unless a research question implies the use of a particular paradigm, it is acceptable to use a mixture of paradigms in order to successfully address the question (or questions).

In terms of the thesis, the author's focus is on the addressing of the research questions (*1.4 Defining the Thesis Research Questions*), and in this respect, the author takes the view that there is no 'best' paradigm that can be adopted when attempting to address these questions. From the author's viewpoint, certain aspects of the research questions might best be viewed through the adoption of an empirically-based position (i.e. positivism), but equally, other aspects might benefit from the adoption of a more naturalistic view/position (i.e. Interpretivism).

Therefore, the author favours the adoption of pragmatism as his preferred paradigm, as it potentially offers the most flexibility (paradigm-wise) in terms of which position the author should adopt whilst addressing the thesis research questions.

4.2.2 Qualitative and Quantitative Research

At an early stage of the thesis development, the author considered which methodology should be adopted for the purposes of the thesis research.

After reflecting upon the discussions of Cohen, Manion & Morrison (2008) and Dawson (2009), the author came to the view that his research would encompass both qualitative and quantitative research methodologies. The author found the advice of Dawson (2009) to be the most helpful within this area:

> "*Don't fall into the trap which many beginning (and experienced) researchers do in thinking that quantitative research is 'better' than qualitative research. Neither is better than the other – they are just different and both have their strengths and weaknesses. Both also depend on the skills, training and experiences of the researcher.*
>
> *What you will find, however, is that your instincts probably lean you towards one rather than the other. Listen to those instincts as you will find it more productive to conduct the type of research with which you feel comfortable, especially if you're to keep your motivation levels high.*" (Dawson 2009, p.16).

In a similar vein to thesis research paradigm (*4.2.1 Research Paradigm / Philosophical Position*), It occurred to the author that certain aspects of his planned methodology (such as determining the 'best practice' in educational games design) would lend themselves more naturally to a qualitative methodology, rather than a quantitative one. In contrast, the author reasoned that attempting to address some of the research questions, might require a more quantitative approach.

Therefore, given Dawson's (2009) views that there is no specific 'right' or 'wrong' approach (just strengths and weaknesses), the author felt that it would be appropriate to adopt both methodologies during his research. The specific research methods used will be discussed within subsequent sections of this chapter (Sections 4.4 to 4.7).

4.2.3 Ethical Considerations (BERA Guidelines)

As part of his methodology, the author considered the ethical aspects of the thesis research, and felt it wise to consult BERA's (British Educational Research Association) 'Ethical Guidelines for Educational Research' (BERA 2011) for guidance within this area.

The BERA guidelines "*represent the tenets of best ethical practice*" (BERA 2011, p.3), and are designed to guide researchers (in the process of conducting research) so that they may "*reach an ethically acceptable position in which their actions are considered justifiable and sound*" (BERA 2011, p.4).

Within this section, the author will discuss how his research (and professional conduct) will adhere to these guidelines.

The BERA guidelines are grouped into four areas:

- Responsibilities to Research Participants
- Responsibilities to Research Sponsors
- Responsibilities to Educational Researchers
- Responsibilities to the Wider Audience

4.2.3.1 Responsibilities to Research Participants

This area is concerned with how participants (within a research project) are treated by those conducting research.

The most basic ethical tenet, within this area, is that research participants should be treated with respect, fairly, with dignity and equally with regards to race, sexuality, gender, disability or "*any other significant difference*" (BERA 2011, p.5). In addition to this basic tenet, the BERA guidelines also provide ethical guidance regarding how research is conducted, in relation to research participants.

This includes:

Voluntary Informed Consent

Participants should be informed about the research (and why they are being asked to participate), that participation is voluntary, and that their participation will be monitored (i.e. as part of a data collection process).

Of particular relevance to the author (given his geographical location at the start of his research), is the guidance given to UK researchers working abroad – namely that the research (and the researchers' conduct) "*must adhere to the same ethical standards as research in the UK*" (BERA 2011, p.5).

Openness

Ideally, participants consent should be obtained prior to the start of the research, and should be obtained without "*deception or subterfuge*" (BERA 2011, p.6), unless the nature of the research specifically requires this approach (i.e. as part of the data collection process). In the event of an approach that uses deception/subterfuge, the BERA guidelines advise that the researcher should consult and seek approval from their institution's ethics committee prior to starting the research.

Right to Withdraw

As with voluntary consent, participants should be informed of their right to withdraw from any research, and any subsequent withdrawal should be respected by researchers (irrespective of the participant's reasons).

Children, Vulnerable Young People and Vulnerable Adults

Guidance within this area focuses on research with children or vulnerable participants (children or adults). In this situation, the wellbeing of the participants should be the researcher's primary concern.

While the principle of voluntary consent still applies, in situations where this may be difficult to obtain, the researcher should seek the appropriate consent from the participant's legal guardian (i.e. in the case of children, the children's' parents). Additionally, researchers should have legal permission to work with the participants (i.e. CRB vetted), and endeavour not to place the participants in situations that may cause them to suffer from distress.

Incentives

The use of incentives within research (in order to encourage participation), should be sensible and proportionate. In the event that participants are incentivised to take part in a research project, this should be clearly stated within the research write up. The BERA guidance also advises that the use of incentives (in the first instance) may be problematic, as it could introduce elements of bias into the subsequent research.

Detriment Arising from Participation in Research

Researchers should be concerned with the wellbeing of research participants, both in advance of the planned research and during the research itself. Where there is the possibility of the participant suffering from some form of detriment (as a result of the research), the researcher should inform them (or their legal guardians) at the earliest opportunity. Echoing the basic tenet of research, that participants should be treated equally, the research process should not be seen to favour one participant (or group) to the detriment of another.

Privacy

Data collected during the research process, should be treated with confidentiality and stored securely in order to protect the privacy of the research participants. This process should also be in accordance with the data protection laws where the research takes place (i.e. within the UK or abroad)

Disclosure

A caveat to participant privacy applies to situations where the researcher (during the course of their research) detects 'behaviour', which may be illegal and/or puts the wellbeing of the participants at risk.

In this situation, the researcher may need to make a disclosure to the relevant authorities (i.e. the police, in cases of criminality) and, where appropriate, in consultation with the participant or their guardians.

The BERA guidelines advise that given the ethical difficulties associated with breaching participant confidentiality, researchers should document their decision-making process as evidence, in the event of any complaints or legal action arising from the decision to disclose.

4.2.3.2 Responsibilities to Research Sponsors

Researchers have ethical responsibilities to the sponsor of their research, but also need to ensure that the requirements of the sponsor do not compromise the integrity of the research and subsequent publication.

To this end, the BERA guidelines provide guidance on how researchers and sponsors should work together to ensure high standards of conduct, e.g. keeping the sponsor accurately and honestly informed about the purposes of the research. The guidelines also stress the importance of using valid and reliable methods as part of the research, and provide guidance on the publication of the results (e.g. maintaining publication integrity and the right of both parties to disassociate themselves from the final publication).

4.2.3.3 Responsibilities to Educational Researchers

Researchers should conduct their research to the highest possible standards and not engage in activities that would bring both their research and/or the research community into disrepute.

Such disreputable activities might include the falsifying or sensationalising of research findings, or undertaking research that gives rise to a conflict of interest, e.g. resulting in researchers making financial gains. Additionally, researchers have a duty to report any malpractice, or concerns of malpractice, through the appropriate channels.

Conducted research, and the subsequent findings, should be open to ‘reasonable external’ scrutiny (subject to confidentially or privacy agreements), to both the sponsor (of the research) and the research community as a whole. Where the research involves multiple researchers, the BERA guidelines state that the research/findings should be fairly attributed and include “*everyone who has made a substantive and identifiable contribution to their generation*” (BERA 2011, p.10).

4.2.3.4 Responsibilities to the Wider Audience

Related to their responsibilities to the research community, the BERA guidelines also provide guidance on researchers’ responsibilities to the wider audience, i.e. educational professionals, policy makers and the general public.

The guidelines advocate that researchers should endeavour to publish their results/findings to the wider community, subject to the previously discussed issues of confidentiality and participant privacy. Publication should be in a format that makes the research accessible, ideally using language that is “*clear, straightforward fashion and in language judged appropriate to the intended audience*” (BERA 2011, p.10).

4.2.4 Ethical Considerations (Thesis Specific)

This section describes the author's ethical approach to the thesis research, using the BERA guidelines (*4.2.3 Ethical Considerations (BERA Guidelines)*) as a template for best practice. Accordingly, this section discusses the author's ethical approach in the context of the four areas that comprise the BERA guidelines:

- Responsibilities to Research Participants
- Responsibilities to Research Sponsors
- Responsibilities to Educational Researchers
- Responsibilities to the Wider Audience

Responsibilities to Research Participants

As the author was intending to work with a primary school level sample group, this dictated the requirement to seek voluntary informed consent from the parents/guardians of the pupils attending both UK/KSA schools.

Informed consent was sought through the use of letters explaining the author's research, and the reasons for the voluntary participation of Key Stage 2 age pupils. Additionally, during the implementation of the piloting (Design/Prototyping) and the main study, the author re-explained the purposes of the research/pupil participation, in person, to the sample group.

As part of this process, the author sought and received ethical approval (from the University of Warwick) to conduct the pilots and the main study. As part of this approval, the author gave his commitment to ensure the wellbeing of the participants, including the undertaking that the pilots/study would be suspended in the event of any sample group members becoming distressed. Additionally, the author fully accepted that in this situation, the distressed sample member would be withdrawn from the pilot/study.

During the pilots/study, the author worked with the schools to ensure that his research fit within the school timetable, and therefore did not disrupt the normal flow of lessons, nor cause detriment to the sample group's overall education.

The author is aware of the ethically difficult area of offering incentives in order to encourage participation within research. However, at the beginning of the research process, the author took the view that the nature of the pilots/study (i.e. 'game playing') would in itself act as an incentive to encourage voluntary participation within the subsequent research. The author's experience during the pilots/study proved this view to be well founded.

As part of University of Warwick's ethical approval process, the author gave undertakings to protect the privacy and anonymity of the research participants. As a consequence, limited data was collected in relation to the (pilots/study) sample groups, and this was fully anonymised prior to inclusion within the thesis. Additionally, the original pilot/study data (i.e. the questionnaires) is being stored securely for the duration of the thesis research..

Responsibilities to Research Sponsors

The author was aware that the research sponsors (i.e. KSA/UK primary schools) would be 'facilitating' his research (for no financial benefit) and therefore the author was conscious of creating and maintaining good working relations with the sponsors. Equally, the author was also aware of the risks associated with sponsors exerting undue pressure on the research/publication process, but fortunately (in the case of the author's research) this has proven not to be an issue.

As part of the process of securing sponsorship, the author met with the Head Teachers of the primary schools, and discussed his preferred methodological approach (e.g. chosen research methods) and his requirements for the planned research/pilots (i.e. sample size, age etc.).

In terms of the research methods used, the author referred to the work of Cohen, Manion & Morrison (2008) and Dawson (2009) for guidance, in addition to seeking supervisorial advice.

Responsibilities to Educational Researchers

Throughout the process of the research, the author has acted with the upmost integrity. This commitment to integrity can be seen through the author's use of mechanisms designed to ensure a high standard of research conduct, such as the University of Warwick's ethical approval process and the application for a CRB check (as part of the process for working with primary school age children)

The thesis research, along with the author's research journey, has been clearly and reflectively (*9.7 Thesis Reflections*) documented within the thesis. The author is therefore confident that the research (and subsequent findings) will withstand 'reasonable external' scrutiny, as per the BERA guidelines.

Responsibilities to the Wider Audience

As part of his commitments to the wider research community, it is the author's intention to publish his research (with findings) in due course.

The BERA guidelines stress the importance of making research (and the related findings) accessible to the wider community in a style that is 'straightforward' to access for the intended audience.

The author would argue that two of the thesis strengths, lay within the comprehensive literature review (designed to present the subject in an accessible way, to a wider audience) and the author's style of academic writing. The author has approached the writing of the thesis with the intention that it will be read by both the target audience (anticipated to be GBL researchers), as well as the wider (more general) community, who have a shared interest in gaming and educational gaming.

4.3 Research Methods (Background)

Having discussed the thesis research methodology (*4.2 Research Methodology*), this section discusses some of the considerations that influenced the implementation of the author's chosen research methods (Sections 4.4 to 4.7):

- Sampling
- Questionnaire Design
- Observations

4.3.1 Sampling

As part of the thesis research, the author sought to utilise a sample group.

This was an area complicated by several factors, and the author relied primarily upon the guidance of his supervisors, supplemented by the work of Cohen, Manion & Morrison (2008) and Dawson (2009).

The selection of an appropriate sample group can be influenced by several factors, such as access to the participants, expense, research time scales, and the number of researchers available to conduct the research (Cohen, Manion & Morrison 2008, Dawson 2009). As a sole researcher, the approach to sampling was complicated by the author's geographical work location for the majority of the thesis research, that being the Kingdom of Saudi Arabia (KSA). Unforeseen job redundancy also resulted in part of the sampling process taking place back within the United Kingdom (UK).

The author sought guidance from his supervisors on the selection of a sample group, and subsequently the author was advised to draw a sample (of approximately 30 respondents) from a primary school level (Key Stage 2, 8-10 years old). Additionally, it was suggested that the area of Key Stage 2 mathematics might be considered as the design basis for educational computer games, which the author was interested in developing as part of the thesis research.

Upon reflection, the author felt that it was wise to adopt this advice, due to a number of factors:

The author was mindful of Dawson's (2009) advice that a researcher should not select a sample group based on convenience ('convenience samples'), however a number of factors did constrain and influence the author's selection of appropriate sample groups.

Initially, the author had intended to draw a sample group from Royal Saudi Air Force cadets, whom the author was teaching at the time. However, the constraints of the military environment made an appropriate level of access difficult to obtain. Additionally, had the sample group been drawn from within the air force, the subject matter of any educational games (developed by the author) would have needed to have been based on military aviation due to the politics of the author's military environment.

Conducting primary school level sampling (whilst working within Saudi Arabia) also presented a number of challenges. Saudi Arabia is considered to be a conservative country (Lacey 1982, Lacey 2009, FCO 2014) and this equally applies to the schooling system. Access to appropriate sample groups can be difficult and there is the inevitable (but understandable) language barrier when dealing with pupils of the recommended age range. However, Saudi Arabia does have a large expatriate workforce and this has led to the development of a small number of 'international' schools designed to support the education of expatriate children. These schools are less constrained in terms of access, have ICT resources on par with Western schools and the language barrier is less of an issue. It was for these reasons that a local (British) international school was ultimately approached for the purposes of sampling.

Having secured the co-operation of the international school, it transpired that the Head of School was enthusiastic about utilising educational computer games based on double-digital multiplication. Given the previous supervision advice, and wanting to maintain the co-operation of the school, the author took the decision to base his educational game development on Key Stage 2 maths, and specifically the area of double-digit multiplication.

The Questionnaire Based Survey (*4.4 Questionnaire Based Survey*) and Design Pilot (*4.5 Game Review / Design Pilot*) stages of sampling took place within Saudi Arabia. However, subsequent sampling for the Prototyping Pilot and Main Study (*4.7 Prototyping Pilot / Main Study*) took place within the United Kingdom, the author's new geographical work location after his unforeseen job redundancy. By this stage, the author felt it wise to continue the chosen approach to sampling, and subsequent samples were drawn from a UK primary school, and the subject matter of the author's educational game development remained the same (double-digit maths).

The author was reminded of Cohen, Manion & Morrison (2008) and Dawson's (2009) advice, that a researcher should be realistic when determining the size of a sample group, and that factors, such as a financial budget and the research timescale, should also be considered. Therefore, upon reflection, the author followed the advice of his supervisors, and subsequently selected manageable sample groups (within KSA and the UK) consisting of approximately 30 primary school pupils.

4.3.2 Questionnaire Design

As part of his methodology, the author devised questionnaires for use within the Questionnaire Based Survey, subsequent piloting (Design/Prototyping) and the Main Study stages of the thesis research.

Initial drafts of the questionnaires were devised following the design principles of Cohen, Manion & Morrison (2008), Dawson (2009) and Cozby & Bates (2007), and then subsequently refined based on advice from the author's supervisors and teachers at the primary schools located within both KSA and the UK. Additionally, the experience gained through the Questionnaire Based Survey (KSA), subsequently shaped the design of the questionnaires used within the subsequent piloting and the Main Study. All of the questionnaires were semi-structured, as this offered the most flexibility in the types of questions that could be asked.

Due to the nature of the Questionnaire Based Survey, the majority of the questions were open-ended, allowing the respondents the opportunity to express their views on computer games (*Appendix A*). As will be discussed within Chapter 5 (*5.2.5 Questionnaire Based Survey Conclusions*), the author was disappointed with the questionnaire returns from the Survey, and specifically with the variable quality of feedback from the open-ended questions. With hindsight, this reflects Cohen, Manion & Morrison's view that the use of open-ended questions can lead to "*irrelevant and redundant information*" and that "*responses are difficult to code and to classify*" (Cohen, Manion & Morrison (2008), p.322).

As a consequence of this experience, the questionnaire designed for the Design Pilot utilised closed questions (Likert scales) which focused on the grading of a selection of educational games. However, as the author wanted to elicit any additional feedback (beyond the Likert scales), each closed question was accompanied by a 'comments box', which members of the sample group could use to provide written feedback. It was the author's intention to analyse the responses to the closed questions, while regarding any additional written feedback (through the 'comment boxes') as supplementary information, which might complement the observational data.

Similarly, the questionnaires for the Prototyping Pilot and Main Study (*Appendix E*) utilised closed questions (with optional 'comment boxes') and featured a limited number of open-ended questions in order to elicit feedback in relation to the author's developed games. As with the Design Pilot, the author intended to analyse the responses to the closed questions, while utilising any written feedback (along with observational data) in the prototyping of the author's developed games.

4.3.3 Observations

In addition to the use of questionnaires, the author was present in an observational role at the Design Pilot, Protoyping Pilot and during the Main Study. Relying on the guidance of Cohen, Manion & Morrison (2008) and Dawson (2009), the author approached the observational aspects of the pilots with the following in mind:

As the author was initially unclear as to what to expect during the Design Pilot, he chose to conduct an ‘unstructured observation’, where an environment is initially observed, notes taken and then the significance of the observational data is determined at a later date.
Later observations (during the Prototyping Pilot and Main Study) broadly adopted the same approach, but were influenced by the experience gained during the Design Pilot. This experience focused the author on maintaining sample group commonality between the pilots/study (i.e. drawing samples from the same key stage/age range) and guided the author towards areas of observational interest during the Main Study (primarily relating to the research questions).

Prior to the observations, the author was aware of the ‘Hawthorne Effect’, or what Cohen, Manion & Morrison (2008) refer to as ‘reactivity’ to the presence of an observer and any recording apparatus during an observation. Mindful of this, the author attempted to adopt a non-interventionist approach during the observations. However, given the technical nature of the Main Study, the author did intervene (on occasion) in order to resolve unexpected technical problems that arose (such as a netbook computer requiring an alternative power source due to low battery power).

Again, mindful of the ‘Hawthorne Effect’, the author chose not to formally record (e.g. video record) the pilot/study sessions, due to not wanting to unduly influence the behaviour of the sample group during the observations. As a consequence of this decision, the author relied upon writing quick notes in situ, and then subsequently writing expanded notes (based on the author’s mental recall) immediately after the observation.

The author was aware that this use of 'Ad Libitum' sampling (Altmann 1974) was not without issue, given the criticisms that it is an 'unsystematic approach' to observation (Altmann 1974), is reliant on memory recall (Mack *et al*. 2005), prone to observer bias (Mann 1999), and runs the risk of 'attention deficit' (Cohen, Manion & Morrison 2008) – where the observer potentially misses an 'event' due to being distracted – such as in the author's case, whilst resolving a technical problem.

However, given his dual roles of observer and technical troubleshooter, the author was of the view that the 'Ad Libitum' approach was more practical than comprehensive note taking (in situ), especially when considering Dawson's (2009) acknowledgement (in reference to observations), that "*in many situations it is not possible to take notes at the time.*" (Dawson's 2009, p.109).

4.4 Questionnaire Based Survey

The first stage of the author's methodology was the implementation of a Questionnaire Based Survey. The survey involved the distribution and completion of three different questionnaires (*Appendix A*) relating to computer games and Games Based Learning. The intention of the Survey was to elicit the views on these topics from parents, teachers and school pupils of the international school.

A detailed commentary on the Questionnaire Based Survey, along with the survey's findings, will be discussed within Chapter 5.

4.5 Game Review / Design Pilot

4.5.1 Game Review

Having reviewed the literature on Games Based Learning, the author was aware of four approaches to educational game design:

1. Designing games using a generic instructional design methodology, such as ADDIE.
2. Designing games using ‘classic’ computer game design principles and then blending educational content into the games retrospectively.
3. Designing games by basing them on a recognised learning theory (e.g. Multiple Intelligences).
4. Designing games based on, or influenced by, the work of Malone & Lepper (i.e. Challenge, Control, Curiosity, Fantasy).

Based on these different approaches to games design, which design approach should be used for the purposes of this thesis? The author distinguishes between the first approach (i.e. ADDIE) and the remaining approaches by considering instructional design as a generic design methodology. Instructional design is concerned with the wider picture – i.e. the environment within which the games will be used, the profile of the learners – the author would suggest that this design methodology is complementary to the actual design process for educational computer games.

As a consequence, the author felt that it would be appropriate to use an instructional design methodology in addition to a more specific (educational) game design approach, as part of addressing the thesis research questions.

In terms of specific games design, there are three approaches that can be taken:

- Games design based on established learning theory.
- Games design based on ‘classic’ games design principles.
- Games design based on ‘educational’ games design principles (Malone & Lepper).

During the literature review, the author experienced difficulty sourcing practical examples of learning theory based games design (*3.8 Educational Games Design*) on which to base the thesis games. In contrast, the author was able to source numerous journal articles on the remaining approaches to games design. Based on the findings of the literature review, and the author's limited confidence in his ability to design learning theory based games, the author decided to discount this design approach. Discounting the learning theory approach leaves the author with the two remaining approaches, both of which are based on incorporating a set of 'principles' into the games design process.

For the author, this is where the discussion on games design becomes interesting. A considerable amount of the literature on educational games design can be attributed directly and indirectly to the seminal work of Malone & Lepper (1987). In their research, Malone & Lepper studied the motivational properties of computer games, arguing that they can be used to motivate learners, and therefore enhance the learning process. The games used within their research (including 'BreakOut' and 'Star Wars'), were not explicitly designed to enhance learning, but rather to motivate for purely entertainment purposes.

It could be suggested that these 'classic' game design principles have influenced the work of Malone & Lepper, who in turn have influenced the development of educational game design. From this point of view, the author argues that both 'classic' and 'educational' game design principles could be considered one and the same. A review of the literature within this area confirms this view by revealing a high degree of commonality between both sets of design principles, i.e. both sets commonly share the motivational properties of *Control*, *Curiosity* (exploration), *Fantasy* (narrative) and *Challenge* (i.e. through game mechanics).

The author therefore decided to base the design of the thesis games on these principles, using the literature as guidance and primarily referring to the work of Habgood & Overmars (2006), for reasons which will be discussed later within this chapter. Complementing the literature on educational game design 'best practice', the author sought to conduct a review of the current market for educational games, as a pre-amble to a formal design process. For reasons of practicality, the following considerations were taken into account prior to undertaking the review.

4.5.2 Game Review Considerations

It is the author's view that a number of educational games, although commercially produced, are not as commercially available to the consumer as is the case with traditional (i.e. non-educational) games. 'Commercially available' in this context is defined as meaning that the educational games are not generally available in the same manner as the latest mainstream gaming blockbusters. By their very nature it is unlikely that you will be able to purchase specialist titles such as 'Virtual U' (higher-education management simulation) or 'Dimension M' (Maths/Algebra) alongside the latest edition of 'Call of Duty', during the weekend shop at the local supermarket (Wilson *et al*. 2009, Moreno-Ger *et al*. 2008, Harteveld *et al*. 2007, Panoutsopoulos, Sampson & Mikropoulos 2014, Klopfer & Osterweil 2013, Foster 2012, Burgos, Tattersall & Koper 2007).

The author contends, therefore, that most learners' access to educational games will be through the limited range of boxed (commercial) titles stocked at the larger consumer electronics stores, or more commonly, through availability on the Internet. Furthermore, in the currently austere economic climate, parents (and perhaps learners themselves) may have a preference for low-cost or 'free' educational games, rather than the more expensive (but professionally produced) games. Based on these considerations, the author sought out educational games for the game review based on the following criteria:

4.5.2.1 Content

As per supervisorial advice, the author sought out games that contained maths content aimed at pupils within Key Stage 2 or equivalent (8 – 10 years old). After advice from the international school, the author refined the review to concentrate on games specifically promoting single and double digit multiplication – as this was an area that both the Head of School and the school's ICT Co-ordinator viewed as providing the most challenge to the target/sample group of pupils.

4.5.2.2 Commercial Availability

The author had intended to source educational software, from both retail stores and through the Internet, as per the reasons stated previously. However, due to the author's geographic location (KSA), finding appropriate boxed retail educational games proved to be difficult.

The main source of (legal) consumer software in Riyadh is 'Jarir Bookstore' (the equivalent of stationery retailers 'Staples' or 'W.H. Smiths' in the UK). Understandably (given the geographic location), the majority of educational software available within Jarir's was developed in Arabic and aimed at native speaking learners, thus posing a language barrier for the author. Additionally, this software was predominately pitched at teaching 'English as a Second Language' (ESL), rather than mathematics. Where the author was able to locate appropriate educational software, typically the software was not a 'game' or the retail box was missing either the actual software or the user instructions, or in some cases, both.

It was while reflecting on the difficulties of sourcing appropriate software locally, that the author considered the alternative purchase of software from online UK-based retailers. However this too was to prove problematic due to many retailers refusing to sell their software products outside of the European zone.

4.5.3 Final Software Selection

Due to the documented difficulties in accessing commercially available educational software (boxed and electronic download), the author took the decision to base the game review on educational games freely available (and downloadable) from the Internet. While this decision potentially restricted the possible range and quality of the available games, it was considered to be the most practical solution.

All of the educational games that were sourced, were small in size (in terms of megabytes), required a low computer specification in order to be successfully played, and were (in theory) straight forward to install on the international school's computer network. This last aspect was considered important, as the author was concerned about potential technical problems (caused by network security settings) occurring whilst installing the games onto the school's network as part of the eventual Design Pilot.

The games were sourced from specialist (educational) software company websites (e.g. Primary Resources), independent websites (typically created/maintained by teachers or primary schools) and from dedicated education websites (that offered games as part of freely available teaching material).

The Game Review will be discussed in greater detail within Chapter 5.

4.5.4 Design Pilot

During the game review, the author detected certain recurring characteristics within the sourced educational games. These characteristics included the 'style' of the games (such as question & answer or maze games) and the approaches taken in terms of mixing (or 'blending') the educational content with the game's 'game play' or 'mechanics'. For the author, the most pertinent questions were how would these characteristics inform the games design process and which approach to 'blending' education would be the most effective (in terms of maintaining the balance between fun and learning)?

Whether designing a computer game based on ‘principles’ or a recognised learning theory, it is generally acknowledged that for an educational game to be successful, it needs to blend ‘fun’ and education in such a way that one element does not overpower the other (i.e. more ‘fun’ than educational or more educational than ‘fun’). Some researchers argue that an educational game should be designed educationally first, with ‘fun’ retrofitted afterwards, whereas other researchers argue the opposite. However, there is agreement that managing the balance between the amount of education and ‘fun’ is a challenging task (Moreno-Ger *et al*. 2008, del Blanco *et al.* 2012, Clyde & Thomas 2008, Martinez 2006, Chee 2007, Blanchfield 2009, Tan 2010, Che Pee 2011, Royle 2009, Kickmeier-Rust, Hillemann & Albert 2011) and can result in educational games suffering from ‘Shavian Reversal’ where the game is either ‘fun’ (but not very educational) or educational (but not ‘fun’) or in some cases, fails to be either (Papert 1998, Van Eck 2006, Cross 2009, Kickmeier-Rust 2012).

In an attempt to address these issues, the author embarked upon an informal Design Pilot. The purpose of the Design Pilot was to elicit feedback from a sample group (consisting of the previously identified Key Stage 2 pupils) on what constituted educational game design ‘best practice’. The intention was to take the subsequent feedback and incorporate it into the designs for the author’s educational games. The Design Pilot took place in one of the international school’s ICT rooms, as part of the sample group’s weekly (1 hour) ‘ICT Club Class’.

The room in question consisted of a suite of standard PC’s, which shared the following features:

- A 19 inch LCD monitor.
- Internal Sound Speakers (although headphones were provided in order to allow pupils to discreetly listen to any output audio).
- Windows XP Operating System.
- Connected to the Internet via the school network.

At the front of the room, was a similar specified PC for dedicated teacher use, which in turn was connected to an interactive whiteboard. While the room did not feature any window panes, it was brightly lit through florescent lighting and the temperature was maintained through air conditioning.

A selection of games, identified during the game review, were installed (on the author's behalf) on the school's internal computer network. Where selected games were based on Adobe Flash technology (i.e. embedded within a web page), the internet web addresses were provided so that the sample group could access the games 'live' over the internet. In addition to the games themselves, a questionnaire ('Game Style Grading Sheet') was devised for the sample group to complete during the Design Pilot. For the questionnaire, the author followed the design guidance of Cohen, Manion & Morrison (2008) / Cozby & Bates (2007) for the initial drafts, and then subsequently refined the questionnaires based on supervisorial advice and advice from the school's ICT Co-ordinator.

On the day of the Design Pilot/ICT Club Class, the sample group (13 pupils, Key Stage 2, ages 7 to 10), were given a brief introduction to the topic by the ICT Club Class Teacher ('to play some games and provide some feedback'), before being shown the location of the games on the school computer network. The author also addressed the class and asked if (during the subsequent game playing) the pupils had any opinions about the games, could they write them on the provided 'Game Style Grading Sheet', which in turn would aid the author in creating his own maths games. The author and the ICT Club Class Teacher then proceeded to hand out the 'Game Style Grading Sheet's.

Feedback on the games was derived through two mechanisms:

- Observation by the author and the ICT Club Class Teacher (during the 1 hour class), and
- The simple questionnaire/grading sheet ('Game Style Grading Sheet') which members of the sample group could use in order to grade the games and make any comments.

It should be noted (in a positive way) that during the observation, the sample group seemed to be so engrossed in exploring and playing the games that they frequently forgot to write on their questionnaires/grading sheets. In some instances this prompted both the author and the ICT Club Class Teacher to verbally elicit individual sample group member's opinions on the games, and then write their grading on the questionnaire/grading sheet for them. This level of engagement, while positive, resulted in a lower questionnaire return rate than had been hoped for, but it is the author's opinion that the quality of the sample group observations compensated for this shortfall.

Another constraint (cited previously within the literature) was the length of the ICT Club Class. Unfortunately, due to the 1 hour time constraint, the sample group were unable to play all of the games made available to them (during the class time) and this is also reflected within the questionnaire results, as will be discussed within Chapter 6 (*6.2.3 'Unpopular' / Un-played Games*).

On the technical side, some of the installed games would not load correctly on the international school's computer network, and therefore the sample group were unable to play these specific games. It was suggested to the author that this failure (to load the games) may have been caused by the school's computer network security settings, but at the time of the observation it was not possible to resolve this issue.

The Design Pilot (along with the results of the observations and questionnaires) is discussed in greater detail within Chapter 6.

4.6 Game Design / Development

In terms of games design, the author decided upon a dual design approach for the design of the author's educational games. The first design approach involved the use of the ADDIE methodology to create a higher level overview for each educational game (*Appendix B / Appendix C*). This was found to be beneficial as it allowed the author to specify the general foundation and background for each game, including:

- Narrative / Characterisation.
- Scoring System.
- Implementation of the educational content (single / double digit maths)
- Character control mechanisms (Arrow Keys, plus Space Bar).
- Level Design.

The second design approach was guided by the work of Habgood & Overmars (2006) and the feedback from the Design Pilot. The feedback from the Design Pilot (6.3 *Design Pilot Conclusions*), in turn, influenced the decision to base some of the game designs on pre-existing 'classic' games i.e. 'Pac-Man' and '1942'. The decision to follow the work of Habgood & Overmars (2006) was made for two reasons:

- Firstly, Habgood & Overmars advocate the design of computer games through the incorporation of 'games design principles' i.e. *Control*, *Curiosity* (exploration), *Fantasy* (narrative) and *Challenge* (through game mechanics). As discussed previously (*4.4.1 Game Review*), this is the author's preferred approach to games design.

- Secondly, Habgood & Overmars's work is closely tied to the games development package 'GameMaker', which is the author's chosen development tool (for the reasons discussed in the next paragraph).

The author, while having some software development experience, is by his own admission not a games designer/developer. It was felt to be unwise to attempt game development using a 3D game engine, given the high level of skill and technical knowledge that is generally required for game engine programming. The author would regard himself (at most) as a novice games designer, and in light of this, a review was conducted into the games development packages currently available on the consumer market. These packages are typically aimed at the novice games developer, and were felt to be better suited to the author's game development needs.

For inclusion within the review (Table 4.2), the development packages were required to meet certain criteria:

- The packages should be (relatively) consumer orientated and therefore relatively accessible to non-game developers (such as the author).
- Should be relatively up to date, in terms of the operating systems required and the type of graphics technology supported.
- Will ideally have a reasonable level of support from both the product developer and the Internet/user community.

While there is limited academic literature within this area, the product 'GameMaker' was eventually chosen as the development tool of choice. The software has an academic background (having originally been developed to teach computer programming to PhD students) and has had several dedicated books and journal articles published in relation to it. Finally, 'GameMaker' is the development package utilised by Habgood & Overmars – the author's chosen guidance for games design.

	Blitz3D	Torque *1	FPS Creator	DarkBasic	GameMaker
Skill Level	Medium	Pro	Beginner	Medium	Beginner, Medium
Game Style Supported	2D / 3D, Role Playing, Shooter, Adventure	2D / 3D, Shooter, Maze, Adventure	Shooter	2D / 3D, Shooter, Maze	2D, 3D, Sport, Shooter, Maze
Plug-ins *2	Y	N	Y	Y	Y
Network *3	Y	Y	Y	Y	Y
Scripting / GUI *4	Scripting	Scripting	GUI, Scripting	Scripting	GUI, Scripting

*1 Refers to both Torque Game Builder and Torque Game Engine (Torque 3D/2D)
*2 Support for extensions/'plug-ins' that extend the capabilities of the developed games (**Y**/**N**)
*3 Support for networked multiplayer games (local network/Internet) (**Y**/**N**)
*4 How are the games created? **GUI** ('Drag and Drop') or **Scripting** (Game Programming Language)

Table 4.2: Game Development Software Comparison Matrix

4.6.1 Implementation / Development

The development of the author's educational games was not without issue.

Initially, designs for six educational games were produced (Table 4.3), which in turn were influenced by pre-existing 'classic' or 'retro' games. The reasoning behind this influence was based partly on the feedback received through the Design Pilot (*6.3 Design Pilot Conclusions*), and on the acknowledgement that these 'classic' games utilise what is now considered to be games design 'best practice' (i.e. they contain the design principles of *Control*, *Curiosity*, *Fantasy* and *Challenge*.)

Game Designs
194X (*Appendix C*)
Gauntlet (Later Pyramid Panic) (*Appendix C*)
BombJack
Pac-Man
BoulderDash
Choplifter

Table 4.3: Initial Game Designs

It was during this period that the author experienced job redundancy, which resulted in the game development process being halted for a period of several months until the author had secured employment and relocated back to the UK. After a period of reflection, it was decided that the original six game designs would be scaled back, and ultimately only four of the designs would be actually implemented. This decision was taken for two reasons:

- Upon reflection, the designs for both 'BoulderDash' and 'Choplifter' were felt to be too ambitious to implement, in part due to the author's limited games design skills and experience.

- The author had fallen behind schedule (due to the disruption associated with job redundancy), and it was felt that by reducing the number of implementable games, it would allow the author to return back to schedule.

As a consequence, development resumed within the UK, resulting in the implementation of the following games.

- BombJack.
- Gauntlet.
- Pac-Man.
- 194X.

Disruptions notwithstanding, the software development process was reasonably issue free, with a few exceptions:

While having software development experience, the author still experienced a ‘learning curve’ in order to become proficient in the ‘GameMaker’ software’s internal programming language, ‘Game Maker Language’ (GML). While generically similar to other computer programming languages, GML did feature a number of ‘quirks’ that the author needed to seek advice on. Fortunately, YoYo Games (the developer of the ‘GameMaker’ software) provide community forums, and through these, the author was able to address these initial ‘quirks’.

Sourcing the appropriate multimedia materials for use with the individual games (i.e. images and sound files) proved to be challenging. As the author has limited multimedia design and editing skills, the majority of (pre-produced) material was sourced through the Internet, with variable results in terms of quality.

With ‘194X’, it was realised early on that the planned multiple levels would add considerably to the overall game development time. The levels themselves were relatively straight forward to implement, but it soon became apparent that to develop and implement the more challenging game mechanics (on the higher levels) was going to take more development time than the author had anticipated. For the same reasons that led to the dropping of the ‘BoulderDash’ and ‘Choplifter’ designs, the author took the decision to scale back ‘194X’ and ultimately only one (continuously scrolling) game level was actually implemented.

The development of the game ‘Gauntlet’ proved to be particularly challenging. With the benefit of hindsight, the original ADDIE design was overly ambitious and subsequently had to be simplified in order to make the game more manageable to implement. The author also attempted to implement the game with pseudo 3D graphic effects (Figure 4.1), as per the original (Atari) ‘Gauntlet’ game. Unfortunately, due to the author’s limited ‘GameMaker’ experience, this ‘3D’ approach led to *imprecise* collision detection, resulting in inconsistent and error prone game play.

‘Collision Detection’ allows a game developer to determine if a player’s character has ‘collided’ with another object, such as walls, collectable items or enemy characters (Habgood & Overmars 2006). Based on the type of collision, the developer can then program how the player’s character reacts to that collision, e.g. bounce off the wall, increase the score for collecting the collectable item or lose a life due to collision with the enemy. For collision detection to work successfully, it needs to be *precise*, otherwise *imprecise* detection can result in inconsistent behaviour – the player becomes stuck to the wall, the collectible item becomes uncollectable, and the player can lose a life by merely being ‘near’ to the enemy, rather than actually colliding with them.

Eventually, the decision was taken to abandon the development of ‘Gauntlet’ (Figure 4.1), and instead implement a simpler ‘maze’ style game based on Habgood & Overmars’s (2006) ‘Pyramid Panic’ (Figure 4.2).

Figure 4.1: Early Prototype of ‘Gauntlet’

Figure 4.2: Educational version of ‘Pyramid Panic’

4.7 Prototyping Pilot / Main Study

The final stages of the author's methodology were implemented in the form of a Prototyping Pilot and a subsequent Main Study. The Prototyping Pilot was designed to trial the author's implemented games (for subsequent use within the Main Study), while the Main Study was designed to collect data as part of addressing Research Questions 1 to 3. Both pilot and study consisted of a series of classroom based 'game playing' sessions, with data collection through the use of questionnaires and observation.

4.7.1 Selecting a Primary School

The process of piloting the completed educational games was beset with initial problems. Due to job redundancy, the author was now re-located back in the UK, which resulted in a new (UK) primary school being sought for the piloting and the Main Study. The author felt that it was wise to select a new primary school based partly on location (accessible from the author's new work location), and partly on the school's perceived level of I.T. support (due to the technical nature of the pilots).

To this end, the author consulted the Department for Education's website, which held workforce data for schools located within the UK (DfE 2010). At the time of writing, this workforce data included the staffing levels for each school, including the number of I.T. Technicians currently employed. It was the author's contention that schools employing full-time dedicated I.T. Technicians would be in a better position to offer a level of technical support typically required for Games Based Learning studies. Based on the collation of this workforce data, a shortlist was compiled containing 6 primary schools identified as employing a full-time technician. After a formal approach, the second school (listed on the shortlist) welcomed the opportunity to participate in the author's pilots.

4.7.2 Pilot / Main Study Game Selection

Prior to the start of the Prototyping Pilot and the subsequent Main Study, the author undertook an additional period of reflection, aided by the feedback derived from a pilot conducted by the author's supervisors. In light of this reflection and supervisorial feedback, the author reappraised the educational implementation of both 'Pac-Man' and 'Bombjack' games (Figure 4.3 and 4.4).

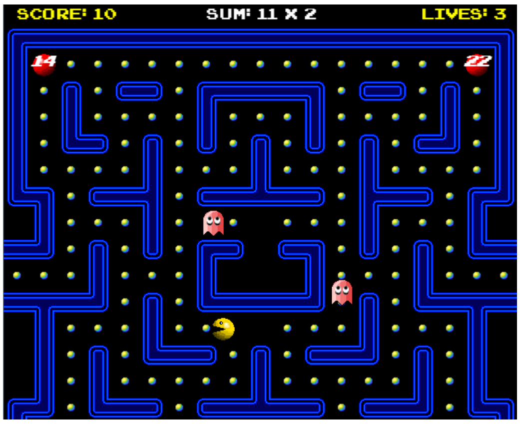


Figure 4.3: Final version of 'Pac-Man'

Figure 4.4: Final version of 'BombJack'

With the benefit of hindsight, both games could be considered too 'game heavy', with the educational content (Key Stage 2 Maths) overwhelmed by the gaming content. Due to the nature of their game designs, it became apparent that players/learners could play both games while completely avoiding interaction with the educational content. This was due in part to the educational objectives being physically avoidable (in the first instance), and their third place behind the primary objectives of 'collecting items' while avoiding 'enemies'. Ironically, this situation might be regarded as a classic example of 'Shavian Reversal' where educational games have failed to incorporate 'fun' and education in balanced proportions.

As a consequence, the decision was made to remove both games from the planned Prototyping Pilot. After taking supervisorial advice, a further decision was also taken to substitute the games (for use within the Main Study) with three (smaller) games that had been originally sourced for the Game Review (*4.4.1 Game Review*) and had received positive feedback during the Design Pilot. Therefore, the Main Study utilised the following educational games:

- Gauntlet (redeveloped by the author as ‘Pyramid Panic’).
- 194X (developed by the author).
- Moon Maths (From the Game Review).
- Math Balls (From the Game Review).
- Math Magic (From the Game Review).

4.7.3 Prototyping Pilot / Main Study

At a local primary school, the author conducted a series of ‘game playing’ sessions. The initial sessions formed the basis of a ‘Prototyping Pilot’, designed to trial the author’s educational games (for subsequent use within the Main Study), while the Main Study was designed to address thesis Research Questions 1 to 3, supported by the literature review (Chapters 2 & 3). For the purposes of consistency, the same sample group was used throughout the Prototyping Pilot and the subsequent Main Study.

Feedback was obtained through both observation of the sample group (i.e. physical reactions, verbal comments) and their written feedback via questionnaire. The concept of prototyping is discussed within Chapter 3 (*3.5.1 User Centred Design*), while the Prototyping Pilot and Main Study (along with the specific feedback received) will be discussed within Chapter 7 (*7.4 Prototyping Pilot / Main Study Background*).

Both pilot/study sessions were conducted in the same school classroom, which was well heated (due to the colder weather at that time) and was well lit through natural and (when appropriate) artificial lighting. The I.T. provision will be discussed shortly (*4.7.4 Technical / ICT Usage Issues*), but in general consisted of a small number of desktop computers which were supplemented by a greater number of 'netbook' computers. The sessions were conducted by the class teacher, with the author assuming an observational role, with the exception of occasionally assisting the class teacher to troubleshoot any unexpected technical problems.

4.7.4 Technical / ICT Usage Issues

Prior to the start of the Prototyping Pilot, the author visited the primary school in order to review their I.T. facilities. In terms of I.T. provision, each school classroom featured a small number of physically connected desktop computers (including one connected to an interactive whiteboard) and was supported by the availability of 'netbook' computers (designed for mobile use, and therefore not dedicated to any specific classroom). While the desktop computers used physical network connections, the netbooks relied upon the school's wireless network.

The author had anticipated technical issues with the implementation of the Prototyping Pilot (and the subsequent Main Study), and the decision to select a school with full time I.T. support would prove to be a prudent one. During the pilot/study sessions, a number of technical and usage issues were encountered. Technical issues related to the use of the school's netbook computers (as a basis for game playing), and their reliance on the wireless network for network connectivity. In contrast, usage issues pertained to the (ICT) classroom preparation required as part of each pilot/study session.

Both these issues will be discussed in greater detail within Chapter 7 (7*.4.2 Technical Issues (General)* / 7*.4.3 ICT Usage Issues*).

4.8 Conclusion

Within this chapter the author discusses the methodological approach that was followed in order to address the thesis research questions.

The author adopted a pragmatist philosophical position, and decided on the use of both qualitative and quantitative research methodologies, as the author felt that this was most appropriate for the needs of his research. In terms of ethical considerations, the author discusses how the thesis research adheres to the BERA guidelines for educational research.

After discussing the considerations that influenced the implementation of the chosen research methods, the implementation of the methods themselves form the basis of discussion for the remainder of this chapter:

Questionnaire Based Survey

Due to geographical location, the survey was conducted at an international school in Saudi Arabia, and elicited the views (on computer games and Games Based Learning) from pupils, parents and teachers, the results of which will be discussed within the next chapter (*Chapter 5*).

Game Review / Design Pilot

As part of the author's research into educational game design 'best practice', the author conducted both a Game Review and a Design Pilot. The selection of games (featured within the Game Review) was drawn from publically available resources and consisted predominately of open source or 'free' software. The author conducted a Design Pilot (with a sample group) in order to elicit feedback on the Game Review games, which in turn would aid the design/development of the author's educational games. The Game Review will be discussed within the next chapter (*Chapter 5*), while the Design Pilot will be discussed within Chapter 6.

Game Design / Development

Utilising both ‘classic’ game design principles and the ADDIE instructional design methodology, six educational game designs were initially produced by the author. Due to a combination of over ambitious design and unforeseen disruption (caused through job redundancy), the author reduced both the number and scale of the original game designs. The process of actually implementing the final game designs was not without issue. The author’s relative lack of experience with the ‘GameMaker’ software, the reliance on pre-produced multimedia material and over ambitious implementation resulted in a challenging development process.

Prototyping Pilot / Main Study

Finally, the chapter on methodology concludes with a discussion on the series of ‘game playing’ sessions (Prototyping Pilot and a Main Study), which were conducted at a local primary school within the UK (the author’s new geographical location).

The Prototyping Pilot’ was designed to trial the author’s educational games (for subsequent use within the Main Study), while the Main Study was designed to address thesis Research Questions 1 to 3, supported by the literature review (Chapters 2 & 3). Feedback was obtained through the use of observation and questionnaires.

The initial stages of the author’s implemented methodology will be discussed within Chapter 5 (Questionnaire Based Survey) and Chapter 6 (Design Pilot).

Chapter 5: Questionnaire Based Survey / Game Review

5.1 Introduction

As briefly discussed within Chapter 4, this chapter is concerned with discussing the initial stages of the author's methodological approach to addressing the thesis research questions. The author conducted a Questionnaire Based Survey, Game Review and a Design Pilot (Chapter 6), the primarily purposes of which were to obtain feedback (from a sample group) on educational game design 'best practice', which in turn would feed back into the design of the author's own educational games.

The Questionnaire Based Survey consisted of three questionnaires designed to elicit the views (on Games Based Learning) of pupils/parents and teachers at an international school, based in Riyadh, Saudi Arabia (the author's geographical location at the time). In preparation for the Design Pilot (Chapter 6), the author also conducted a Game Review of the current market for mathematical games aimed at Key Stage 2 (or equivalent) learners.

5.2 Questionnaire Based Survey

For the Questionnaire Based Survey, a set of questionnaires (*Appendix A*) were devised to elicit information on Games Based Learning. It was hoped that the data collected from the questionnaires would feed into the design/development of more relevant (in terms of the sample group) educational games for use at the international school.

The set consisted of three questionnaires, aimed respectively at Teachers, Parents and Pupils. All the questionnaires were semi-structured, as this offered the most flexibility in the types of questions that could be asked. Additionally, the majority of the questions were open-ended allowing the respondents the opportunity to express their views on computer games.

The Teacher Questionnaire was distributed by the school, amongst the teaching staff, and subsequently collected and returned to the author by school's ICT Co-ordinator. The Parent Questionnaire was distributed to parents (along with an informed consent letter) by the school, and only those questionnaires that were returned with a (positively) completed consent letter were passed onto the author, again by the school's ICT Co-ordinator.
Due to work-related constraints, the author was unable administer the Pupil Questionnaire in person, and as a consequence the questionnaire was administered within the school by two members of staff (in the author's absence).

5.2.1 Sample Groups

For the purposes of the survey, the questionnaires were distributed to:

- 10 (international school) Teachers, and
- 37 Parents / Pupils (matched pairs)

Given that the questionnaires were distributed during a particularly short school term (between the religious breaks of Ramadan and Hajji) the overall return rate was reasonable, with more than half of the Parents' Questionnaires and consent forms being returned. The return rate for the Teachers' Questionnaires was disappointing, but given the shortness of the school term (and the general workload of the school teachers), the low returns were understandable, if slightly disappointing. In the end, the final sample groups consisted of the following:

- 3 Teachers
- 18 Parents
- 21 Pupils

5.2.2 Teacher Questionnaire

The teachers questionnaire sought to establish the current usage (if any) of computer games within the international school's curriculum and the teachers' views on these games (positives/negatives and what constitutes a 'good' game). The results of the data collected, are summarised as follows:

- Two out of three Teachers played games (for leisure).
- All three respondents felt that there was educational benefit in using computer games within education, although preferably ones related to the curriculum (such as Maths or History).
- One respondent felt that even (non-educational) leisure games could be used within school to either familiarise pupils with ICT or to promote logical thinking (through playing adventure games).
- Reassuringly, the respondents' views on what constitutes a good educational game reflected the game design principles discussed within Chapter 3.

  Ideally, the respondents felt, a good educational game should:

  - Allow the pupils to practice (a given task).
  - Be fun and engaging with a degree of interaction.
  - Try to incorporate differentiation into the game.
  - Feature eye-catching / pleasing graphics.
  - Be appropriate for the age group (presumed to mean the educational level / Key Stage).
  - Have clear goals / objectives, preferably linked in with the English National Curriculum (ENC).
- In terms of positives / negatives, two of the respondents felt that computer games have a positive effect on pupils, generating motivation / enthusiasm and potentially making less palatable subjects more appealing. It was also suggested that games can increase a pupil's confidence.
- On the negative side, there was a feeling that games do not always reflect the full range of learning styles and do not focus on learning objectives enough. One respondent felt that children / pupils already spend too much time using computers, potentially at the cost of more traditional pen / paper based educational activities.
- While two of the respondents felt that educational games should be tied to the ENC, there was a view that professional judgement (on the educational value of a given game) could be used in the absence of explicit ENC outcomes.

5.2.3 Parent Questionnaire

The parent's questionnaire was distributed with a covering letter and an informed consent letter (asking parents' permission for their children to participate in the subsequent Survey/Design Pilot). The questionnaire itself was designed to elicit parents' views on the playing of computer games and their role within education (with the emphasis on educational computer games).

The following results were of note:

- Ten of the eighteen respondents play computer games.
- In terms of using computer games within the school environment, the results were largely positive, but with some provisos.

  Twelve of the eighteen respondents felt that the use of games (to learn) would be fun and interesting, as long as there was an educational purpose attached to them.

  Four (of the twelve) respondents expressed the view that computer games should be mixed with traditional teaching, and used purely as a complementary tool. There was also a view that the use of games should be moderated or at least used proportionally within the classroom.

  Five questionnaires (of the eighteen) were returned with no reply and one questionnaire specified a preference for 'traditional' teaching.

- Two respondents commented on how they felt leisure-based games could still be educational. The first respondent expressed the view that games can promote competition, while the second respondent suggested that a football game can prompt questions about various countries and their location on a world map.
- In terms of whether educational games should be tied to the English National Curriculum, ten of the respondents felt that they should be.

  Six respondents disagreed, stating that although the ENC was important, it was not the "*be all and end all of education"*. Two (of the six) respondents expressed the view that learning can come from many sources outside of school (such as travel or "*Life Lessons*").

  Two respondents expressed views that were neither in favour nor against linking games to the ENC.

5.2.4 Pupil Questionnaire

The pupil questionnaire was designed to elicit information from the target group of pupils on a variety of I.T./Game related themes. Additionally, a number of opening questions were included in order to collect optional data about the sample group (such as favourite school subject or hobbies). The predominant purpose of the questionnaire was to provide the pupils with the opportunity to design their own computer game, complete with a 'Screen Design' form for sketching their ideas on what their game might look like. It was hoped that the data collected would aid the design of the author's subsequent educational game prototypes. The following series of tables/charts summarise the data collected from the pupil questionnaires. The data is grouped into two areas, *Pupils* and *Computer Game Design*.

Pupils

This area sought information about the respondent (i.e. the pupil's favourite school subjects, hobbies and general ICT usage) and served as an opening to the questionnaire, before feeding into the *Computer Game Design* area.

Popularity (Ranked)	Subject
1	P.E.
2	ICT
3	Art
4	Math
5	Science
6	D.T.
7	Swimming
8	Golden Time / Numeracy / History
9	English / French
10	Literacy / Geography

Table 5.1: What are your favourite subjects at school?

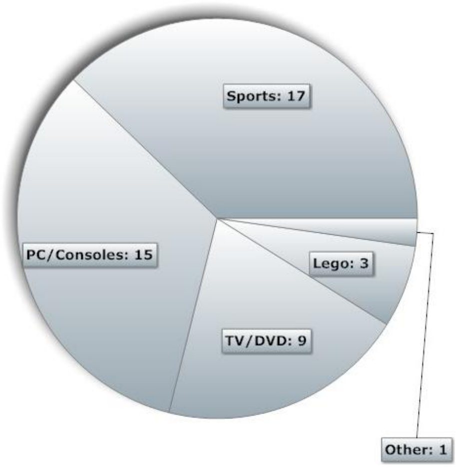


Figure 5.1: What are your favourite hobbies?

Regularity	Response
Every day	11
Weekly	8
Monthly	1
Rarely	1

Table 5.2: Do you like to play computer games?

Technology	Own / Use
Both	14
Console	5
PC	1
None	1

Table 5.3: Do you use a computer (PC) or games console (Xbox, Wii etc.) to play games?

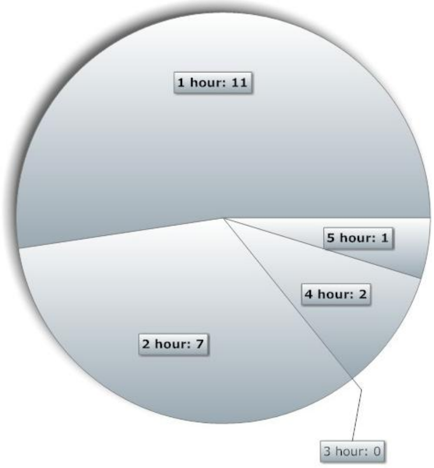


Figure 5.2: Whenever you play games, how many hours will you play the game for?

Computer Game Design

This area of the pupils' questionnaire explored the type of computer games that the respondents enjoy playing, as well as what they would like to see in a design for their own computer game.

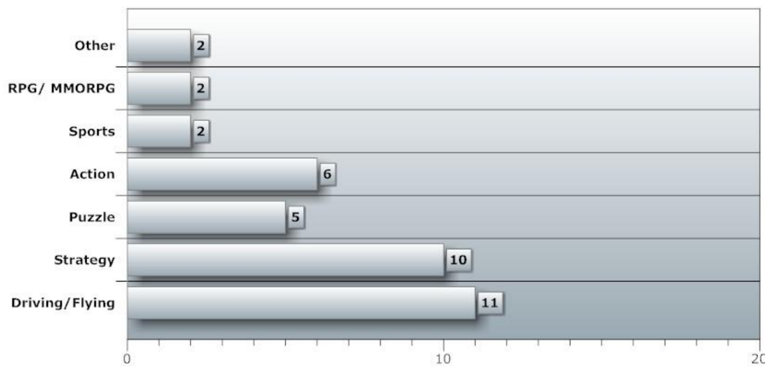


Figure 5.3: What type of computer games do you like to play?

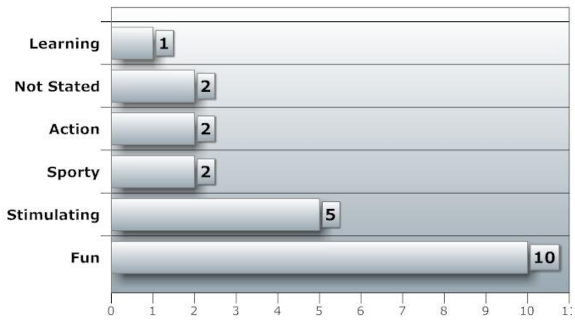


Figure 5.4: Why do you like to play these types of game?

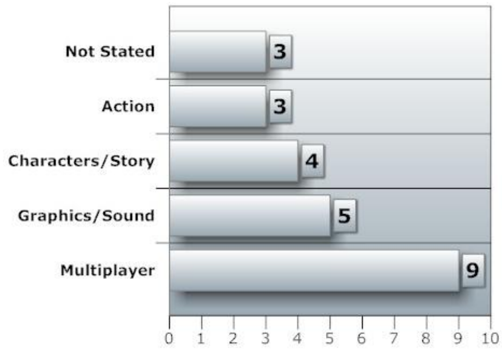


Figure 5.5: What Makes a Good Computer Game?

Respondents were asked what type of computer game they would like to design and what the game would be about. As the replies were similar for both questions, they have been amalgamated into one chart (Figure 5.6).

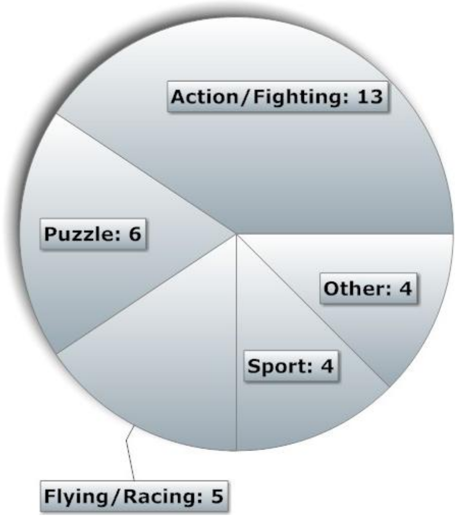


Figure 5.6: What type of game would you design?

5.2.4.1 Pupil Questionnaire Results

In terms of the opening questions, the results suggest that gaming is popular, with the majority of respondents playing every day for at least 1 hour. Additionally, the majority of the respondents state the use of both PC's and consoles for game playing activities. In terms of favourite school subjects, P.E., followed by ICT, emerged as the most popular, which mirrors the results of 'Sports' and the use of PC's/Consoles as the most popular hobbies.

Many of the opening questions were designed to be open-ended, allowing the respondents the opportunity to provide written answers. Unfortunately, the author found the replies to these questions to be of variable quality and difficult to analyse. For example, while many respondents stated 'PC' or 'Consoles' as their favourite hobbies, there was no clear indication as to why.

Unfortunately, due to work commitments at the time, the author was unable to administer the pupil questionnaire in person, and therefore was not present to provide guidance on the meaning and context of some of the design related questions.

As a result, the responses to some of the design related questions were less informative than the author had hoped for.

For example, in relation to the following questions:

1. What sorts of things make a good computer game?
2. What is your favourite computer game(s) at the moment and Why?
3. If you could create your own computer game, what would it be about?
4. Who would be in the game (i.e. your friends, family)?

The author received a number of one word answers, such as

- 'Running', 'Jumping' (in relation to Question 1).
- 'Mario', 'Lego' (in relation to Question 2).
- 'Justin Bieber' (in relation to Question 3).
- 'Yes' or 'No' (in relation to Question 4).

Similarly, a low number of screen designs were returned, which in many cases were difficult (for the author) to interpret, or bore no relation to the respondents previous answers (on their suggested game design).

5.2.5 Questionnaire Based Survey Conclusions

The results from the Questionnaire Based Survey provided a mixed review of Games Based Learning. The author also had limited confidence in whether the returned data could be of benefit to the games design process.

From a positive viewpoint, despite the low returns for the Teacher/Parent questionnaires, the respondents did not dismiss the concept of Games Based Learning out of hand, and considered that it might have a role to play within education. The author's interpretation is that the use of games within the classroom needs to have checks and balances – in other words, games should be used as an additional educational tool, as and when appropriate.

Less positively, the author holds reservations about the quality of the returns for the pupil questionnaire. The use of open-ended questions led to variable quality responses, which were less informative than the author had hoped for. Additionally, the author was disappointed with the low number of screen designs that were actually completed.

However, the author takes the view that the Questionnaire Based Survey was on the whole a productive exercise, serving as the author's introduction to the international school. Additionally, the results from the Pupil Questionnaires guided the author towards conducting a further review of gaming, in the form of the (educational) Game Review, which will be discussed in the next section.

5.3 Game Review

In preparation for the Design Pilot, the author sought to conduct a review of the current market for educational games. As per supervisorial advice, the author sought out educational games that contained mathematical content aimed at pupils within Key Stage 2 or equivalent (8 – 10 years old). After advice from the international school, the author refined the review to concentrate on games specifically promoting single and double digit multiplication – as this was an area that the school's ICT Co-ordinator viewed as providing the most challenge to the target/sample group of pupils.

The educational games vary in their approach to maths, but are intended to be 'fun' (and educational) when played. Although generally similar when asking/delivering maths questions, the games do differ in how the player can respond with their answer:

- A number of games present the player with a question, and then prompt the player to select the correct answer from a range of possible answers (*5.3.1 Present a Question – Select an Answer*).
- A number of games present the player with a question, and then prompt the player to input or type in an answer (*5.3.2 Present a Question – Input an Answer*).

5.3.1 Present a Question – Select an Answer

The games within this classification all use a generic 'Present a Question – Select an Answer' approach as the basis of their game design.

This type of game involves asking the player for the answer to a maths question, possible answers are then displayed on screen, and the player has to select (in some fashion) the correct answer. Typically, the games will provide some form of feedback on whether the correct or incorrect answer has been selected. The method used for presenting the questions, and selecting an answer, can vary but the author has classified the differing approaches as follows:

- Shooting / Target Style Games.
- 'Whac-A-Mole' Style Games.
- Quiz Style Games.
- Navigation / Maze Style Games.

5.3.1.1 Shooting / Target Style Games

With Shooting/Target Style Games, possible answers are displayed on the screen, and the player must ‘shoot’ the correct answer using the computer mouse cursor, which has typically been designed to look like a ‘Cross Hair’ or Target symbol (Figure 5.7).

Figure 5.7: 4x Tables Shooting Game (Mad4Maths 2011)

5.3.1.2 ‘Whac-A-Mole’ Style Games

In real terms, the computer based ‘Whac-A-Mole’ style games might be regarded as belonging to the same class as the Shooting/Target style games. The purpose of both game types is the same - select the correct answer using the computer mouse cursor.

However, ‘Whack-A-Mole’ style games derive their name from the original 1971 arcade game, which involved artificial moles ‘popping up’ out of a hole, which the player would then try and ‘whac‘, with a foam hammer (Figure 5.8 / Figure 5.9).

The computer-based variant of ‘Whac-A-Mole’ will typically feature multiple characters (such as aliens or mice) ‘popping up’ on the screen, each character displaying a potential answer to a given maths question. The player’s task is to click (or ‘whac’) the character displaying the correct answer to the question, before the character disappears or ‘pops down’ from the screen (Figure 5.10 / Figure 5.11).

Figure 5.8: Original Flyer for ‘Whac-A-Mole’, circa 1993 (International Arcade Museum 2013a)

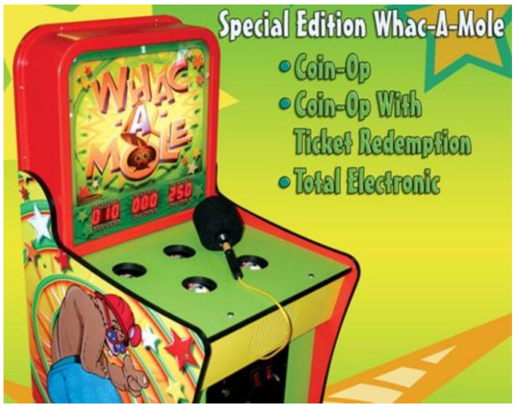


Figure 5.9: Original Flyer for ‘Whac-A-Mole’, circa 2005 (International Arcade Museum 2013a)

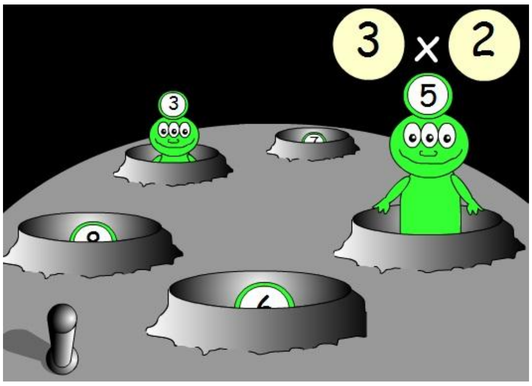


Figure 5.10: Moon Maths (Primary Resources 2011a)

Figure 5.11: 5x Tables Whack a Mouse Game (Mad4Maths 2011)

5.3.1.3 Quiz Style Games

At their simplest, quiz style games follow the format of asking the player a series of questions, and then providing a range of possible answers for the player to select from. Examples within this genre include ‘WipeOut Wall’ (Figure 5.12) and ‘Who wants to be a Mathionaire’ (Figure 5.13),

Beyond the initial challenge of answering the questions correctly, the element of challenge can be further increased through the use of various game mechanics, such as timer mechanisms (which restrict the time available for answering questions) or penalty systems (that punish the player for any incorrect answers).

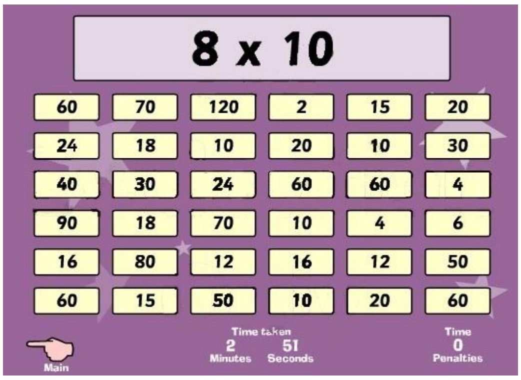


Figure 5.12: WipeOut Wall
(Primary Games 2011a)

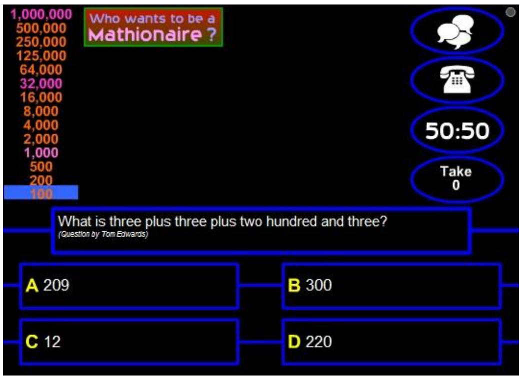


Figure 5.13: Who wants to be a Mathionaire
(Keith 2006)

5.3.1.4 Navigation / Maze Style Games

Another method for presenting/answering math questions is to use a navigation/maze game style format where the player has to navigate around the computer screen in order to select the answer to a given question.

This method could be as simple as the one implemented within the game 'Math Balls' (Figure 5.14). Within 'Math Balls' a maths question is displayed on screen along with two (or more) possible answers. The player needs to navigate a red ball (using the Arrow keys on the computer keyboard) towards the correct answer in order to proceed onto the next screen/question. This task is complicated by the presence of two (or more) blue balls which float around the screen. Should the player come into contact with these blue balls, they will lose one of their (three) lives. The challenge therefore is to navigate to the correct answer, while avoiding loss of life.

A similar variation on 'Math Balls', is the clone of 'Donkey Kong Jr Math' (Figure 5.15).
Playing an ape with a Jet pack, your role is to jet around the screen, colliding with the numbers that will add up to a specific total (displayed by the large ape in the top right of the screen). As depicted in Figure 5.15, Donkey Kong Jr needs to collide with the numbers, 8, 2 and 1, in order to make up the total of 11 (as displayed in the top right corner).

Another arcade game clone is ‘Math Man’, based on the famous 1980’s ‘Pac-Man’ game. For those unfamiliar with the game ‘Pac-Man’, the player must navigate a maze in order to collect points (in the form of pellets of food), while avoiding contact with enemy ghosts that will cause the player to lose a life. In the case of ‘Math Man’ (Figure 5.16), the player is given a total, and he/she must ‘eat’ the numbers (scattered around the maze) that will add up to that total.

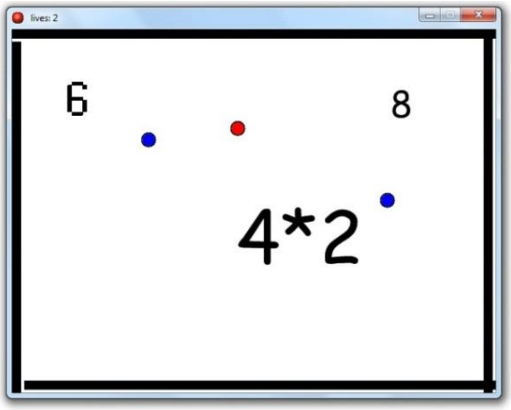


Figure 5.14: Math Balls
(Yoyo Games 2009c)

Figure 5.15: Donkey Kong Jr Math 2
(Yoyo Games 2008b)

Figure 5.16: Math Man (Yoyo Games 2009a)

5.3.2 Present a Question – Input an Answer

As with the 'Select an Answer' approach, 'Input an Answer' style of games involve asking the player for the answer to a maths question. However, the player has no choices to select, but instead must work out the answer to the question and then manually type it into a text box or text area.

Games based on this style are essentially the same, but with slight variations (Figure 5.17 / Figure 5.18). It might be argued, that this style of 'game', is not really a game at all (i.e. 'fun' to play), but rather a Question/Answer session or a computer based quiz testing prior knowledge.

Some games attempt to vary this premise, by linking the answering of questions to some form of in-game progress. An example of this is the '8 x Table Tree Climbing Game' (Figure 5.19) which has 'Dad' trying to retrieve his children's lost toys, which are currently lodged at various levels within a tree. In order to climb the tree, the player has to correctly answer the displayed math questions. The more questions correctly answered, the higher 'Dad' climbs, and the more toys he is able to retrieve. If the player incorrectly answers a question (or takes too long to answer it), 'Dad' falls down the tree a few branches. In effect there are two goals: The 'fun' goal of trying to successfully climb the tree (collecting the toys) and the 'educational' goal of answering the maths questions correctly.

In a similar vein, 'Table Mountain' (Figure 5.20) pits two players (or mountaineers) against each other. Starting at the foot of the mountain, each player takes turns answering multiplication questions. With every correct answer, the player progresses (or 'climbs') up the mountain, but with every incorrect answer, the player 'slips' back down the mountain – the objective is for one of the players to reach the peak first. Again, there are dual goals, one to successfully answer the questions, the other to beat the other player to the top of the mountain.

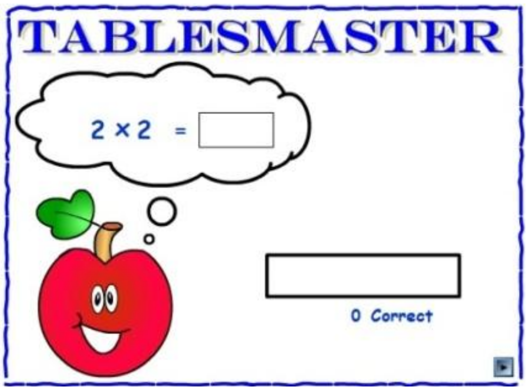


Figure 5.17: Table Master
(Transum Software 2011a)

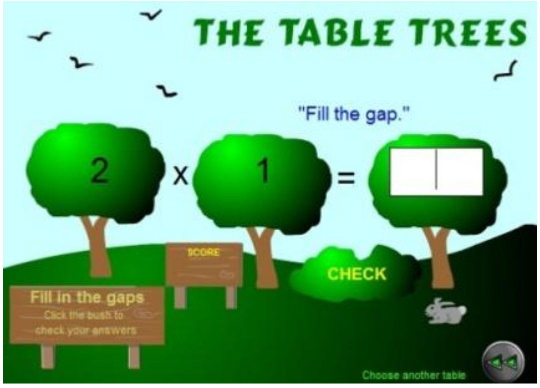


Figure 5.18: Table Trees
(Ambleside Primary School 2011)

Figure 5.19: 8 x Table Tree Climbing Game
(Mad4Maths 2011)

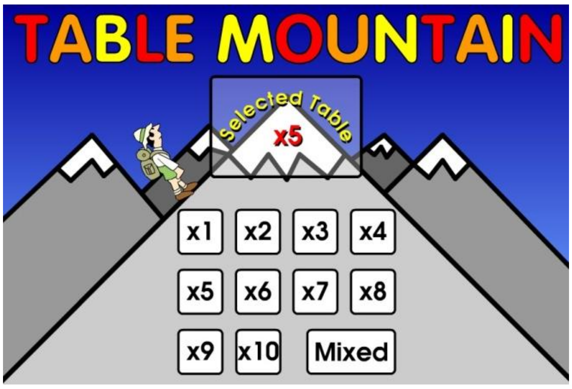


Figure 5.20: Table Mountain
(Primary Games 2011b)

With both the Tree Climbing/Table Mountain games, the emphasis is on answering maths questions with related progress. In contrast, a number of games surveyed seem to take the opposite approach and retrofit math questions onto an ordinary game. The end result could be considered as game play, occasionally interrupted by the odd maths question.

The game 'MathsBall' (Figure 5.21) is essentially a remake of the classic 'BreakOut' (Figure 5.22) or 'Bricks and Bats' game, which was one of the games originally featured in the research of Malone & Lepper (1987). In this classic game, the player controls a bat and uses it to hit a ball against a brick wall. Every time the ball hits the brick wall, one or more bricks will disintegrate and the player is rewarded with some points. Certain 'Bonus Bricks' are considered special, and if hit successfully, will carry extra points. 'MathsBall' modifies this genre, so that when the player hits a Bonus Brick, they are prompted to answer a question. If successfully answered, the extra (bonus) points are awarded.

Another ‘remake’ example is ‘Math Man’ (Figure 5.23). This is based on the ‘Platform’ game genre and involves the player running across a platform or similar landscape, typically jumping over or shooting at an enemy of some description. In ‘Math Man’, upon approaching an enemy, the player is prompted to answer a question. The correct answer ‘eliminates’ the enemy, whereas an incorrect answer results in the game ending.

It might be argued that retrofitting an existing game, with maths questions, has a detrimental effect on the game play. This prompts the author to ponder the following questions – Is the game still fun to play, now that it is asking maths questions? By adding questions, has the game been reduced to a mere Question/Answer/Quiz session (admittedly, with fancy computer graphics)?

‘Math Magic’ (Figure 5.24) adopts a slightly subtler approach (when compared to ‘Math Man’) to blending the levels of game play with maths questioning. In a scrolling variation of a maze game, the player (playing the character of a magician) has to defeat a number of green slime ‘fiends’ on his/her journey to destroy an Evil Wizard’s Magic Sphere. When the magician comes into close contact with a green ‘fiend’, the ‘fiend’ displays a sum (*1 + 6*. Figure 5.24) and unleashes lightning bolts that will drain the magician’s energy level upon impact.

The magician can defend him/herself by unleashing their own lightning bolt, but in order to do this the player must first type in the correct answer to the ‘fiend’s sum (the incorrect answer, in this case, of 13. Figure 5.24). This approach makes the answering of the maths questions firmly part of the game play, but does not stop or pause the game in the event of the player refusing to answer the questions (although it will make the game harder to play, as the number of ‘fiend’s starts to build up).

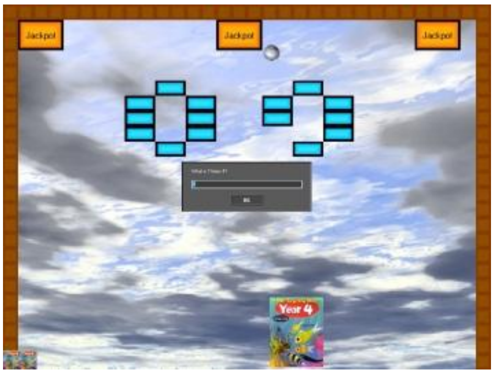


Figure 5.21: MathsBall
(Yoyo Games 2007)

Figure 5.22: BreakOut (AtariAge 2013h)

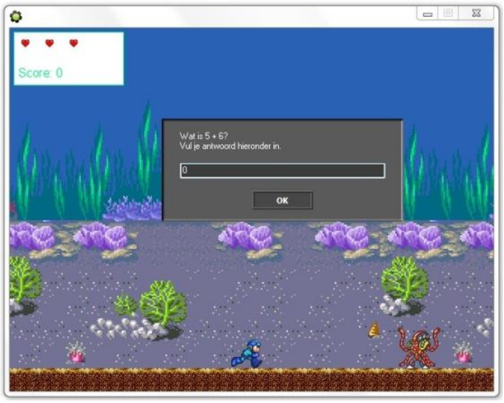


Figure 5.23: Math Man
(Yoyo Games 2010)

Figure 5.24: Math Magic
(Yoyo Games 2008a)

5.4 Conclusion

As part of the methodology for addressing the thesis research questions, the author conducted a Questionnaire Based Survey, Game Review and a Design Pilot (Chapter 6), in order to obtain feedback on what constitutes educational game design ‘best practice’.

This chapter discussed both the Questionnaire Based Survey and the Game Review, while the Design Pilot will be discussed within the next chapter (Chapter 6).

Questionnaire Based Survey

The results from the survey provided a mixed review of Games Based Learning, and the author had limited confidence in whether the returned data could be of benefit to the games design process. However, the survey did serve as the author's introduction to the international school, and guided the author towards conducting a further review of gaming, in the form of the (educational) Game Review.

Game Review

Despite geographical constraints, the author sourced a variety of open source/free mathematical games, which design-wise fell into two categories

- Games allowing the player to select an answer to a given maths question.
- Games requiring the player to explicitly input/type an answer to a given maths question.

Within these categories, there were a number of different styles of game, including

- Shooting / Target Games.
- 'Whac-A-Mole' Style Games.
- Quiz Games.
- Navigation / Maze Style Games.

Regardless of the category or style, the reviewed games were notable for their approaches to blending maths content into the mechanics of the game play:

- Quiz style games might be considered as colourful looking maths tests, which are not particularly 'fun' to play.
- Certain games were designed to be 'fun' first, with maths content 'retro-fitted' afterwards, resulting in game play interrupted by prompts to answer maths questions.
- A smaller number of games managed to balance both maths content and game play in such a way that neither aspect overwhelms the other.

Chapter 6 continues the discussion of the initial stages of the author's methodological approach to addressing the research questions, in the form of a Design Pilot.

Chapter 6: Design Pilot

6.1 Introduction

As briefly discussed within Chapter 4, this chapter is concerned with discussing the initial stages of the author’s methodological approach to addressing the thesis research questions. The author conducted a Questionnaire Based Survey/Game Review (Chapter 5) and a Design Pilot, the primarily purposes of which were to obtain feedback (from a sample group) on educational game design ‘best practice’, which in turn would feed back into the design of the author’s own educational games.

This chapter discusses the Design Pilot, which consisted of a sample group ‘playing’ a selection of mathematical games, which had previously been sourced through the Game Review. Observations made during the pilot are discussed, along with the results of the questionnaires that were designed to elicit feedback on the selection of games used during the pilot. Finally, the author draws conclusions (based upon the pilot results), on what constitutes educational game design ‘best practice’.

6.2 Design Pilot / Sample Group

As discussed within Chapter 4 (*4.5.4 Design Pilot*), the author embarked upon an informal Design Pilot. The purpose of the Design Pilot was to elicit feedback from a sample group at an international school (13 pupils, Key Stage 2, ages 7 to 10) on what constituted educational game design ‘best practice’. The intention was to take the subsequent feedback and incorporate it into the designs for the author’s educational games.

The Design Pilot took place in one of the international school's ICT rooms, as part of the sample group's weekly (1 hour) 'ICT Club Class'. A selection of educational games was identified from the Game Review (*5.3 Game Review*) and subsequently installed on the school's internal computer network for use during the Design Pilot. Feedback on the games was derived through two mechanisms:

- Observation (during the class) by the author and the ICT Club Class Teacher, and
- A simple questionnaire / grading sheet ('Game Style Grading Sheet') which members of the sample group could use in order to grade the games and make any comments.

6.2.1 General Observations

During the observation, it was observed that some of the Design Pilot games were played more frequently than others, and were played for a greater period of time.

Conversely, the author perceived that some members of the sample group did not like the 'look' of some of the more graphically sparser games. This perception was based on the author observing individual group member's reactions to certain games e.g. upon loading the game, the group member would seem to express a negative reaction (facial and/or verbal) and then promptly close the game down, before moving onto another of the Design Pilot games. One member of the sample group was dissuaded by the more blatant maths content of the Question/Answer/Quiz style games ('Table Master' and 'Table Trees') and asked disparagingly if "*all the games were about maths?*".

An interesting observation concerned the use of textual information within some of the Design Pilot games. Some of the games ('Math Magic', being the most prominent) would begin game play with a text based introduction screen (setting out the narrative or explaining the game control keys), which would be frequently ignored or dismissed by some members of the sample group.

The author’s perception was that this was due to impatience (i.e. the sample group member wanting to start the game immediately) and resulted, in certain instances, with the observers being asked to explain what the introduction text had meant, and whether it was ‘important’. This observation reflects the views of a number of researchers who argue that, where possible, textual information should be substituted with graphical images (Tobias, Fletcher & Wind 2014, Belanich, Orvis & Sibley 2013, Ibáñez, Crespo & Kloos 2010), and is further reflected by Kelly *et al.* (2007), who state that “*Players usually skip introductory text—educational and otherwise—going immediately to gameplay.*” (Kelly *et al.* 2007, p.48)

The Design Pilot games that worked best in this context used minimal text or had an obvious game objective that allowed the player to jump straight into playing the game (e.g. ‘Moon Math’). The logical assignment of computer keyboard keys (Arrow keys for movement and Enter/Spacebar to fire), also made these games more intuitive for the sample group to play.

The Design Pilot games followed two different approaches in terms of how maths content is presented to the game player. Games, such as ‘Math Balls’, integrate the maths content *into* the game itself, making the content an integral part of the game play. In contrast, games such as ‘Math Man’, place the math content *onto* the game, thereby presenting the content separately from the game itself.

Typically, these latter type of games play out as a normal game, but periodically pause the game play in order to present the player with a maths question (via a dialogue box). Where games took this latter approach, the author observed the following behaviours within the sample group:

- Some group members asked the author how to dismiss the dialogue box, in some cases complaining that it was ‘stopping’ them from playing the game.
- Other group members were observed dismissing the dialogue box (by continuously clicking the ‘OK’ button or pressing the ‘Enter’ key) in order to continue game play.
- Some group members dismissed the dialogue box (as above), but asked the author how to stop the dialogue box from constantly re-appearing as it was making the game ‘difficult’ to play.

6.2.2 Specific Observations / Grading Sheet Feedback

Due to time constraints and (in certain cases) technical issues, it was not possible for the sample group to play all of the games during the Design Pilot. As previously noted (*4.5.4 Design Pilot*), the questionnaire return rate was also lower than had been hoped for. Therefore, the remainder of this chapter concentrates on the observations relating to specific games, coupled with their feedback and grades collated from the returned questionnaires.

At the beginning of the class observation, 'Game Style Grading Sheet's were handed out to the sample group. Each sheet contained a list of games, which the sample group members were asked to grade on a scale of **1** to **5** (Table 6.1). In addition to the grades, additional space was provided for the sample group to leave any comments/feedback on the individual games.

Scale	Meaning
1	'Very Good'
2	'Good'
3	'Don't Know'
4	'Bad'
5	'Very Bad'

Table 6.1: 'Game Style Grading Sheet' Grades

Of the 13 Grading Sheets distributed within the class, 12 were returned either filled in, or completed to varying degrees. The Grading Sheet listed a total of 25 games, which with the benefit of hindsight, was perhaps too many games to play within the (1 hour) class session. Removing the games that did not run correctly (on the network) or were not commented upon, left a total of 12 games that were ultimately played by the sample group. These games will be individually discussed, with the appropriate grades, comments and (where applicable) specific observations.

6.2.3 'Unpopular' / Un-played Games

The following games have been grouped together into this category, due to receiving a poor reception from the sample group during the observation.

- 'Connect It!'
- 'WipeOut Wall'
- 'Moon Maths'
- 'Table Master'
- 'Table Trees'

For the above games, only one grading sheet (out of the 12) was actually returned with a grading for these specific games. Unfortunately, the grading for each game was either 'Good' or 'Bad', with no additional commentary to elaborate on the grading decision.

However, during the observation, it was apparent that the majority of the sample group did not play these games or played them only very briefly. Possible reasons for this (based on observation) include:

- The more blatant mathematical content featured within these particular (i.e. quiz themed) games.
- The popularity of the other games being played (i.e. 'Math Balls' / 'Math Magic')
- The time constraints of the observation

In the case of 'Table Master' and 'Table Trees', it could be argued that these games were more akin to maths tests (asking the player to answer a series of questions) rather than being 'games' that could be played.

In the case of ‘WipeOut Wall’, the game loaded and initially displayed a clean and graphically appealing selection screen, prompting the player to select a times table. However, upon actually starting the game, the game play area was instantly obscured by a large intrusive watermark, stating ‘For Evaluation Only’ (Figure 6.1), therefore making subsequent game play difficult. This ‘watermarking’ surprised the author, as he had previously played the game on the international school’s computer network, without issue. It subsequently transpired that the author had actually played the commercially licensed version of the game, but during the observation, the sample group had been provided with the web address to play the website version. Unbeknownst to the author, the website version of ‘WipeOut Wall’ was actually a demo designed to encourage the purchase of the ‘full’ commercial version, which ironically had already been installed on the school network.

Figure 6.1: WipeOut Wall
(Primary Games 2011a)

6.2.4 Tran Towers

'Tran Towers' (Figure 6.3) might be considered a hybrid game. Essentially 'Tran Towers' falls into the Questions/Answers/Quiz style of 'game', but contains an element of exploration.

The player must navigate through the rooms of 'Tran Towers' (portrayed as a mysterious gothic Transylvanian building) and ultimately achieve the goal of reaching the 'Treasure Room'. In order to reach the 'Treasure Room', the player must correctly answer a series of maths questions.

Through observation, some members of the sample group seemed to enjoy the concept of exploration offered within the game. However, other members appeared to be discouraged from playing due to the large amount of text displayed on screen. Additionally, those who played the game expressed the view that the presented maths content was too 'difficult' (Figure 6.3). The author is unclear as to whether this was due to the level of maths presented, or whether the game presented topics that sample group had yet to study. The author notes however, that the developers of 'Tran Towers' do not explicitly state the target age group or key stage for which the game has been developed.

A number of respondents failed to grade 'Tran Towers', resulting in the few grades that were given, being evenly distributed between 'Very Good', 'Good' and 'Very Bad' (Figure 6.2).

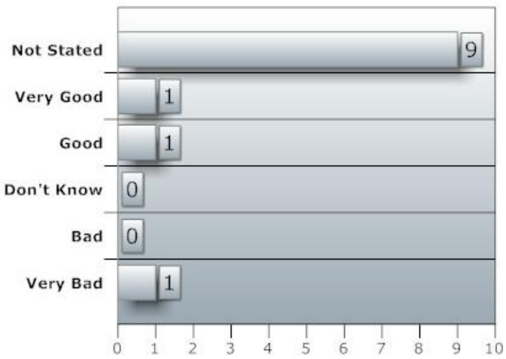


Figure 6.2: Grading Sheet Grades
(Tran Towers)

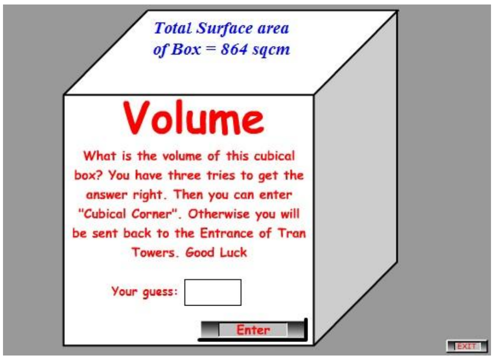


Figure 6.3: Tran Towers
(Transum Software 2011b)

6.2.5 Donkey Kong Jr Math 2

Through observation, ‘Donkey Kong Jr Math 2’ seemed to be popular with the sample group (in comparison with the other Design Pilot games). The most obvious reason for the game’s popularity is it’s resemblance to the well-known Donkey Kong series of computer games produced by the Nintendo Corporation. Despite these games being a number of years old, some members of the sample group expressed familiarity with the game, with one member commenting that she had played the game before.

‘Donkey Kong Jr Math 2’ has been produced using the game development package ‘GameMaker’, and seems to have been inspired by the Nintendo game ‘Donkey Kong Jr Math’ (originally released on the Nintendo Entertainment System (NES) in 1983). The computer graphics faithfully re-capture the original game and as a consequence, could be considered crude by today’s gaming standards. However, during the observation, no comments were made about the graphics and they did not seem to detract from the game play. This leads to the author’s belief that while important, a good computer game (educational or otherwise) is not entirely dependent on high resolution or realistic looking graphics.

Another observation was that the mathematical content, although present, was not considered as discouraging or ‘interrupting’ as it was in other games (i.e. ‘Math Man’ and ‘MathsBall’). In ‘Donkey Kong Jr Math 2’, the player has to navigate their character (Donkey Kong Jr) around the screen (on what appears to be a ‘jet-pack’), colliding with the numbers that will add up to a specific total, as displayed by Donkey Kong Sr at the top right of the screen (Figure 6.5). The sample group members, who played the game, seemed to enjoy the challenge of ‘jet-packing’ their character around the screen and colliding with the appropriate numbers.

This makes for an interesting contrast to the original ‘Donkey Kong Jr Math’ game, which was critically panned upon release, and is still regarded as one of Nintendo’s worst selling games of all time (X-Entertainment 2003, Jensen 2012a and Provo 2007). ‘Donkey Kong Jr Math’ has subsequently been re-released (in its original form) on the Nintendo Wii games console (as a ‘Virtual Console’ game), which might explain the sample group’s familiarity with this specific Donkey Kong game.

A number of respondents failed to grade ‘Donkey Kong Jr Math 2’, resulting in the few grades that were given, being positively distributed across ‘Very Good’, ‘Good’ and ‘Don’t Know’ (Figure 6.4).

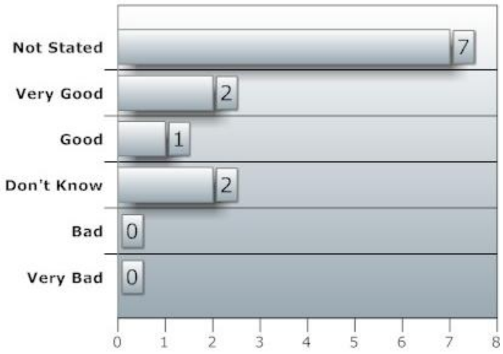


Figure 6.4: Grading Sheet Grades (Donkey Kong Jr Math 2)

Figure 6.5: Donkey Kong Jr Math 2 (Yoyo Games 2008b)

6.2.6 Math Man

'Math Man' presents a bit of a curiosity. Through observation it seemed that quite a few of the sample group played this game for a period of time (i.e. not dismissing it automatically), but of those who completed the questionnaire, more than half did not enjoy the experience. As with 'Math Explorer 2' (*6.2.7 Math Explorer 2*), 'Math Man' is based on the popular Namco 'Pac-Man' arcade game, which requires the player to navigate around a maze, while avoiding various enemies. In this maths related variation, the player must collect various numbers (scattered around the maze) until they accumulate the required total (displayed in the middle of the game area, Figure 6.7). The game may have caused dissatisfaction, due to the following observations:

- Some sample group members queried why 'Math Man' was failing to 'start' once the game had been 'clicked on' (started). Upon further examination, it was determined that the game was actually just slow to load. Upon discovering this issue, the sample group were advised (by the author) that the game was just 'slow to start', but would eventually 'start'.

- Some members of the sample group expressed the view that the game was 'slow' to play. Upon examination, it did appear that the game was generally slow to react to keyboard input, making it less responsive in use. The author is unclear as to why this was the case.

- When the player's character approaches (or attempts to collect) the 'wrong' answer, the screen changes to warn the player of the impending danger, effectively interrupting the game play. Some members of the sample group expressed the view that this 'spoiled' the game and questioned the need for this type of warning.

- 'Math Man' features a start screen allowing the player to select (mathematical) variations of the game. This allows the player to play 'Math Man' with addition, subtraction, multiplication or division questions. However, once a variation has been selected, there appears to be no way to exit the game and return back to the start screen in order to select another variation of the game. As a consequence, the player must exit the game completely, reload the game, and then select another variation. During the observation, one sample group member asked the author how to play the other 'versions' (variations) of 'Math Man'. Upon explaining the (above) procedure, the member decided against reloading the game, stating that he did not want to wait for the game to load again as it was too slow to start (as per the first observation).

A number of respondents failed to grade 'Math Man', the few grades that were given, were almost evenly distributed across 'Very Good', 'Bad' and 'Very Bad' (Figure 6.6).

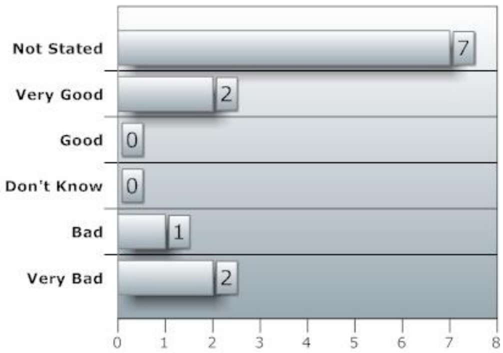


Figure 6.6: Grading Sheet Grades (Math Man).

Figure 6.7: Math Man (Yoyo Games 2009a).

6.2.7 Math Explorer 2

'Math Explorer 2' (Figure 6.9) follows the same design/game play as 'Math Man' (*6.2.6 Math Man*). While there seems to be more items for the player to collect, the 'enemies' seem to be permanently prevented from entering the maze, resulting in no sense of danger, and therefore no challenge.

There are a number of question mark (?) characters scattered around the maze. When these are collided with, the game play halts and a dialogue box is displayed, prompting the player to answer a maths question. However, the player does not actually answer the question, but clicks on either a 'Yes' or 'No' button ('Is 5 x 6 = 40?').

Based on observations during the session, the sample group seemed to regard this approach to asking maths questions as an unwelcome interruption into their game play. In many cases when presented with the dialogue box, members of the sample group would frequently either just click on the Yes/No buttons or press the 'Enter' key in order to dismiss the dialogue box and resume game play.

A number of respondents failed to grade ‘Math Explorer 2’, the few grades that were given, were evenly distributed across ‘Very Good’ / ’Good’ and ‘Very Bad’ (Figure 6.8).

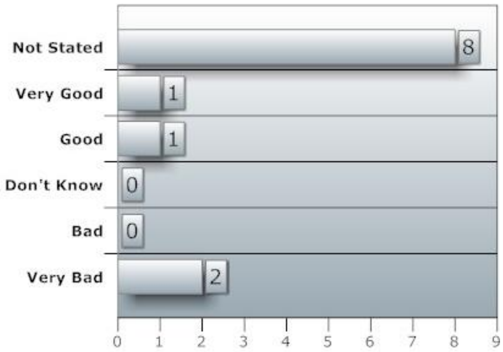


Figure 6.8: Grading Sheet Grades (Math Explorer 2).

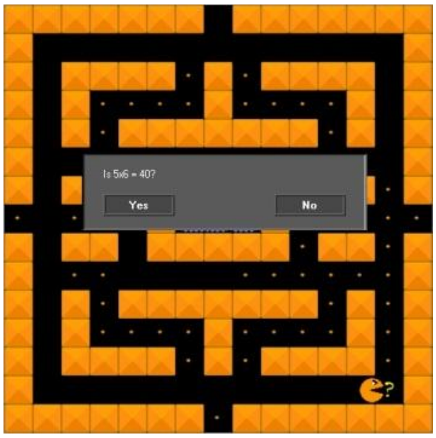


Figure 6.9: Math Explorer 2 (Yoyo Games 2009b).

6.2.8 MathsBall

The game play of ‘MathsBall’ (Figure 6.11) is based on Atari Corporation’s 1976 arcade game ‘BreakOut’. Often generically referred to as a ‘Bricks and Bats’ game, the basic game play involves the player batting a ball across the screen and trying to hit as many ‘bricks’ (located along the top of the screen) as possible.

The element of challenge is derived from the fact that the ball (once ‘batted’) will ricochet off the sides of the playing area as well as hitting any ‘bricks’. The player must ensure that the ball does not fall down beneath the playing area otherwise the player will lose a life. Scattered around the screen are larger special (‘Jackpot’) bricks, which if hit, will result in the player being awarded bonus points. When the ball hits one of the Jackpot bricks, the game play is halted, whilst the player is prompted (with a dialogue box) to answer a maths question.

The dialogue box requires the player to manually input the answer and then click on the ‘OK’ button, before game play can resume. Dependent on whether the correct answer has been entered or not, will determine whether the player is awarded the bonus points. As with ‘Math Explorer 2’ (*6.2.7 Math Explorer 2*), based on observations, the sample group seemed to regard this approach to asking maths questions as an unwelcome interruption into their game play. In many cases when presented with the dialogue box, members of the sample group would frequently just press the ‘Enter’ key in order to dismiss the dialogue box and resume game play.

A number of respondents failed to grade ‘MathsBall’. The few grades that were given were distributed between ‘Very Good’ or ‘Don’t Know’, with one respondent grading it as ‘Bad’ (Figure 6.10).

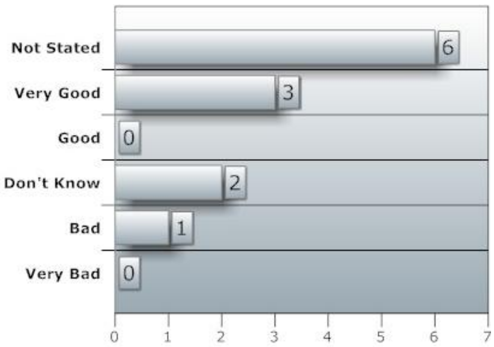


Figure 6.10: Grading Sheet Grades (MathsBall).

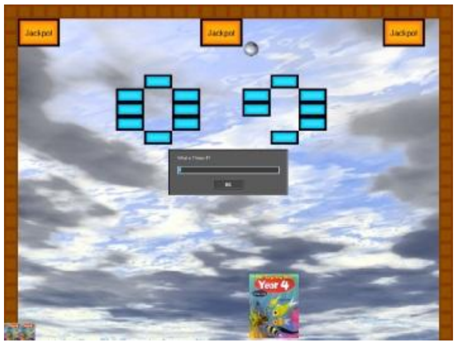


Figure 6.11: MathsBall (Yoyo Games 2007).

6.2.9 Math Magic

‘Math Magic’ (Figure 6.14) prompted quite a mixed reaction from the sample group. While the grading sheet return rate was disappointing, in-class observations helped provide much richer information. ‘Math Magic’ is a scrolling maze game, reminiscent of Nintendo Corporation’s ‘Legend of Zelda’ series of games (Nintendo Corporation 2014). The player (playing the character of a magician) has to travel around the game area and defeat a number of green slime ‘fiends’ on his/her journey to destroy an Evil Wizard’s ‘Magic Sphere’. When encountering the player, a ‘fiend’ will display a maths sum above its ‘head’ (Figure 6.12). Using the keyboard, the player must type in the (correct) answer to the sum, and then press the ‘Enter’ key in order to shoot a lightning bolt at the ‘fiend’.

Figure 6.12: A ‘Fiend’.

During the observation, it was noticed that the game takes slightly longer to load up (when compared to some of the other Design Pilot games) and features a ‘Logo’ screen, followed by a short textual introduction screen (usually considered good practice). When starting the game, a couple of screens are displayed explaining the keyboard layout and asking if the player wants to read the tutorial before playing the game.

During the observation, a number of characteristics were noted:

Judging from their facial and body expressions, a few members of the sample group seemed to grow inpatient as they waited for the ‘Logo’ and ‘Introduction’ screens to complete, before they could then start playing the game. This prompted some members to ask the observers how to skip the screens in order to play the game more immediately, which in turn resulted in further questions about the meaning of the introduction text, and whether it was ‘important’.

Having passed the ‘Logo’ and ‘Introduction’ screens, most members of the sample group dismissed the keyboard layout/tutorial screens in order to start the game. Again, this resulted in the observers being asked to explain the keyboard control mechanisms, in order for some members to be able to play the game.

During the observation it was noted that those who played ‘Math Magic’, complained about the ‘difficulty’ in controlling the ‘magician’ character. This ‘difficulty’ stemmed from the control mechanisms employed by the game, specifically the steps that the player would need to undertake when trying to defeat the green slime ‘fiends’. Upon encountering a ‘fiend’, the player would need to take the following steps:

1. Mentally work out the sum being displayed over the fiend’s ‘head’.
2. Type the correct answer on the computer keyboard, and then press the ‘Enter’ key (to fire a lightning bolt).
3. Repeat Steps 1 and 2, until the player has fired enough lightning bolts to drain all of the fiend’s energy.

The feedback (from those playing ‘Math Magic’) was that the speed of the ‘fiends’ was “too fast”, making the execution of the (above) steps difficult to achieve in a timely manner (i.e. before the ‘fiends’ overwhelm and drain the magician’s energy).

This element of challenge was also increased considerably if there were additional fiends within the vicinity of the player. As a consequence of this, many members of the sample group complained that the game was too difficult to play (as reflected in the grading sheet grades). Surprisingly, despite this, the majority of the group seemed to enjoy the challenge and continued re-playing the game.

Once one member of the sample group had discovered ‘Math Magic’, word soon spread around the class and the majority of the group began playing the game. In a few instances, members were observed discussing strategies with each other as to the best way to try and beat the ‘fiends’.

These strategies included:

- One pair of members discussed dividing the control of the magician, so that one member controlled the magician’s movement (i.e. Up, Down, Left & Right), while the other member typed in the answer to the maths sum and pressed the ‘Enter’ key. The author was unable to ascertain whether this strategy was successful, but noted that the members subsequently made ‘groaning’ noises.

- One sample group member was overheard advising another, to try and ‘out run’ the fiends.

- Another sample group member suggested to his immediate neighbour that he should run away from ‘fiends’ displaying ‘hard’ sums and only attack ‘fiends’ displaying ‘easy’ sums. Upon questioning, the sample group member regarded ‘easy sums’ as sums featuring low single digit addition (i.e. 2 + 7). Unfortunately, neither sample member was successful in this strategy due to the magician control difficulties described previously.

During the observation, it was apparent that ‘Math Magic’ was by far the most popular game in the Design Pilot. Unfortunately, this resulted in only two sample group members taking the time to actually grade the game (‘Bad’ and ‘Very Bad’, Figure 6.13). The author suspects that the few bad grades the game did receive were more a comment on the game’s control mechanism, rather than the game itself.

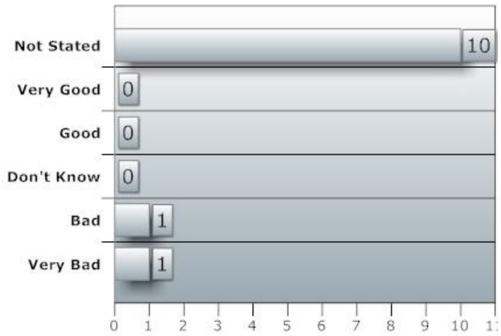


Figure 6.13: Grading Sheet Grades (Math Magic).

Figure 6.14: Math Magic (Yoyo Games 2008a).

6.2.10 Math Balls

As with 'Donkey Kong Jr Math 2' (*6.2.5 Donkey Kong Jr Math 2*) and 'Math Magic' *(6.2.9 Math Magic)*, 'Math Balls' seemed to be quite popular with the sample group.

In 'Math Balls' (Figure 6.16), a maths question is displayed prominently in the lower middle part of the game play area, with two possible answers displayed in the upper left and upper right sides of the game play area. The player controls (via the keyboard) a red ball, which they need to navigate towards the correct answer in order to proceed to the next screen/question. This task is made complicated by the presence of two (or more) blue balls which float around the game play area. Should the player come into contact with these blue balls, they will lose one of their (three) lives. The challenge therefore is to navigate to the correct answer, while avoiding loss of life. With every correctly answered question, the number (and speed) of the blue balls increases, thereby increasing the element of challenge within the game.

The game itself could be considered less colourful and graphically cruder than even 'Donkey Kong Jr Math 2'. However, this did not seem to detract from the sample group's enthusiasm for playing the game, which based on observation, was probably the most popular game after 'Math Magic'. While 'Math Balls' was not quite as popular as 'Math Magic' (based on observation), the game did seem to attract more descriptive grades on the grading sheet, the majority of which were positive ('Very Good').

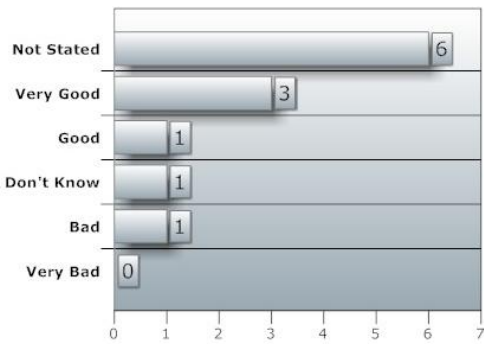


Figure 6.15: Grading Sheet Grades (Math Balls).

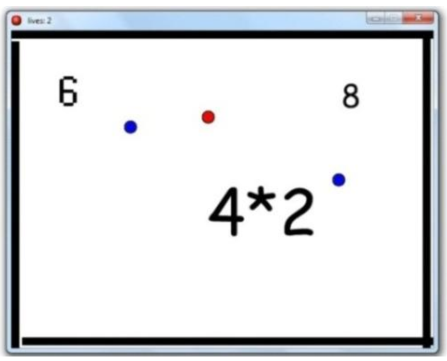


Figure 6.16: Math Balls (Yoyo Games 2009c).

6.3 Design Pilot Conclusions

It was the intention of the author to use the Design Pilot feedback (in conjunction with a design methodology) to develop a series of educational games for the purposes of addressing the thesis research questions (specifically Research Question 1).

Based on the feedback from the Design Pilot, the author draws the following conclusions on what constitutes educational game 'best practice' (for a similar target audience):

In terms of maths presentation, the Design Pilot games adopted two different approaches. Games such as 'Math Explorer 2' and 'MathsBall' use what could be considered a more 'intrusive' approach in terms of delivering their educational content, i.e. both games halt the game play until a maths question is answered. In contrast, games such as 'Math Balls' and 'Donkey Kong Jr Math 2' use a more integrated approach, making the maths content the 'heart' of the game by blending it with the game mechanics and 'fun'. While these games are essentially educational, they present their maths content in a less intrusive way. It was clear from the observation of the sample group, that this latter approach was more popular (in game play terms, if not educationally) than the former approach.

Therefore, for the design of the author's educational games, the author has decided to 'blend' maths content into a game (which in turn, is based on 'classic' games design principles), in such a manner as to make it as non-intrusive as possible. Related to the issue of blending educational content, is the 'art' of balancing 'fun' and education in the appropriate proportions, and in turn avoiding 'Shavian Reversal' – where a game is 'fun' (but not educational) or just 'educational' (and not 'fun').

It could be argued that games such as 'Table Master' and 'Table Trees' are not really games at all, but quizzes designed to test maths knowledge. Of course, for an intrinsically motivated learner there may be no difference between a quiz and a 'fun' game, but during the observation it was apparent (from the few sample group members who did play these 'Table' games), that the quiz like format was unappealing.

Within the literature review, the concept of 'exploration' within a game was suggested as being a motivational feature. This in turn ties in with Malone & Lepper's (1987) views on the motivational qualities of computer games. The majority of the Design Pilot games were simple and single screen based, with limited or no opportunities for exploration (such as 'Math Explorer 2' or 'Math Balls'). The exception to this was the scrolling platform game 'Math Magic' and in a similar vein, 'Tran Towers'. Given the difficulty that the sample group experienced whilst playing 'Math Magic' (the early defeat by the green slime 'fiends'), the element of exploration (along with other factors, such as the challenge and peer interaction) may have contributed to the popularity of the game. 'Tran Towers' might be considered a single screen game, but the game's narrative of exploring a gothic building in search of a 'Treasure Room' did seem (initially) to appeal to some members of the sample group during the observation.

The observation of the sample group playing 'Math Magic' vividly illustrated that not everyone wants to read lengthy instructions prior to the start of playing a game. This should not come as a complete surprise and reflects the different styles (or in the context of education – learning styles) of game players/learners. Therefore, the author is of the opinion that whilst game playing instructions should be provided, they should also be optional. In other words, the provision of in-game help should be as non-intrusive as possible, but still provided to those who wish to utilise it.

Finally, there are two views within the literature on the fidelity of computer game graphics (*3.7.3 Attractive Graphics & Sound*). Some researchers stress the need for the inclusion of high fidelity graphics, whilst others place a greater importance on the implementation of game design principles instead (such as challenge or narrative). During the Design Pilot, it was the author's observation that part of the appeal of 'Math Magic' was the game's polished graphics (and perhaps its similarity to Nintendo's 'Legend of Zelda' games). Equally so, the relative popularity of 'Donkey Kong Jr Math 2', and the greater popularity of 'Math Balls', suggest that high-fidelity computer graphics are not always necessary as long as the game is 'fun' to play and is (generally) aesthetically appealing.

6.4 Conclusion

As part of the methodology for addressing the thesis research questions, the author conducted a Questionnaire Based Survey/Game Review (Chapter 5) and a Design Pilot, in order to obtain feedback on what constitutes educational game design 'best practice'.

In terms of the Design Pilot, the author took a selection of educational games (sourced through the Game Review (Chapter 5)) and trialled them with a sample group. Through a combination of observation and questionnaires, the following conclusions were drawn:

- The sample group preferred games that integrated maths content into the game play as non- intrusively as possible.
- Conversely, the sample group disliked the blatantly mathematical quiz style games and those games which would halt or 'interrupt' the game play, in order to ask a maths question.
- As 'Math Magic' vividly illustrated, the majority of the sample group did not attempt to read the onscreen introductory text, choosing instead to dismiss it in order to proceed more quickly to the game itself. Based on this observation, it is suggested that game instructions are provided through an optional mechanism such as a separate menu item or printed user instructions.
- While higher fidelity graphics may help enhance a game's appeal (as in the case of 'Math Magic'), low fidelity graphics do not necessarily detract from a game, as long as the game is genuinely 'fun' to play and has a general aesthetic appeal (such as 'Donkey Kong Jr Math 2' and 'Math Balls').

Chapter 7 discusses the latter stages of the author's methodology, through the design and development of a series of educational games, a Prototyping Pilot, and the implementation of a Main Study.

Chapter 7: Prototyping Pilot / Main Study

7.1 Introduction

As briefly discussed within Chapter 4, this chapter is concerned with discussing the latter stages of the author's methodological approach to addressing the thesis research questions.

Using the feedback from the Design Pilot (*6.3 Design Pilot Conclusions*), the author utilised both 'classic' game design principles and the ADDIE instructional design methodology to create a series of educational game designs. These designs were subsequently implemented through the use of the games development package 'GameMaker'.

The majority of this chapter discusses the Prototyping Pilot and Main Study conducted by the author (at a local primary school), as part of addressing the thesis research questions. The Prototyping Pilot was designed to trial the author's educational games, using sample group feedback to make further refinements / prototypes, prior to the games' use within the Main Study. The Main Study was conducted with the objective of collecting data, which in turn, would contribute to the addressing of Research Questions 1 to 3.

The associated technical and development issues are discussed, along with the unanticipated ICT usage issues that were encountered during the Prototyping Pilot and the subsequent Main Study. Finally, the results of both the pilot and study are presented and summarised, but research question specific results will be discussed in greater detail within the penultimate chapter (*Chapter 8*)

7.2 Game Design / Development

As detailed in Chapter 5, a Design Pilot was conducted using a selection of educational games. The purpose of the Design Pilot was to obtain feedback on what could be considered 'best practice' in educational game design, and then to utilise this feedback in the development of a series of author developed educational games. The intention was to use these games within the main study, designed to address a number of the research questions identified at the beginning of the thesis (*1.4 Defining the Thesis Research Questions*).

Using the Design Pilot feedback, combined with classic game design principles (identified within Chapter 3) and the application of the ADDIE methodology (*Appendix B* / *Appendix C*), the author produced six educational game designs. Due to issues documented within Chapter 4 (*4.6.1 Implementation / Development*), only four of the original game designs were actually implemented, and then two of these games were subsequently discarded after a period of reflection and feedback from a supervisor conducted pilot (*4.7.2 Pilot / Main Study Game Selection*).

7.3 Final Game Selection

Before discussing the Prototyping Pilot and subsequent Main Study, this section serves to introduce the reader to the final selection of games used within the pilot/study sessions:

Prototyping Pilot:
- Pyramid Panic (Maze game, developed by the author)
- 194X (Flying Shoot 'em Up, developed by the author).

Main Study:
- Pyramid Panic / Space Maze Panic / Block Panic (Developed by the author).
- 194X / 294X / 1982 (Developed by the author).
- Moon Maths ('Whac-A-Mole' style game, sourced from the Game Review).
- Math Balls (Sourced from the Game Review).
- Math Magic (Scrolling Platform game, sourced from the Game Review).

7.3.1 Pyramid Panic

'Pyramid Panic' (Habgood & Overmars 2006) was designed as a traditional maze game and involves the player collecting diamonds scattered around a maze, while at the same time avoiding various enemies. As an educational game, the original game design was developed and modified to include maths content. Therefore, in addition to the diamonds, the game also features a series of multiplication questions with associated answers (1 correct, 3 incorrect) for the player to 'collect' (Figure 7.1).

Figure 7.1: Pyramid Panic

Observations from the Design Pilot suggested that pupils preferred (or tolerated) mathematical content within a game, as long as it was not considered too intrusive (i.e. halting the game play and then 'forcing' the player to answer a maths question before the game play can resume). With this in mind, the author was conscious of 'blending' the educational content into 'Pyramid Panic', as discreetly as possible.

This led the author to place the maths content strategically around the maze area in such a way as to present the player with the following approaches to game play:

- The player could fully participate in the game, and collect the diamonds and attempt to 'collect' the correct answers to the maths questions.
- The player could ignore the maths content and play the game as it was originally designed (i.e. collecting diamonds for 'fun'). However, the design of the maths content was such, that if this approach was used, the player would be penalised, points-wise.
- The player could combine both of the above methods, playing the game for fun, but only attempting the (correct) answering of maths questions where it is unavoidable or appropriate for continued points gathering.

7.3.1.1 Space Maze Panic / Block Panic

Research Question 3 focuses on whether the quality (or fidelity) of a computer game's graphics can have an impact on the game's successful (educational) use.
In order to address this question, two additional versions of 'Pyramid Panic' were produced, one version featuring higher fidelity graphics ('Space Maze Panic') and another version featuring low fidelity graphics ('Block Panic').

Both games are functionally the same as 'Pyramid Panic', in terms of game play, but differ graphically. 'Space Maze Panic' (effectively 'Pyramid Panic in Space', Figure 7.2) features polished science-fiction themed graphics, whereas 'Block Panic' (a 'retro' version of 'Pyramid Panic', Figure 7.3) features low quality graphics, consisting of single coloured shapes (i.e. yellow blocks) and deliberately badly draw stick characters.

As part of the pilot/study, User Guides were produced for all of the games. A representative example (for 'Pyramid Panic') is included within Appendix D.

Figure 7.2: Space Maze Panic

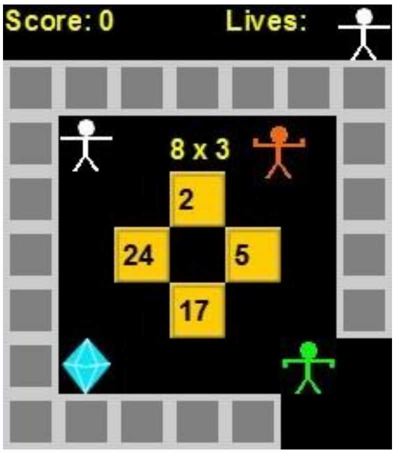


Figure 7.3: Block Panic

7.3.2 194X

'194X' (Figure 7.4) is a flying themed 'shoot 'em up' that involves a player battling a series (or 'waves') of enemy planes. The enemy planes fly in from different directions, some with the ability to fire at the player. Upon completion of the single level, the player is presented with an End of Level 'Big Boss' which they must defeat in order to complete the game.

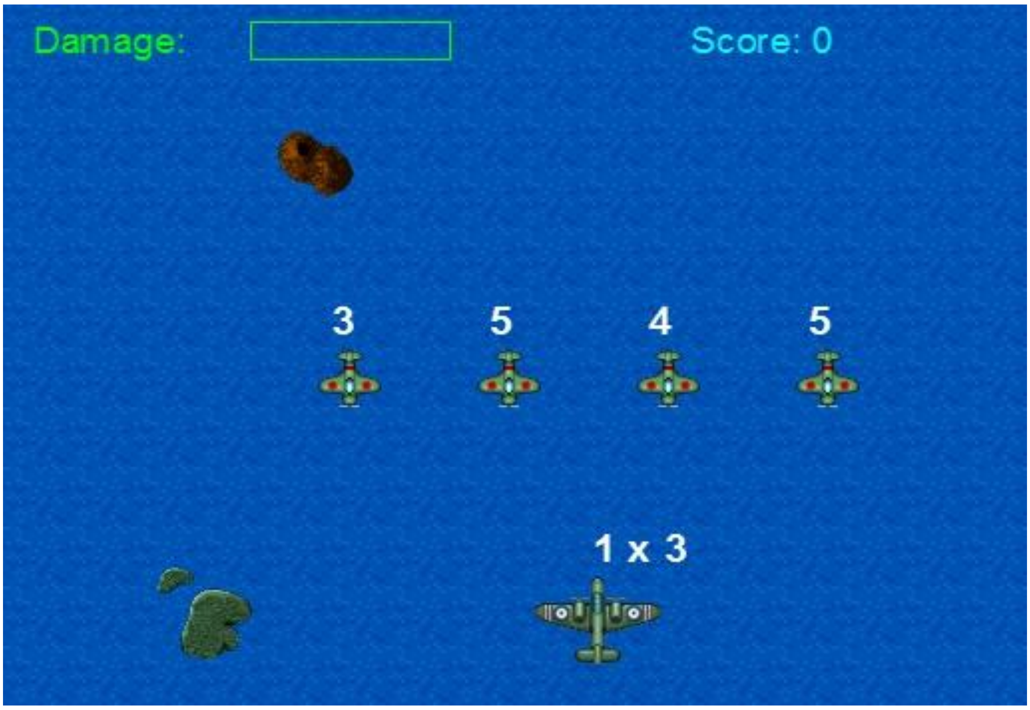


Figure 7.4: 194X

As with ‘Pyramid Panic’, ‘194X’ blends maths content into the ‘classic’ game design of Capcom’s ‘1942’ series of arcade games (Campbell 2008). A maths question is displayed (above the player’s plane), and each enemy plane within the current ‘wave’ (four planes in total) displays a potential answer to that question. The level contains a total of twelve ‘waves’ – reflecting the twelve levels (i.e. 1 x 7, 2 x 7 ... 12 x 7) of the selected time’s table.

Within ‘194X’, the maths content is strategically placed to allow the following approaches to game play:

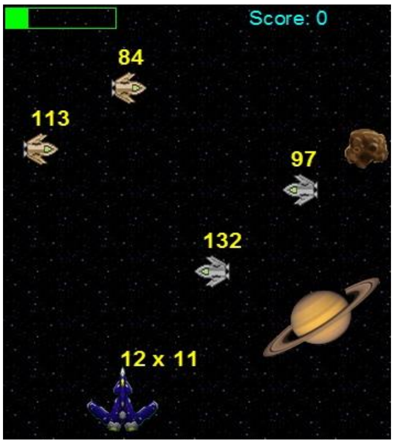
- The player could fully participate in the game, and strategically shoot down only the enemy planes displaying the correct answer to the current maths question. This approach requires the most game playing skill and will attract the highest level of points.
- The player could ignore the maths content of the game and concentrate on shooting down as many enemy planes as possible. This process may be considered more ‘fun’, but will also result in negative points i.e. the player is penalised for shooting the (mathematically) ‘wrong’ planes.

7.3.2.1 294X / 1982

Research Question 3 focuses on whether the quality of a computer game’s graphics can have an impact on the game’s successful (educational) use.
In order to address this question, two additional versions of ‘194X’ were produced, one version featuring higher fidelity graphics (‘294X’) and another version featuring low fidelity graphics (‘1982’).

Both games are functionally the same as ‘194X’ (in terms of game play), but differ graphically. ‘294X’ (effectively ‘194X in Space’, Figure 7.5) features polished science-fiction themed graphics, whereas ‘1982’ (a ‘retro’ version of ‘194X’, Figure 7.6) features low quality graphics (reminiscent of early-1980’s arcade games) consisting of single coloured shapes (i.e. yellow triangles).

As part of the pilot/study, User Guides were produced for all of the games. A representative example (for ‘194X’) is included within Appendix D.



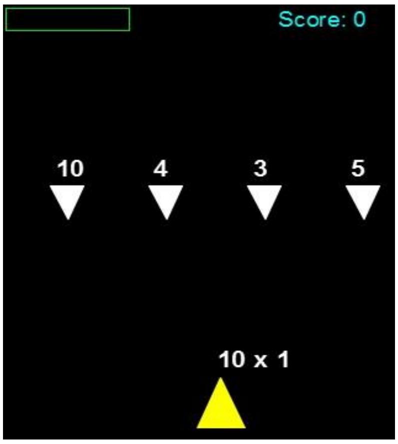


Figure 7.5: 294X

Figure 7.6: 1982

7.3.3 Moon Maths

‘Moon Maths’ is the first (of three) substitutions for the author developed games removed from the Main Study. ‘Moon Maths’ is an Adobe Flash based game available online (Primary Resources 2011a) and takes the approach of the well-known ‘Whac-A-Mole’ game format. The lunar landscape of ‘Moon Maths’ (Figure 7.7) consists of five craters, from which green aliens ‘pop up’ displaying potential answers to the currently displayed maths question (displayed in the top right of the screen). The player has to click on the alien (displaying the correct answer) before it disappears off screen (or ‘pops down’ back into the crater).

7.3.4 Math Balls

‘Math Balls’ (Figure 7.8) is the second (of three) substitutions for the author developed games removed from the Main Study. ‘Math Balls’ is available as a free download from the YoYo Games Community website. As YoYo Games are the developers of the game development package ‘GameMaker’, the Community website serves as a repository for user-submitted games developed with the ‘GameMaker’ software. ‘Math Balls’ is an interesting game, due to its simplicity and the fact that it is openly ‘educational’.

In the game, a maths question is displayed with two possible answers. The player needs to navigate (via the keyboard) a red ball towards the correct answer in order to proceed to the next screen/question. This task is complicated by the presence of two blue balls which float around the screen. Should the player come into contact with these blue balls, they will lose one of their (three) lives. Therefore the game could be considered openly educational, with elements of challenge (i.e. avoiding the blue balls) thrown in to create 'fun'. This approach was generally well received by the sample group during the Design Pilot.

7.3.5 Math Magic

'Math Magic' (Figure 7.9) is the final substitution for the author developed games removed from the Main Study. As with the game 'Math Balls', 'Math Magic' is available as a free download from the YoYo Games Community website.

'Math Magic' is a scrolling maze-like game, where the player has to defend him/herself against maths-sum-displaying ('Green Slime Fiend') enemies. As the enemy approaches the player, it displays a maths question. In order to shoot the enemy, the player must first type the correct answer to the maths question and then press the 'Enter' key. This process needs to be repeated several times over in order to ultimately defeat the enemy.

During the Design Pilot, 'Math Magic' divided the opinion of the sample group. Group members were attracted by the game's polished graphics and professional presentation. However, many had difficulty with the game's control mechanism, finding the process of shooting the enemy unintuitive. Additionally, the high speed of the game made this process difficult to complete, resulting in (more often than not) the premature ending of the game. Despite these flaws, the enthusiasm for the game was visibly noticeable. Because of 'Math Magic's originality in its approach to maths, it was felt that it would be appropriate to re-include this game as part of the Main Study.

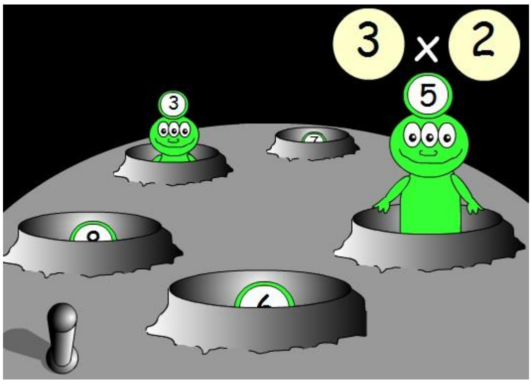


Figure 7.7: Moon Maths
(Primary Resources 2011a)

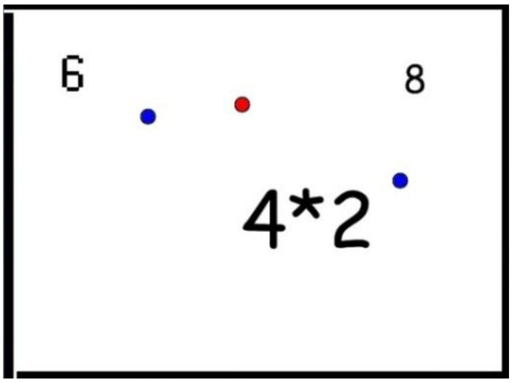


Figure 7.8: Math Balls
(Yoyo Games 2009c)

Figure 7.9: Math Magic
(Yoyo Games 2008a)

7.4 Prototyping Pilot / Main Study Background

7.4.1 Overview

Having initially completed the game development process, the author conducted a series of 'game playing' sessions, at a local primary school. The initial sessions formed the basis of a 'Prototyping Pilot', designed to trial the author's educational games, using the sample group feedback to make further refinements / prototypes, prior to the games' use within the Main Study. The Main Study itself was designed to address thesis Research Questions 1 to 3, supported by the literature review.

The pilot and subsequent study formed part of the primary school's 'Funky Friday' programme. Every Friday, pupils can opt to participate in a range of activities (both indoor and outdoor) including orienteering, sports or (as in this case) ICT related classroom activities. As such, the pilots featured a sample group that were not a standard form class, but consisted of those pupils whom had opted for the ICT class component of the 'Funky Friday' programme.

7.4.1.1 Sample Group

For the purposes of consistency, the same sample group was used throughout the Prototyping Pilot and the subsequent Main Study. The sample group comprised of 28 pupils, drawn from Key Stage 2, Years Three and Four. According to the Class Teacher, the group contained a mixture of maths attainment, including 3 or 4 pupils who were considered to have 'higher level maths skills'.

7.4.1.2 Pilot / Study Environment

The pilot/study were conducted in the same school classroom, which was well heated (due to the colder weather at that time) and was well lit through natural and (when appropriate) artificial lighting. In terms of ICT provision, the classroom permanently featured three desktop computers (one connected to an interactive whiteboard) and was supported by the availability of 'netbook' computers (designed for mobile use, and therefore not dedicated to a specific classroom).

The Prototyping Pilot and the subsequent Main Study consisted of several classroom sessions over a period of nearly three months. The Main Study saw slight fluctuations in the class size (i.e. due to pupil sickness) and a brief interruption by the break for Easter term. The sessions were conducted by the Class Teacher, with the author assuming an observational role (*4.3.3 Observations*), with the exception of occasionally assisting the Class Teacher to troubleshoot any unexpected technical problems.

7.4.1.3 Main Study Scope

As part of addressing Research Questions 1 to 3, the Main Study was concerned with introducing a selection of educational games to the sample group and obtaining feedback on the games themselves, the various genres that they represent, their graphical fidelity, and the maths content of the games.

7.4.2 Technical Issues (General)

The author had anticipated technical issues with the implementation of the Prototyping Pilot (and the subsequent Main Study), and therefore the decision to select a school with full time I.T. support proved to be a wise one.

Prior to the start of the Prototyping Pilot, the author visited the primary school in order to review their I.T. facilities. All of the games (to be used during the Prototyping Pilot/Main Study) were tested on all of the available school computers, and could be played without issue. However, when attempting to play the author developed games on the school's netbook computers, the games would fail to display correctly due to the low resolution screens that are part of the netbook standard. This prompted the author to conduct additional development work on 'Pyramid Panic' and '194X' (and their low/higher fidelity variants) in order to ensure their display compatibility when played on the netbook computers.

During the Prototyping Pilot sessions, a number of technical issues were encountered.
Initially, all of the pilot/study games were stored on the school's network servers. However in the early pilot sessions, the netbooks had difficulty connecting to the school wireless network, which in turn prevented the sample group from being able to access and play the games. As a consequence, the author (along with the school's I.T. Technician) had to manually copy the games, via a USB memory stick, onto all 17 netbooks in order for the sample group to be able to initially access the games.

It was later discovered that the wireless connectivity issues were due to energy saving ('eco-power') settings on the wireless network backbone (routers) and the mixture of (Samsung/MSI) branded netbooks using differing (but 'compatible') wireless networking standards. Once these issues were resolved, both the wireless network connectivity and the performance improved with no significant problems for the duration of the Prototyping Pilot and subsequent Main Study.

Throughout the pilot/study sessions, it was noticeable that the netbooks (by their very nature) were underpowered due to the combination of their limited memory and low speed Intel Atom processors. This resulted in a general perception that the netbooks were 'sluggish' to use, especially when loading the pilot/study games. As a consequence, members of the sample group would load a game, mistake the slow loading as a failure, and attempt to load the game again – resulting in multiple copies of the game loading up and causing the netbook to lock up. There was no real solution to this problem, other than to tell the sample group to click on the program icon once and wait for the game to load (which in some cases, took up to several minutes).

7.4.3 ICT Usage Issues

While not a 'technical' issue as such, the fact that most of the pilot/study games featured music and sound effects did pose an unforeseen problem. Unlike the desktop computers, the netbooks featured built-in speakers, which were enabled by default. During the setup of the first Prototyping Pilot session, it quickly became apparent that the volume of noise generated by the multiple netbooks individually playing different music (and sound effects) would interfere with the teacher's classroom management. This led to the author having to individually mute each netbook's built-in speakers (via the Windows Sound Panel) and ensure that they remained muted during the subsequent sessions.

For the initial pilot sessions, the author attended the school approximately two hours before the start of each session, in order to prepare the designated classroom. This preparation involved locating the resident I.T. Technician in order to discover the current location of the netbooks, which due to their mobile nature, would be utilised within different classrooms. Once located, the netbooks would then need to be transferred to the designated classroom, which (depending on the netbooks current classroom location) involved walking between two separate (but joined) buildings of the school. This situation was further exacerbated by the lack of a trolley to carry the (17) netbooks, necessitating several trips between the current classroom and the designated classroom.

In order to maximise the in-class ‘game playing’ time, the netbooks (and two of the desktop PC’s) were ‘set up’ prior to the start of the pilot/study sessions, thereby allowing the pupils to enter the classroom and use the netbooks/desktops immediately (after a brief introduction by the Class Teacher).

The process of ‘setting up’ the netbooks was quite time-consuming, and involved the following steps:

- Switching on each netbook and waiting for it to boot into Microsoft Windows XP. This procedure alone would take several minutes due to the underpowered hardware inherent within the netbooks. In theory, the netbooks would be fully charged, but in situations where this was not the case, a power lead would have to be sourced and a power socket located, in order to power the netbook from the mains electricity.

- Upon boot up, the netbooks (and desktops) would be manually logged into the school computer network, using the credentials provided to the author, by the I.T. Technician. The process of successfully logging into the network also took several minutes to complete, more so on the netbooks due to their wireless connection.

- The netbook internal speakers would be muted through the Windows XP volume control. This was a necessary step to perform, as mentioned, in order to avoid the sound pollution of the 17 netbooks playing sound and music at the same time. This step was skipped for the desktop PC’s, as they did not feature internal speakers or have external speakers attached.

- Due to the ‘sluggish’ time delay encountered when loading the pilot/study games, the author felt it wise to start each session with at least one game pre-loaded, reducing the amount of in-class time spent on loading the games. As a result, one of the games would be loaded, which in turn took one or two minutes to complete. This issue only applied to the netbooks, and was not present when loading the games on the two desktop PC’s.

Although this setup process initially took two hours, with practice, the author was able to streamline it to around an hour (on average) per session. Over the subsequent weeks the setup process was further reduced to around 45 minutes, whenever the I.T. Technician was available to assist. Once members of the sample group became familiar with the author's presence, one or two of the pupils were able to assist the author in transferring the netbooks to the designated classroom. On these occasions, it was possible to reduce the setup process time by a further 10 to 15 minutes.

This process was further complicated by the following additional issues:

- On occasion, the time available to successfully complete the setup process was reduced due to the author not having immediate access to the designated classroom (i.e. because of a previous class still using the classroom).
- Conversely, upon completion of the session, the author would have to shut down all of the netbooks and transfer them back to their original classroom location, a process made difficult (without assistance) if the designated classroom was to be used immediately by another class.

The author found the experience of classroom preparation to be an informative one, and while expecting technical issues (*7.4.2 Technical Issues (General)*), was not anticipating the usage issues described within this section. For the author, the experience illustrated the importance of planning (i.e. allowing enough setup/preparation time for the sessions) and the value of classroom assistance (i.e. in this case, the availability of an I.T. technician) when conducting ICT (classroom) related activities.

7.4.4 Development Issues

In response to the feedback from the Prototyping Pilot, additional development work was conducted on the author developed games, 'Pyramid Panic' and '194X', in preparation for the Main Study. In order to test Research Question 3, two additional versions of 'Pyramid Panic' and '194X' were produced: one version featuring higher fidelity graphics and another version featuring low fidelity graphics.

Producing the low fidelity versions of both games was relatively straight forward and involved substituting the reasonable quality (2D multi-coloured) in-game graphics with single coloured one dimensional graphics, such as squares, rectangles or triangles. Additionally, sound and music within the games was removed (or reduced) in order to enhance the games' 'low fidelity' image.

Producing higher fidelity versions of both games proved to be a greater challenge, and was constrained by the author's limited graphical design skills and experience. Due to this constraint, the author was heavily reliant on sourcing pre-produced 'higher quality' graphics (often referred to as 'sprites') from the Internet, in order to replace the existing in-game ones. The consequence of this dependency placed limitations on how higher the fidelity the final versions of 'Pyramid Panic' and '194X' could be.

During subsequent Internet searches, the theme of science fiction seemed to yield higher quality sprites (in comparison to other 'themes'). Given the view that a fantasy-based narrative increases interest and motivation in a game, this theme was adopted for the higher fidelity versions of both games (Van Eck 2006, Habgood & Overmars 2006, Gunter, Kenny & Vick 2008).

In theory, the implementation of alternative sprites should have been straightforward. However, in the author's experience, this was not the case. Producing sprites is both an important and a time-consuming part of the development process which, within a commercial setting, would be produced by several graphic designers within a quality controlled environment (Handby 2012). However (as previously mentioned) due to the author's limited graphical design skills and a lack of access to commercial quality graphic designers, alternative sprites had to be sourced from the internet.

In one respect, it could be argued that the use of pre-produced sprites should reduce game development time, which would have ordinarily been spent on creating the sprites in the first place. However the downside to this approach is that game developers have no control or influence over how these sprites are actually produced, and if the sprites are not quite as required, additional graphics/editing work may have to be performed. This was certainly the author's experience of the Internet sourced sprites.

Aside from the (expected) issues relating to the quality/resolution and resizing of the sprites, there was also the issue as to whether the sprites featured background transparency (so that they would transparently blend into the existing in-game graphics). Editing these graphics and manually creating background transparency was both a time consuming and (dependent on the actual graphic) a difficult process. Technical difficulties aside, the process of sourcing the sprites was not without issue – namely trying to ensure that the sprites were of consistent quality and that they reflected the same theme/style as the rest of the graphics featured within the game(s).

7.5 Prototyping Pilot

7.5.1 Background / Overview

The Prototyping Pilot was conducted in order to obtain feedback, from the sample group, in relation to the author developed games 'Pyramid Panic' and '194X'. For the duration of the pilot, individual group members (at the request of the Class Teacher) paired-up and took turns playing the author's games and filling in the related sections on a questionnaire ('Game Format Grading Sheet', *Appendix E*). In addition to the questionnaires, the sample group were also observed while playing the games.

7.5.2 Observations

The author approached the pilot sessions with an open mind in terms of how the sample group would react to the author's developed games. Fortunately, through observation, the sample group generally appeared to react positively towards the games, which the author credits to the decision to base the games on classic 'games design' principles. The exception to this positive reaction was the sample group's view that the games were 'too fast' to play.

Through observation it appeared that the sample group found the speed of the enemies difficult to deal with, leading some to complain that they were losing their 'lives' too quickly (or 'planes' in the case of '194X'). It occurred to the author, that the speed of the enemy characters was originally programmed *before* the maths content was added to the games. Originally the player was only required to 'shoot the enemy', whereas post maths content, they were now required to 'complete the sum and then shoot the enemy' – a process that requires more steps to complete, with no additional (in-game) time allowance made for this increased complexity.

7.5.3 Questionnaire Results

Each paired set of group members was given a questionnaire (*Appendix E*) to fill out, in order to gain feedback on the pilot games. The results of the (13) returned questionnaires are summarised below.

Initial questions used a ranking system of grading the games on a scale of **1** to **5** (**1** = Very Good, **2** = Good, **3** = Don't Know, **4** = Bad, **5** = Very Bad). Additionally, space was provided for the sample group to provide optional comments on the individual questions.

How would you grade the following games?

194X

In terms of grades, respondents expressed a mixed reception towards '194X'. This was also reflected in some of the comments – "*Ok but difficult*", "*Little bit hard and a little bit good*".

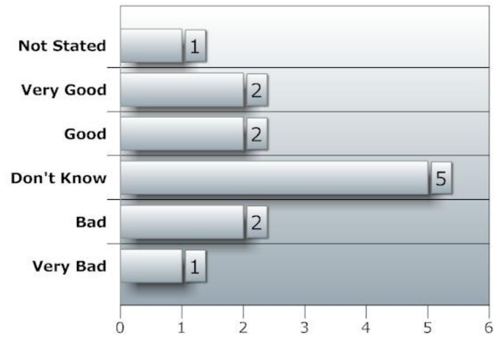


Figure 7.10: 194X Grades

Pyramid Panic

Both grades and comments showed a general liking for the game. Comments included, "*Another one that is good for times tables*", "*The game is amazing it is the best one*" and "*I like it very good*".

Verbal feedback (during the observation) suggested that the game speed and the presence of enemies made the game harder, hence the few 'Very Bad' grades.

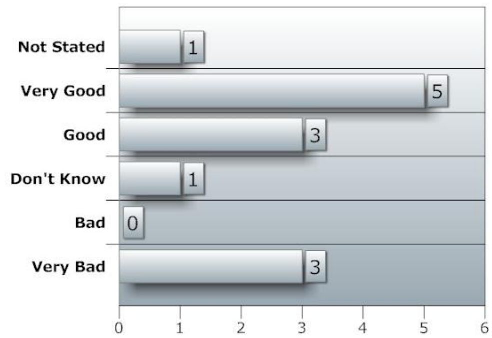


Figure 7.11: Pyramid Panic Grades

If you could, how would you improve the following games?

This question is open-ended and designed to elicit feedback about the pilot games in general. The intention was for this feedback to aid the further development of the author's developed games, in preparation for their use within the Main Study.

194X

A number of suggestions were made as to how to improve '194X'. However, the majority of these related strictly to game play ("*more planes*", "*make the* (players) *plane invisible*"), rather than anything educationally related. Two comments were made about making the game 'easier' to play ("*Make it a bit more easy*", "*A bit easier*"), whilst one respondent stated "*It needs to go slower*".

Pyramid Panic

Broadly, the comments returned for this question related to how much fun the game was, rather than specific improvements ("*Very very like it*", "*It is so good*"). Specific comments of interest referred to removing or reducing the enemies within the game ("*Less monsters*", "*Without zombies*", "*No creepy crawlys*").

7.5.4 Prototyping Pilot Summary

Reviewing the feedback from the Prototyping Pilot, the author was generally reassured that his developed games would be suitable for inclusion in the subsequent Main Study.

However, feedback (both verbal and through observation) suggested that the pace of game play within the games was too 'fast'. It was the author's contention that the game play was not in itself 'too fast', but that the process of performing mental arithmetic *and* performing the expected game task (i.e. such as collecting diamonds or shooting enemy planes) was more time consuming/challenging than the original game design had anticipated.

Specific questionnaire comments of interest related to the removal of the enemy characters from within the 'Pyraimid Panic' game.

7.6 Main Study

7.6.1 Background / Overview

The Main Study was conducted with the objective of collecting data, which in turn, would contribute to the addressing of Research Questions 1 to 3.

At the request of the Class Teacher, members of the sample group paired-up and took turns playing the study games and filling in the related sections on a questionnaire ('Game Graphics Grading Sheet', *Appendix E*). In addition to the questionnaires, the sample group were also observed while playing the games (Appendix F).

The results from the questionnaires (along with notes from the observations) will be presented within this chapter, while the research question specific results will be discussed in greater detail within the next chapter (*Chapter 8*).

During the Prototyping Pilot, feedback indicated that the author developed games ('Pyramid Panic' and '194X') were 'too fast' in terms of game play. Feedback, in relation to 'Pyramid Panic', also suggested the removal of enemy characters from within the game. As part of addressing Research Question 3, the author embarked on the production of higher and low fidelity versions of the author's original (medium fidelity) games. During this process, the author also took the opportunity to incorporate the pilot feedback into all of the final games (Low, Medium and Higher Fidelity versions)

As a result, the game play speed of '194X', '294X' and '1982' was reduced in order to make the games 'easier' to play (or at least "*less fast*", to quote one sample group member). In practice, the player would have more time to answer the maths question and perform additional tasks (i.e. shoot the enemy) in unison.

Within ‘Pyramid Panic’ and ‘Space Maze Panic’, the speed of the multiple enemies was reduced in order to achieve the similar effect of slowing down the game play speed.
Based on the comments made during the Prototyping Pilot sessions, the decision was taken to specifically remove the presence of enemies from ‘Block Panic’, simplifying the game to collecting diamonds and/or answering the maths questions scattered around the maze.

7.6.2 Observations

During the Main Study sessions, a number of observations were made:

Once loaded, the game ‘Math Balls’ presents the player with a menu screen featuring a set of options, including the option to select the level of game difficulty and an option to begin playing the game. During one of the sessions, two sample group members asked the author for help in ‘starting’ the game, stating that the ‘Start game’ option was ‘not working’. Upon initial inspection, the author discovered that none of the menu options would actually respond to being ‘clicked on’ by the mouse cursor. Through repeated attempts, the author discovered that the player had to mouse ‘click’ slightly off to the left from the menu items, in order to actually select them. This issue was not resolved, but once the sample group was made aware of it, they were able to successfully start the game.

The author observed two sample group members alternating between the game’s two difficulty settings (‘Easy’ or ‘Hard’). Upon questioning, both members expressed the view that selecting the ‘Easy’ option made the game ‘too easy’, but the ‘Hard’ option made the game ‘too hard’. These opinions may have been a result of the game’s maths content not being specifically aimed at the sample’s age group (i.e. Key Stage 2) or the mixture of maths levels (Year 3 / 4) within the sample group.

The game ‘Math Magic’ prompted some negative feedback, with those playing the game expressing dissatisfaction with the game play, specifically, the speed with which they were required to type an answer and then press the ‘Enter’ key in order to ‘fire’ upon the green slime fiends. In light of the Design Pilot, this observation was not unexpected.

The sample group seemed familiar with the game 'Moon Maths'. Upon questioning, one sample group member explained that they (i.e. his class) were occasionally allowed to play the game in class. While unable to be more specific, the Class Teacher confirmed that occasionally school pupils would be introduced to the Primary Resources website (where 'Moon Maths' is hosted). During one of the sessions, one paired set of sample group members discovered that the game would occasionally (incorrectly) correct the player's answers. This was repeated on two occasions, but was not reproduced by other members of the sample group.

In terms of the author developed games, the following behaviours were noted:

Within one early session, one sample group member was observed playing '194X' for approximately 10 minutes, at which point he enthusiastically pointed at the computer monitor screen and asked the author to look at his 'high score'. The score was high, but in negative (-) numbers. It was apparent to the author that this group member was shooting all of the enemy planes for 'fun' and ignoring the maths content of the game.

In contrast to the Prototyping Pilot, two sample group members were observed playing '194X' from a maths point of view i.e. only shooting down enemy planes displaying the 'correct' answer to the current sum.

Some sample group members expressed views or asked questions to the effect that suggested that they regarded 'Space Maze Panic' as a 'new' game (despite being 'Pyramid Panic' with outer space themed graphics / music).

In spite of its crude 'retro' graphics, 'Block Panic' was surprisingly popular in contrast to 'Space Maze Panic' and 'Pyramid Panic'. The author's perception was that the sample group was finding the game easier to play. The author notes that 'Block Panic' is the only version of the 'panic' games with the enemy characters removed, The game '1982' also seemed to be quite popular with the sample group, despite its old fashioned 'retro' computer graphics. Two group members verbally referred to the game as "*Ace!*" and (the) "*best game!*".

7.6.3 Questionnaire Results

Each paired set of group members was given a questionnaire (*Appendix E*) to fill out, in order to gain feedback on the study games. The results of the (13) returned questionnaires are summarised below.

Initial questions used a ranking system of grading the games on a scale of **1** to **5** (**1** = Very Good, **2** = Good, **3** = Don't Know, **4** = Bad, **5** = Very Bad). Additionally, space was provided for the sample group to provide optional comments on the individual questions.

How would you grade the following games?

Moon Maths

'Moon Maths' received good feedback from the respondents. This may be due, in part, to prior familiarity with the game (as noted during the observation) and its relative simplicity.

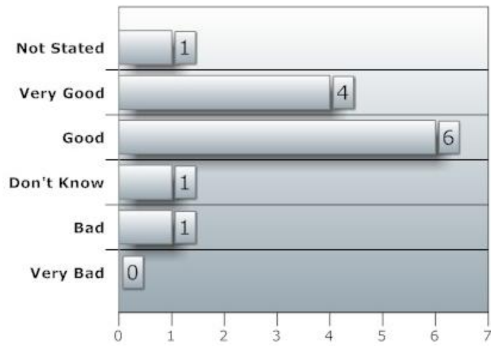


Figure 7.12: Moon Maths Grades

Math Balls

Both the observation and the grades from the questionnaires reveal the popularity of 'Math Balls'. Comments associated with this question, suggested that the game was considered difficult to play ("*It was confusing but still a good game*", "*Think its a bit hard*"). However, this difficulty seemed not detract from the overall respondent enjoyment of the game ("*It was quite good*", "*Awesome*").

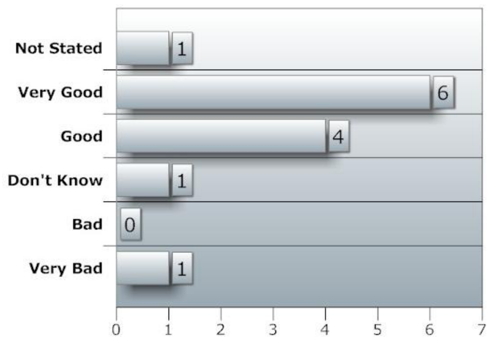


Figure 7.13: Math Balls Grades

How would you grade the following games? (cont.)

Maths Magic

While a polished game (graphically), comments suggested that 'Math Magic' was considered difficult to play – "*It is too hard*", "*It needs to be a bit easier*".

Respondents were observed having difficulty with the player control system and the general speed of the game, mirroring the observations made during the Design Pilot (*6.2.9 Math Magic*).

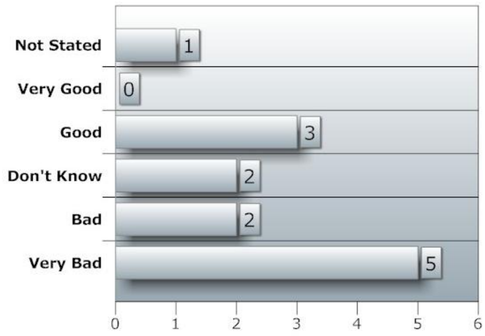


Figure 7.14: Maths Magic Grades

Which format of game do you prefer?

While the grades awarded were straightforward to analyse, the questionnaire comments were sometimes difficult to interpret and did not always clearly indicate that they were specifically about the genre/game format itself.

The questionnaire responses should therefore be interpreted with this aspect in mind.

Point and Click

A number of respondents left the comments section blank. Where comments were made, they seemed to be in favour of the 'genre' (as reflected in the grades given).

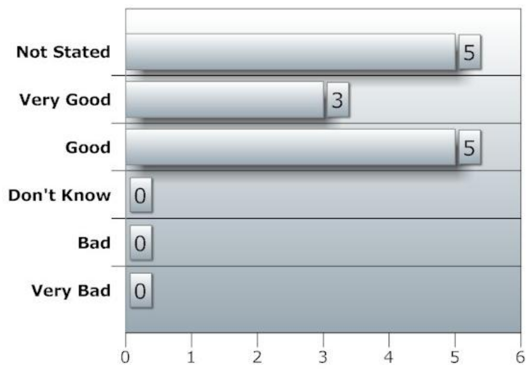


Figure 7.15: Point & Click Grades

Which format of game do you prefer? (cont.)

Flying Games

A number of respondents left the comments section blank. Where comments were made, they seemed to be split between liking and not liking the 'genre' ("*Hard*", "*I did not know what to do*", "*I like this game*", "*I feel very good*").

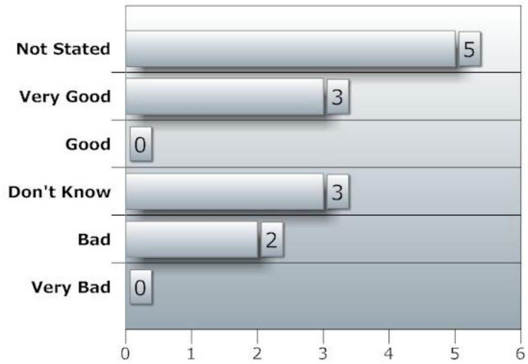


Figure 7.16: Flying Games Grades

Maze Game

While the grades suggest a positive view of the maze game genre, written comments suggest a more even like/dislike split: "*I like this better because it is more complicated*", "*Pyramid panic (5), maths magic (2)*".

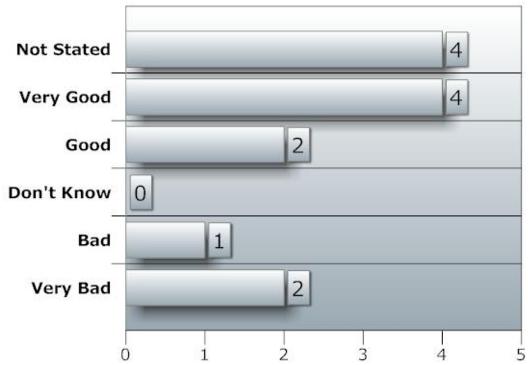


Figure 7.17 Maze Game Grades

How did you find the math questions in the games?

As with the previous question, while the grades awarded were straightforward to analyse, the questionnaire comments were sometimes difficult to interpret and did not always clearly indicate that they were specifically about the maths content itself.

The questionnaire responses should therefore be interpreted with this aspect in mind.

As before, a ranking system was used to grade the maths content on a scale of **1** to **5** (**1** = The Math was Good!, **2** = It was OK, **3** = Don't Know, **4** = I Disliked the Math!, **5** = Would Prefer No Math!).

How did you find the math questions in the games? (cont.)

Moon Maths

While comments* suggested a favourable view of the maths content (within this game), the grades awarded suggest otherwise. This may be due to ‘Moon Maths’ being the most openly ‘educational’ game within the pilot i.e. there is no option but to play the game *educationally* (by clicking on potential answers).

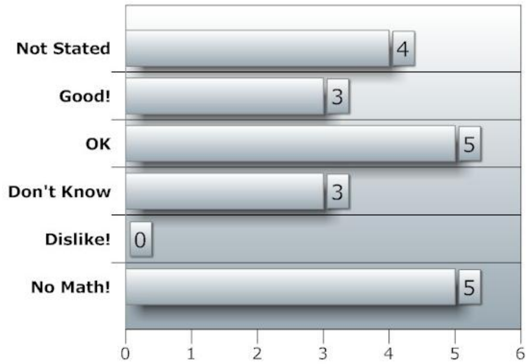


Figure 7.18: Moon Maths Grades

* “*The maths was really fun*”, “*It is good and the maths is very good as well*”, “*I think it needs more maths*"

194X

The grades suggest a split between ‘Don’t Know’ and ‘Dislike’.

Where comments* were included, it was unclear as to whether the respondents were referring to the maths content (within this game) or the actual game itself.

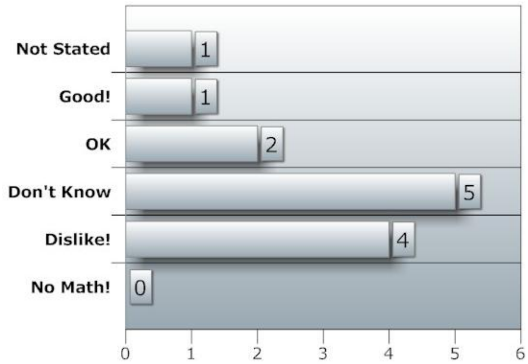


Figure 7.19: 194X Grades

* “*You have to be fast*”, “*I did not get it*”, “*Good*”, “*We think it was ok*”

How did you find the math questions in the games? (cont.)

Math Balls

In terms of grades, the respondents awarded slightly more favourable grades (4 x 'Good', 3 x 'OK'), than unfavourable grades (3 x 'Dislike!', 2 x 'No Math!').

In terms of comments, respondents expressed favourable views ("*The maths was quite fun*", "*The maths was really good*") towards the maths content (within this game), while also commenting on the 'difficulty' of the game ("*Easy maths, hard to get numbers*", "*Hard even when on easy*", "*It gets harder*").

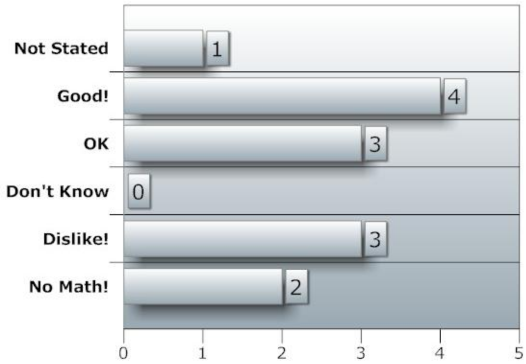


Figure 7.20: Math Balls Grades

Pyramid Panic

The grades suggest that this game was popular with respondents, with comments along the lines that the maths content was "*OK*" and "*helped me with my times tables*".

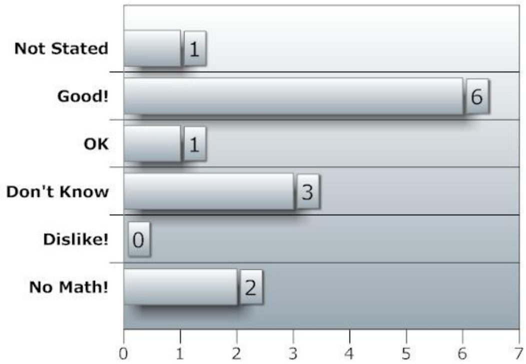


Figure 7.21: Pyramid Panic Grades

How did you find the math questions in the games? (cont.)

Maths Magic

While the grades suggest a three way split between 'OK', 'Don't Know' and 'No Math!', the respondents' comments were overwhelmingly negative ("*I did not like it*", "*It is very bad I don't like it at all*", "*It is pretty hard and confusing*").

It was unclear as to whether the respondents were referring to the maths content (within this game) or the actual game itself.

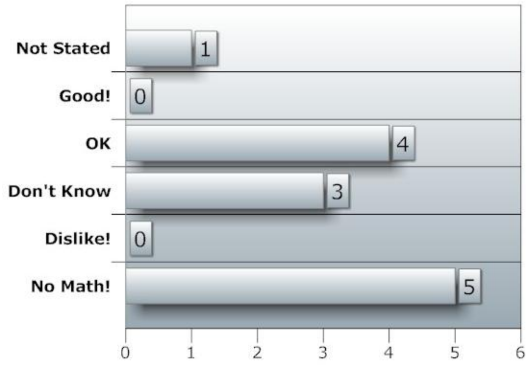


Figure 7.22: Maths Magic Grades

How would you grade the computer graphics for the following games?

It should be noted that some of the written comments to this question suggested that the respondents were commenting (and potentially grading) on the games themselves, rather than the quality of the graphics.

The questionnaire responses should therefore be interpreted with this aspect in mind.

194X

Both grades and comments were positive, but the comments made no reference to the quality of the computer graphics.

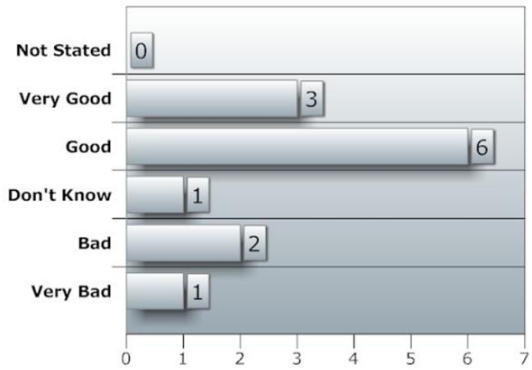


Figure 7.23: 194X Grades

How would you grade the computer graphics for the following games? (cont.)

294X

'294X's graphics were graded higher than '194X' (mirroring '194X's 'Good's with 'Very Good's). Comments were generally positive, but made no reference to the quality of the computer graphics. However, one respondent did specifically comment that the game had a "*Better background*" – presumably when compared to '194X' and '1982'.

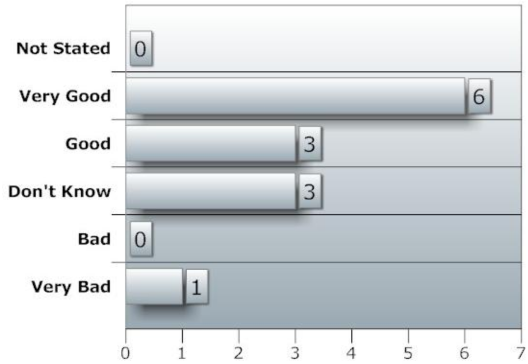


Figure 7.24: 294X Grades

1982

Despite its rudimentary graphics, '1982' was scored well by the respondents. As with the other versions ('194X' / '294X'), the comments were generally positive, but with no reference to the quality of the computer graphics. However, one respondent did comment "*I like the new graphics*".

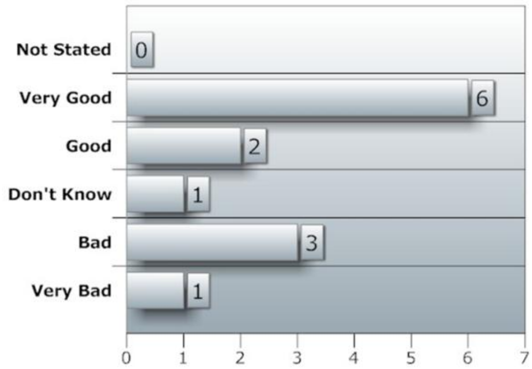


Figure 7.25: 1982 Grades

Pyramid Panic

Grades suggest a split between 'Very Good' / 'Good' and 'Don't Know'. Comments were generally positive, but with no reference to the quality of the computer graphics.

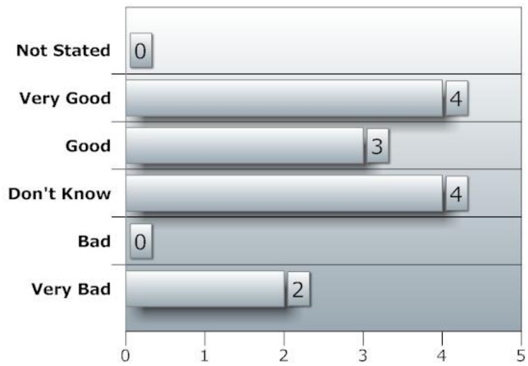


Figure 7.26: Pyramid Panic Grades

How would you grade the computer graphics for the following games? (cont.)

Block Panic

The grades show that 'Block Panic' was (graphically) the most popular version of the 'maze' games. However while most of the comments were positive, they did not reference the quality of the computer graphics.

Figure 7.27: Block Panic Grades

Space Maze Panic

'Space Maze Panic' received a mixed reception in terms of grades with almost equal numbers grading the game graphics as 'Very Good', 'Good' and 'Bad'. The comments were varied but did not reference the quality of the computer graphics.

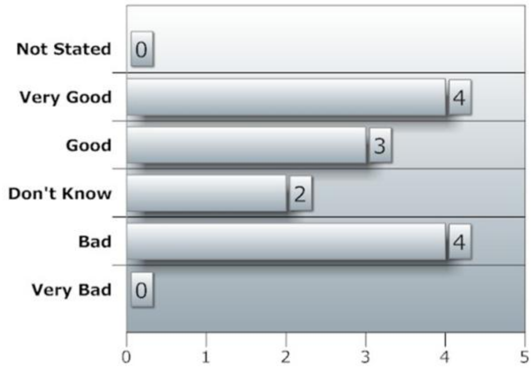


Figure 7.28: Space Maze Panic Grades

However, one respondent stated "*I like the new graphics*", whereas another commented "*A bit hard to see*".

How much fun were the following games to play?

This question required the respondent to rank each game on a scale of 1 to 5 (**1** = Great Fun, **2** = Fun, **3** = Don't Know, **4** = A little Fun, **5** = Not Fun).

To some extent, it could be interpreted that comments on the popularity/unpopularity of the games have already been made within the feedback for the previous questions, although admittedly this was not their intended purpose.

The grades for this question (awarded per game) are summarised overleaf:

Figure 7.29: 1982 Grades

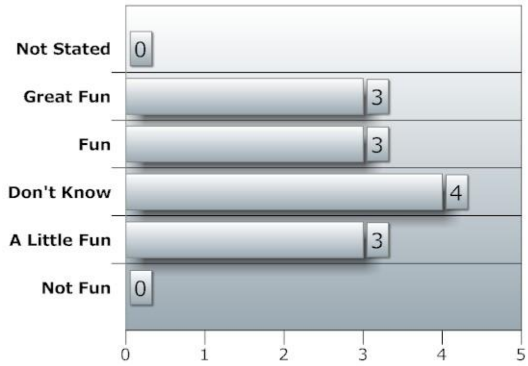


Figure 7.30: 194X Grades

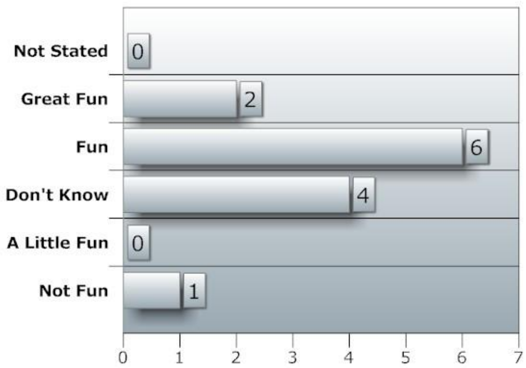


Figure 7.31: 294X Grades

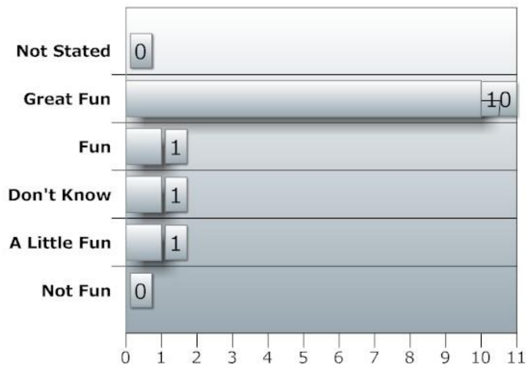


Figure 7.32: Block Panic Grades

Figure 7.33: Pyramid Panic Grades

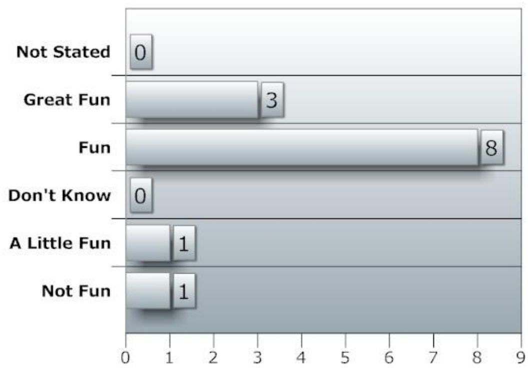


Figure 7.34: Space Maze Panic Grades

Based on grades awarded, the games '1982' and '294X' (Figure 7.29 / Figure 7.31) appear to be more 'fun' (i.e. 'Great Fun' and 'Fun') to play than not, whereas '194X' (Figure 7.30) seemed to split respondent opinion, with grades almost evenly distributed across the scales of 'Fun' and 'Don't Know'.

‘Block Panic’ and ‘Space Maze Panic’ (Figure 7.32 / Figure 7.34) were the most popular of the ‘Panic’ games, with a greater number of ‘Great Fun’ and ‘Fun’ grades awarded. In contrast, the grades for ‘Pyramid Panic’ (Figure 7.33) were distributed across the Likert scale, which the author would interpret as the respondents having a mixed view towards the game.

If you could, how would you improve the following games?

This question is open-ended and designed to elicit general feedback about the games used during the Main Study.

During the observation, it was felt that the general level of enthusiasm shown by the sample group was higher than it had been during the Prototyping Pilot. This enthusiasm manifested itself in a number of ways:

- The low-fidelity games (‘Block Panic’ / ‘1982’) were being played for a longer period of time than the author had anticipated they would.
- The author perceived increased interaction between group members (in comparison to the pilot), with two group members (from different pairings) observed asking each other if they had played ‘Block Panic’. Another two group members (again, from different pairings) were observed (verbally) comparing scores achieved in ‘194X’.

It is perhaps because of this increased enthusiasm for the actual game playing, that the majority of respondents did not leave comments in relation to this question, as they were too ‘busy’ playing the games.

As with previous questions, it should be noted that some of the comments to this question suggested that the respondents were commenting on the games themselves, rather than how the games could actually be improved. The responses should therefore be interpreted with this aspect in mind.

Respondent comments have been summarised overleaf.

Moon Maths

Most of the comments suggested changing the game to either increase the element of challenge ("*make it harder*") or the variety of scenery ("*another world, besides the moon*"). There were also two comments suggesting the inclusion of more maths ("*Add more maths*", "*I would improve it by more math*").

Math Balls

A greater degree of interpretation was required when reviewing the comments for 'Math Balls'. Most of the respondent comments stated that the game should have less or more 'balls' ("*Put in less balls*", "*Add more balls*"), which the author interprets as meaning the game should be made easier to play or feature an increased element of challenge. Two respondents commented on the maths contained within the game ("*Some of the questions are complicated*", "*I would enjoy it with more maths and more fun*"), which as previously stated, is not specifically set at a Key Stage 2 maths level. The remainder of comments expressed the view that the game did not require any further improvements ("*Not really*", "*Does not need to improve*").

Maths Magic

Not unsurprisingly, given the grades/comments made previously, the majority of suggestions centre on making the game easier to play ("*Make it easy*", "*It could be easier*"). Only two game specific comments were made, which the author interprets as relating to making the shooting mechanism easier to use – "*To shoot without answer*", "*Shoot on it anyway with timestable after slime is dead*". In the case of the latter comment, the respondent sought the author's advice as to whether it was clear (to the author) as to what the respondent was stating. Upon questioning, the respondent was suggesting that 'Maths Magic' could be improved by prompting the player (with a maths question) after the 'Green Slime' had been dispatched.

Asked if the respondent would still answer the maths question after "*getting rid of the Green Slime*" (author's words), the respondent said "*No!*". At this point, the author was asked to assist with a technical problem and was therefore unable to continue the conversation. However, the author interprets the respondent's comments as a suggestion to remove the maths content from the shooting mechanism.

194X / 294X / 1982

All of the flying games received positive comments in relation to this question. However, '1982' seemed to be enjoyed the most, with comments including "*It is so good*", "*Really easy best game*" and "*brilliant*". However, no comments were made about how these games could be improved.

Pyramid Panic / Space Maze Panic / Block Panic

The majority of the comments made, while largely positive, were not suggested improvements. However, one respondent commented (in relation to 'Block Panic') that 'monsters' should be added to the game in order to make the game 'harder' (the 'monsters' having been removed in response to the Prototyping Pilot feedback).

7.6.4 Main Study Summary

The results from the Main Study, based on observations, comments (verbal/written) and grades awarded, are summarised below. Research question specific results will be discussed in greater detail within the penultimate chapter (*Chapter 8*).

The game 'Moon Maths' received mixed feedback from the sample group, while the general feedback about the game was positive, the maths content was graded less positively. This may be due to 'Moon Maths' being the most openly 'educational' game within the pilot.

'Math Balls' received very positive feedback from the sample group. The simplistic (some might say, crude) computer graphics did not seem to detract from the game play, nor the sample group's enthusiasm for playing the game.

‘Math Magic’ might be considered a close second to ‘Math Balls’ in terms of popularity. Based on observation, the author feels that the overall polished presentation of the game is what attracted the sample group towards playing it. However, the difficult player control mechanism, combined with the high pace of the game, resulted in the group becoming frustrated with the game after a period of time.

As part of addressing Research Question 3, higher fidelity and low fidelity versions of ‘Pyramid Panic’ and ‘194X’ were produced. Through observation and questionnaire feedback, the low fidelity versions of these games (‘Block Panic’ / ‘1982’) received positive feedback from the sample group, suggesting that simple (or crude) graphics do not necessarily detract from game play. However, in response to feedback from the Prototyping Pilot, the enemy characters were removed from ‘Block Panic’, possibly making the game easier to play. This in turn may have contributed to ‘Block Panic’s popularity over the original ‘Pyramid Panic’ and (higher fidelity) ‘Space Maze Panic’.

In terms of the returned questionnaires, the author holds the view that the answers to some of the game-specific questions may have been directly influenced by the popularity of the specific game itself, therefore casting doubt upon the validity of the answers. This should be regarded as a caveat when interpreting the questionnaire results.

The final (open ended) question sought to elicit general feedback about the games used during the Main Study. Unfortunately, the returned questionnaires contained limited responses to this question, with the only practical response suggesting that the (removed) enemies within ‘Block Panic’ should be reinstated in order to increase the element of challenge.

7.7 Conclusion

As part of the methodology for addressing the thesis research questions, the author conducted a Prototyping Pilot and a Main Study (with the same sample group) at a local primary school.

The Prototyping Pilot was designed to prototype/refine the author developed games ‘Pyramid Panic’ and ‘194X’, prior to their use within the subsequent Main Study.

The Main Study consisted of a mixture of games from the Design Pilot (Chapter 6) and the author’s developed games. Additional versions of the author’s games were also produced, one version featuring higher fidelity graphics and another version featuring low fidelity graphics. During the pilot and study, a mixture of technical, development and ICT usage issues were encountered. These issues included limited wireless network connectivity, low specification netbooks and the lengthy preparation/setup requirements of the ‘game playing’ sessions (7*.4.2 Technical Issues (General) / 7.4.3 ICT Usage Issues*).

In terms of the Prototyping Pilot, due to the ‘retro-fitting’ of maths content, the author developed games (‘Pyramid Panic’ and ‘194X’) were considered ‘too fast’ (i.e. difficult) to play by the sample group (based on observation, and questionnaire responses). This resulted in additional development work, in order to address this criticism.

In terms of the Main Study, through a combination of observation and questionnaire responses, the following conclusions have been reached:

- ‘Math Balls’ seemed to be the most popular game of the Main Study, despite its use of simplistic (some might say, crude) computer graphics.
- ‘Math Magic’ might be considered a close second in terms of popularity. While featuring highly polished computer graphics, the game was ultimately less popular due to the difficult player control mechanism.
- Despite their low fidelity, ‘Block Panic’ and ‘1982’ were surprisingly popular with the sample group. However, in the case of ‘Block Panic’, part of this popularity may have stemmed from the ease of game play due to the removal of the enemy characters (as per the Prototyping Pilot feedback). What can be stated though is that the sample group was not deterred from playing the low fidelity games, despite the author’s best attempts at making the games aesthetically unappealing as possible.

With reference to the returned questionnaires (for both pilot and study), the author holds the view that the answers to some of the game-specific questions may have been directly influenced by the popularity of the games themselves, and therefore this should be regarded as a caveat when interpreting the questionnaire results.

Finally, while the results of the observations and questionnaires are presented within this chapter, the research question specific results will be discussed in greater detail within the penultimate chapter (*Chapter 8*).

Chapter 8: Addressing the Research Questions

8.1 Introduction

The purpose of this penultimate chapter is to formally address the research questions, as identified at the beginning of the thesis (*1.4 Defining the Thesis Research Questions*).

In summary:

Research Question 1 asks if a teacher (as a non-game developer) can create 'fun' educational computer games (based on GBL principles). The author addresses this question through the chronicling of his experiences during the process of developing and trialling a series of educational games as part of the Main Study.

Research Question 2 focuses on identifying the most suitable format or genre of educational computer game for use within education. The author attempts to address this question through reference back to the literature review, and discussion of the Main Study.

Research Question 3 is concerned with whether the quality or 'fidelity' of computer game graphics can have an impact on the successful use of an educational game. This question is addressed through a combination of references back to the literature review, and discussion of the results from the Main Study.

Research Question 4 is a broadly phrased question, which pragmatically discusses the role of Games Based Learning within the education system. The author addresses this question through references back to the literature review, and reference to changes currently taking place in and around the UK education sector.

Finally, Research Question 5 argues that a number of barriers currently prevent Games Based Learning from becoming 'mainstream', and asks how these barriers can be resolved. The author approaches this question by identifying gaps within in the current literature, and addresses these gaps through a new synthesis of existing knowledge and new contributions to the pool of existing knowledge.

8.2 Research Question 1

Is it possible for a teacher (as a non-game developer) to create 'fun' educational computer games, based on what are (currently) considered good GBL design principles?.

Having conducted the literature review into the area of Games Based Learning, the author is of the view that the literature is somewhat presumptive of the role that teachers will play in the development and use of GBL within an educational environment. Therefore, the motivation for this research question is to explore the practicalities of a teacher developing educational computer games, in order to address what is currently a limited area of discussion within the literature.

The author attempts to address this question, through the chronicling of his own experiences whilst developing a series of educational games, and their subsequent trialling through the study (Main Study) conducted at a local primary school.

8.2.1 Game Design and Development

For the author, the most challenging area of the game development process was actually creating the designs that the author's games would be based upon. With the benefit of reflection, the author can acknowledge that he failed to follow one of the most fundamental principles of software design, that of the 'KISS Principle'.

The KISS (Keep It Simple, Stupid) Principle is commonly used within software development (although historically its foundation is within military plane design) and serves to remind developers that software designs should be kept simple. By simplifying design, it becomes more manageable, reduces the scope for potential design flaws and makes the designs (and subsequent implementation) easier to fix in the event of any errors being detected (Davies 2014, Beuke 2011, Dille & Zuur Platten 2006, Anderson 2014).

Unfortunately, in his enthusiasm to create the game designs, the author forgot to follow this important principle, which resulted in the author adopting an approach to game design that was (in hindsight) far too ambitious. Initially, too many game designs were produced, and it became apparent over time that the author would be unable to implement all of these designs as actual games. Additionally, each game design was too large and complex, and this was especially true in the case of the game 'Gauntlet' (*4.6.1 Implementation / Development*).

The decision to redevelop this game as Habgood & Overmars's (2006) 'Pyramid Panic' proved to be a prudent move, as both the scale of the game and its simplistic graphics were considerably simpler to implement and manage than those of 'Gauntlet'. The over-ambitious nature of the designs was also reflected in the time-consuming implementation of multiple levels within each game (i.e. Level 1 up to Level 12). Ironically due to the time constraints of the 'Funky Friday' classes, very few of the sample group actually progressed beyond Level 1 within the author's games, making the time and effort in developing the additional levels somewhat redundant (with the benefit of hindsight).

As was anticipated, the author experienced a 'learning curve' during the development of the thesis games. This was due to a combination of the author's limited game development experience, and the process of learning the 'GameMaker' software. It was during this process that the work of Habgood & Overmars (2006) and Habgood, Nielsen & Rijks (2010) proved to be an invaluable, if somewhat double-edged, sword.

Overall, the author regards the selection of 'GameMaker' (as the preferred game development tool) to have been a wise choice. Had the author chosen less 'user friendly' development software, or less well supported (from an Internet community point of view), the 'learning curve' could have been considerably steeper. Additionally, the author is of the opinion that 'GameMaker' allows for simple (2D) game development (with relative ease) and serves as a good introduction to those wishing to create their own computer games.

However, while Habgood & Overmars (2006) provide valuable guidance to those developing games for the first time, the end results reflect this fact. The author will concede that his finished games could be considered ‘amateurish’ as a result of the author’s limited game design skills and the beginner’s level nature of Habgood & Overmars material. However, in the author’s defence, the games’ low levels of fidelity and sophistication were seen to be appropriate given their target audience (i.e. 8 -10 year olds) – a view reinforced by the enthusiastic reception that the games received during the Main Study.

To a large extent, the ‘look’ of the author’s games was dictated by the quality of the graphics or ‘sprites’ that were used. As documented in Chapter 7 (7*.4.4 Development Issues*), the author’s lack of graphical design skills resulted in his being dependent on freely available graphics, which were of variable quality. Perhaps if the author had followed the example of Blanchfield (2009) and had involved additional (commercial) third parties (for graphic/sprite production), the resulting educational games would have appeared more ‘polished’ and professional looking.

It should be noted however, that commercial game development can cost thousands of pounds and utilise a small army of developers, graphical artists and musicians etc. (Hardy 2012, Dille & Zuur Platten 2006, Whitton 2012). Therefore in this context, the use of ‘GameMaker’ and Habgood & Overmars’s approach to game development is (relatively) in keeping with the KISS Principle.

8.2.2 Are the Author’s Games Fun?

At the end of the development process, and after the conclusion of the Main Study, can the author state that his developed games were ‘fun’?

As with attempting to define the term ‘game’, ‘fun’ is a subjective term. The author can be bold enough to state that his games were not ‘un-fun’, based on the feedback (obtained through observation and questionnaires) from the sample group during the Main Study. A large part of the ‘fun’ found within a game can be traced back to the concept of games mechanics and ‘games design principles’ as discussed within Chapter 3.

As a non-game developer, it was sensible for the author to base his games on the tried and tested design principles incorporated into classic games such as Namco's 'Pac-Man', Atari's 'Gauntlet' and Capcom's '1942'. The philosophy behind this decision was the acceptance that the author (by his own admission) is not blessed with the 'creativity' that aids the game design process, and that his personal definition of 'fun' (i.e. what the author himself actually finds 'fun') is not necessarily shared by the target age group that the educational games were aimed at. Therefore, basing the games on tried and tested game design principles, provided the author with a degree of confidence that his games would be 'fun' to play, and would also allow more time to be concentrated on the difficult aspect of incorporating (or 'blending') educational content into the games, without 'spoiling' their 'fun'.

One of the many themes within the literature review was that of balancing the concept of 'fun' with the perception (by some learners) of education as being distinctly 'un-fun', and so by definition, can an 'educational' game ever be 'fun' or enjoyable?

In terms of the Main Study, some of the piloted games were seen as being more 'fun' than others, namely 'Math Balls', 'Math Magic' and the low-fidelity versions of the author's games ('1982' / 'Block Panic'). This 'fun' was both observed and apparent through the subsequent questionnaire feedback. However it would be easy to state on the basis of these observations/feedback, that the sample group 'had fun' playing the aforementioned games, and by implication, that the games were genuinely 'fun' to play.

What the Main Study does not provide an answer for, and which in hindsight might warrant additional research, is why were the study games (including the author's) found to be 'fun' in the first place? The most obvious answer to this question is to suggest that the games were 'fun' to play due to their use of established 'game design principles' (*3.7 Games Design Principles*). However, it could also be argued that all of the study games were only 'fun', when compared to the (potentially) unappealing nature of 'traditional schooling', i.e. sitting in a classroom and receiving instruction.

The reader is reminded that both the Prototyping Pilot and Main Study were part of the chosen primary school's 'Funky Friday' programme, which offered pupils additional activities outside of the 'normal' classroom instruction. Given the choice of spending a Friday afternoon between participating in an outdoor activity (such as orienteering), playing computer games, or attending a more obviously 'educational' activity, which one would the average learner choose?

It might be argued, that the author's developed educational games were genuinely fun to play, but perhaps in part due to being a preferred alternative to sitting in a classroom and engaging in more 'transparent' learning than that associated with 'playing games'.

8.2.3 Conclusion

As part of addressing a limitation within the existing literature, the author chronicles his experiences as a mechanism for exploring the practicalities of a teacher developing 'fun' educational computer games.

Using a combination of 'game design principles' (as identified within the literature) and the 'GameMaker' software, the author produced a series of educational games. With the benefit of hindsight, the designs (and the games that were subsequently based upon them) were far too ambitious in terms of size and scope, and the process of development was hindered by the author's limited game development experience.

Based on feedback received through the Main Study, the author is of the view that these games are (to a larger extent) 'fun' to play. Admittedly, the author suspects that if the games were played outside of the educational environment (i.e. not used as an alternative to regular classes), then in these contexts, the games might be perceived as being less 'fun'.

The author's lack of graphical design skills resulted in games being developed, which might be regarded as looking 'amateurish'. If these games were used in other situations (i.e. outside of the Main Study), it is conceivable that they might be shunned due to their crude graphics and unsophisticated game play. However, as will be discussed during the addressing of Research Question 3 (*8.4 Research Question 3*), the crudeness of the graphics did not seem to detract from the 'fun' that the sample group found in playing the games.

The author regards this question as having been addressed. It is possible for a teacher (as a non-game developer) to develop 'fun' educational computer games. However, given the design/development issues documented within this question, the author is of the view that expecting teachers to develop educational games may not be the preferred or the most practical approach to delivering GBL into the classroom.

8.3 Research Question 2

Which type, format or genre of game is most suited for use in Games Based Learning?

With the benefit of hindsight, this might be considered an extraneous question. The author was only able to source limited literature on the subject of game genre, and when located, this would focus mainly on describing the various classifications of game genre available.

It is the author's opinion, that of the practical examples featured within the literature (*2.8 Game Genres*), there was a slight bias towards the 'simulation' game genre and 'first person' 3D virtual world environments, such as Second Life and games built upon commercial 3D game engines. This would seem logical, as the simulation genre along with the use of 3D environments, have historically lent themselves to training, with the literature frequently citing corporate and military training examples, such as 'MarineDoom' and 'Military Battlezone' (aka 'The Bradley Trainer') (Tappeiner & Lyons 2008, Djaouti *et al.* 2011, Jayakanthan 2002).

Beyond this aspect, there seems to be little empirical research into the area of game genre. In many examples, games have been designed with little reference as to why a specific genre has been chosen, or the choice has been mandated due to time and financial constraints.

Liu & Lin (2009) suggest that both simulations and puzzle games are the most 'common' form of educational game, but do not elaborate on exactly why this is the case. In the author's view, 'commonality' does not automatically equate with 'suitability' for use within an educational environment. Prensky (2001) and Rapeepisarn *et al.* (2008) offer broader guidance on the various 'styles' (or genres) of COTS games that can be used within the classroom, in the context of preferred learning activities and the type of educational material to be delivered. However, neither Prensky nor Rapeepisarn *et al.* offer empirical evidence to underpin their guidance nor state an overall preferred 'style' / genre of game.

Finally, Charles *et al*. (2012) concluded (based on experience gained through their iSpiral framework) that genre was not seen as important by their students, who instead placed greater emphasis on the inclusion of social aspects within the iSpiral (‘space shooter’) game.

8.3.1 Main Study Findings

The author concedes that the area of ‘genre’ was poorly represented within the Main Study. This was due to the compounding of a number of unexpected issues.

- The initial designs for the author developed games were far too ambitious and subsequently had to be scaled back in terms of size and complexity. In hindsight, a larger number of smaller, simpler games would have been more appropriate for addressing this research question.

- The game development process itself took longer than anticipated. This in turn was exacerbated by the author’s inexperience in developing computer games, and the time consuming nature of sourcing/developing and editing appropriate multimedia material for inclusion within the games (graphics/sprites, audio). The development process was further interrupted by the author’s unexpected job redundancy, and relocation back to the United Kingdom. As a consequence, the author fell behind schedule and ultimately had to curtail the number of planned games for implementation within the Main Study.

- After a period of reflection and supervisorial advice, two (of the four) author developed games were dropped from inclusion within the Prototyping Pilot and the subsequent Main Study, due to their flawed designs. The educational versions of ‘Pac-Man’ and ‘Bombjack’ were faithful recreations of their originals, but with hindsight, their genre/format did not lend themselves well to educational play – the maths content being relatively easy to avoid. The removal of these author developed games further reduced the pool of suitable games for use within the Main Study.

The end result of these issues was that the Main Study consisted of a smaller selection of games than was originally intended, which in turn, did not reflect the wide range of videogame genres available.

As a result, the author regards the genre-specific questionnaire results (returned from the Main Study), to be somewhat superficial (reflecting the lack of genres represented within the study) and therefore of little informative value. With hindsight, the thorough testing of this research question would have required a larger scale study, due to the large variety of videogame genres currently available.

In his book, Wolf (2002) classifies computer games into forty-two different genres (with some overlaps and cross referencing). Clearwater (2011) acknowledges Wolf's work, but is of the opinion that his original genre classifications are based on games from the simpler 'golden age of video gaming' (1970's/1980's) and that game development has since progressed to add additional (more sophisticated) genres to Wolf's original list, e.g. the 'docu-game' or 'documentary videogame' genre as reflected in the 'games' '911 Survivor' and 'JFK Reloaded' (Williamson 2003, Poremba 2009, Raessens 2006, Mirapaul 2003, Schott & Yeatman 2005, Clearwater 2011).

Even with the removal of unsuitable genres (e.g. the First Person Shooter or the aforementioned 'docu-game' genre) from a larger scale study, that still leaves a considerable number of genres that would need to be represented in order to ensure the academic integrity of the study. The author is of the opinion that sourcing this volume of genre specific games would be difficult, both in terms of timescale and game availability.

8.3.2 Conclusion

With the benefit of hindsight, the author questions his wisdom in proceeding with this research question, especially in the light of the aforementioned (unexpected) issues. The area of genre was poorly represented within the Main Study, which in turn, was reflected in the quality of the returned questionnaire results within this area.

As a result, the author can state that this research question has only been partially addressed. However, based on limited experience, the author would go as far as to argue that there are certain game genres that are *not* suitable for use Games Based Learning.

Both the educational versions of 'Pac-Man' and 'BombJack' were (in hindsight) poor design choices for educational games. Ironically, the approach taken by the author (which resulted in the games being too 'game heavy') was the extreme reverse of the Main Study games, 'Math Man' and 'Math Explorer 2' – both of which used the same format/genre, but overpowered the 'fun' with poorly integrated educational content.

Based on its representation within the surveyed literature, if the author were to offer an opinion on the most suitable game genre (for use with Games Based Learning), he would suggest that it can be found in the explicit simulation genre, which may be enhanced through the use of 3D graphics. Although, as will be discussed within the next section (8*.4 Research Question 3*), the level of graphical 'fidelity' required when using 3D graphics is open to debate.

8.4 Research Question 3

Does the quality of the computer graphics (2D or 3D) have an impact on the successful use of a computer game within an educational environment?

Reviewing the literature within this area reveals mixed views on the level of graphical fidelity that should be utilised within educational computer games. These mixed views prompted the author to consider the following scenario – if an educational computer game features low-fidelity graphics, will it deter players from actually playing it, and in turn reduce its effectiveness as an educational game?

Throughout the late 1970’s and early 1980’s, home videogame consoles created primitive, but effective, colour graphics through the clever manipulation of the electronics within cathode ray tube (CRT) based television sets (Lowood 2009, Drury 2011). As the graphical capabilities of competing consoles (such as the Magnavox Odyssey, Atari 2600 and Mattel Intellivision) were broadly similar, their respective successes were due to competitive consumer pricing, the volume of games available and the ability to play ‘home’ versions of popular amusement arcade games of the time (Spencer 2004a / 2004b, Loguidice & Barton 2009).

It was not until the microprocessor based home computer revolution that the graphical fidelity of computer games began to feature as a selling point within manufacturers’ sales literature (Milne 2013). As time progressed, ‘8-bit’ computers gave way to graphically superior ‘16-bit’ computers and games consoles, which in turn were surpassed by more powerful PC’s and the first generations of Microsoft’s Xbox and Sony’s PlayStation consoles.

Yet, in recent years it could be argued that there is a little bit of ‘history repeating’ with the emergence of mobile gaming on Tablet PC’s and mobile phones. As with the 1970s/1980s videogame consoles before them, the majority of the world’s Tablet PC’s and mobile phones are based on the same processor technology (typically licensed from ARM Holdings – formally Acorn Computers, the inventor of the BBC Micro). As a result of this homogeneity, Tablets and mobile phones distinguish themselves not on their graphical capabilities, but on their consumer pricing and the number of ‘apps’ available in their respective ‘App Stores’.

While modern PC and console games offer ever increasing levels of realism and higher graphical fidelity, a review of the ‘Top Selling in Games’ chart at the Google Play App store (Google Play 2014) reveals a dizzyingly large list of mobile-centric games. While the majority of these games offer high fidelity graphics, graphically simple ‘retro’ themed games are also well represented, along with faithful re-makes of ‘classic’ (i.e. ‘old’) games, such as ‘Sonic the Hedgehog’ and ‘Pac-Man’.

Despite the highly publicised launches of the latest Xbox and PlayStation consoles, low fidelity ‘retro‘ games, such as ‘Flappy Birds’ (Figure 8.1) and ‘Minecraft’ (Figure 8.2) have also enjoyed considerable popularity and commercial success within the gaming world (Kay 2014, Williams 2014, BBC 2014b, Goldberg & Larsson 2013, McVeigh 2013, Merz 2014, Mojang AB 2013).

Figure 8.1: Flappy Birds (Kay 2014)

Figure 8.2: Minecraft Characters (Mojang AB 2013)

So given this synergy of high and low fidelity gaming, do computer graphics really have any bearing on the successful use of computer games within an educational environment? To a large extent, addressing this research question is fraught with difficulty, due to the subjective nature of aesthetics in relation to computer generated graphics.

In terms of designing/developing educational games, much of the literature on theoretical EGD frameworks (*3.12 Theoretical EGD Frameworks*) concentrates on the pedagogy of the frameworks themselves, rather than the graphical fidelity of the games that the frameworks will ultimately produce.

Conversely, most of the implemented 'Proof of Concept' frameworks (*3.13 Implemented EGD Frameworks ('Proof of Concept')*), focus on creating games that utilise 3D or 'virtual world' style graphics (Shabalina *et al*. 2009, Champsas *et al*. 2012, Waraich & Wilson 2005) or, in the case of Petridis *et al*. (2012), the use of 'high-fidelity' game engines.

However, within the literature, there are examples where 'high-fidelity' graphics have been eschewed in favour of more simplistic two-dimensional graphics.

Charles *et al*. (2012) use a 'GameMaker' generated 'Space Shooter' game as a 'front-end' to their iSpiral framework. Although the game was co-developed in collaboration with a commercial game studio, Charles *et al*. took the decision to base their game on 2D graphics (as opposed to 3D), due to externally imposed time constraints. Unfortunately, the two-dimensional nature of the game's graphics is not discussed within their paper, nor do the students (using the iSpiral system) seem to express their opinions on the graphical quality of the final game. While graphical fidelity was admittedly not the focus of their paper, Charles *et al*. seem to have afforded game graphics a low-priority (for reasons of practicality). Judging from their conclusions, It could be inferred (in this particular instance) that the quality of game graphics have relatively little impact or consideration on the (otherwise, successful) use of educational games.

Blanchfield (2009) discusses the teaching of software engineering, through the process of his students developing educational games. Again, for reasons of practicality and past experience, he encouraged students to adopt a two-dimensional approach to the game graphics, citing time constraints as well as the difficulty in sourcing quality 3D assets, as the motivation behind this decision. Beyond his view that some of the student produced 2D games "*proved to be more impressive than most of the 3D games*" (Blanchfield 2009, p.27), Blanchfield makes no comment on whether any of these games were educationally better (or worse) as a consequence of using 2D graphics over 3D ones.

In a less academic context, Overmars (2011) discusses the methodology behind developing mobile game applications (or 'apps') for phones and Tablet PC's, using the latest iteration of the 'GameMaker' software. Overmars's view is that most game apps will be played on relatively small screens in bright daylight conditions. As a consequence, he recommends that game apps should be designed with bright colours, lots of contrast and with a preference for simple 2D graphics. This preference stems from the view, that high-fidelity 3D graphics will be underutilised (and therefore will not be beneficial to the game) when viewed on small screen mobile devices. While Overmar's observations are aimed at general (non-educational) gaming, it could be argued that they apply equally to mobile-centric educational games.

Husain (2011) (discussing Shen *et al*. 2009) takes the view that 'bad graphics' can detract from game play. She therefore argues that educational games should utilise graphics that match the sophistication of those found in commercial games, in order to "*capture the attention of young learners*" (Husain 2011, p.13).

Whitton (2012) concedes that the 'amateurish design' of low cost educational games could deter learners from actually playing them. However, she counters this view by offering the opinion that learners do not compare the aesthetics of educational games with high-fidelity commercial ones, but against 'traditional' learning activities instead.

However, it is unclear in this instance as to what Whitton regards as ‘traditional’ activities, as this author takes the view that ‘traditional’ activities might also include non-game based I.T./ICT activities (such as the use of spreadsheets or presentation software).

Finally, in terms of the literature, Klopfer & Osterweil (2013) discuss the ‘boom and bust’ of educational games. While they place the emphasis on achieving the correct balance of game play and education, they also suggest that game developers should not be afraid of adopting “*less-flashy approaches*” (over 3D) to game graphics as “*both offer potential for educational games*” (Klopfer & Osterweil 2013, p.296).

8.4.1 Main Study Findings

As discussed within Chapter 7, a Main Study was conducted at a local primary school, with a view to addressing the thesis research questions.

In addition to the original author developed games, ‘Pyramid Panic’ and ‘194X’, two additional versions of these games were produced – one with low fidelity graphics and one with higher fidelity graphics. While the graphical fidelity differed between all three versions of each game (Table 8.1), the game play remained the same with the exception of additional amendments made in response to feedback received during the Prototyping Pilot.

Low Fidelity Graphic Games	(Original) Medium Fidelity Graphic Games	Higher Fidelity Graphic Games
1982	194x	294x
Block Panic	Pyramid Panic	Space Maze Panic

Table 8.1: Author Developed Games

The sample group were given the opportunity to play all six games (Table 8.1), and were observed by the author during the subsequent sessions. In addition to the observational feedback, the sample group were also asked to complete a questionnaire with questions relating to the games’ graphics.

During the sessions, it was observed that the pupils seemed to play all of the games without any particular discrimination in regards to the game's graphics. 'Block Panic' and '1982' did prompt a few positive (verbal) comments which, in the author's interpretation, suggested a greater enthusiasm for the (low fidelity) games' simple graphics when compared to their higher fidelity counterparts ('Space Maze Panic' / '294X'). To some extent, this view was also reflected within the questionnaire results.

The sample group was asked to grade how much 'fun' each of the games was to play (Table 8.2), and to grade and comment on the graphics for each game (Table 8.3).

The results (ranked by the number of 'Very Good'/'Good' grades awarded) reveal that in both cases, the low fidelity 'Block Panic' was both the most 'fun' to play and had the highest rated graphics. The second low fidelity game ('1982') was ranked second and third (Table 8.2, Table 8.3) respectively, largely surpassing the original and higher fidelity versions of the games.

Rank	Game	Grades (VG/G) *[1]
1	Block Panic	10/1
2	1982	5/2
3	Space Maze Panic	3/8
4	Pyramid Panic	3/4
5	194X	3/3
6	294X	2/6

Table 8.2: Most 'fun' Games (Ranked by 'Very Good'/'Good' Grades).
*[1] Question: "How much fun were the following games to play? (on a scale of 1 to 5)"

Rank	Game	Grades (VG/G) *[2]
1	Block Panic	9/0
2	294X	6/3
3	1982	6/2
4	(Joint 4th) Space Maze Panic	4/3
	(Joint 4th) Pyramid Panic	4/3
5	194X	3/6

Table 8.3: Quality of Graphics (Ranked by 'Very Good'/'Good' Grades).
*[2] Question: "How would you grade the computer graphics for the following games? (on a scale of 1 to 5)"

However, there are some caveats to these results. Firstly, it should be noted, that some of the comments in regards to the graphics question (Table 8.3) suggested that the respondents were commenting on the games themselves, rather than the quality of the graphics. Secondly, in response to the Prototyping Pilot feedback (*7.5.4 Prototyping Pilot Summary*), the game play speed of all the 'Panic' games ('Pyramid Panic', 'Block Panic', and 'Space Maze Panic') was reduced and the enemies were removed specifically from the game play of 'Block Panic'.

It could be argued, that with the removal of the enemy characters, 'Block Panic' has become easier to play in comparison to the remainder of the study games. In turn, this aspect may have been the reason why the game was graded as the most 'fun'. The author is concerned that unconscious bias (in other words, the popularity of the game itself) may have influenced the sample group to grade the graphics of 'Block Panic' equally as highly. However, what can be stated is that the low fidelity graphics of 'Block Panic' did not seem to adversely affect how much 'fun' the game was to play (in the view of the sample group), nor was it observed to discourage the sample group from playing the game in the first instance.

In terms of the game '1982', the author feels more positively about the results. The game '1982' was also rated highly within the Main Study questionnaire, despite there being no differences (except in graphical terms) between it and the other versions of the game ('294X' / '194X'). After ranking (Table 8.3), the grades awarded for graphical quality reveal an interesting picture. The low fidelity '1982' narrowly trails the higher fidelity '294X' by one 'Good' grade (6/2 vs. 6/3) and is ranked considerably higher than the original (medium fidelity) '194X' (6/2 vs. 3/6). Therefore, the author would argue that the low fidelity nature of '1982' did not detract from the game's popularity or use within the Main Study.

8.4.2 Conclusion

Based on the literature within this area, it would seem that there is a mixed view on whether the fidelity of computer game graphics can have an impact on the enjoyment and successful use of computer games within an educational environment.

While some researchers argue that commercial quality graphics are essential, others suggest that they are not. Meanwhile, the work of Blanchfield (2009) and Charles *et al* (2012) demonstrate that practical reality (and time constraints) can dictate the issue of graphical fidelity, seemingly without any adverse effect on the successful use of educational games.

It is the author's opinion that this view is also supported by the results of the Main Study. While the author has documented his concerns in relation to 'Block Panic', the high rankings of this game (and '1982') suggest that an educational computer game can eschew 'state of the art' 3D graphics and still be used successfully within an educational environment.

Therefore, the author feels confident that this research question has been addressed for the purposes of the thesis.

8.5 Research Question 4

How can Games Based Learning be used practically within the education system?

Initial drafts of this research question focused on whether educational games could be aligned with the national curriculum. During the literature review and the subsequent research (pilots and Main Study), it became apparent that the straightforward answer to this question was 'Yes'.

From the point of view of the national curriculum, the learning outcomes (at least for the area of Key Stage 2 mathematics) are broad enough to allow the flexibility in how the curriculum is actually taught or delivered (DfE 2011, DfE 2013a). This broadness (in the author's opinion) allows Games Based Learning to be utilised within the national curriculum as a tool, along with other, more traditional, technology based tools such as laptop computers, Tablet PC's and Interactive White Boards/Smart Boards.

However, during the literature review, the author felt that there were issues, in some cases not fully explored by the literature, which related to the use of Games Based Learning within the education system as a whole, be that schools, colleges or higher education. After a period of reflection, the author came to the view that the original research question was too narrowly focused. As a result, the question was re-phrased in order to allow it to be addressed in greater depth, in light of the issues uncovered during the literature review. This research question asks whether Games Based Learning can be practically used or integrated into the education system, and as will be discussed, the answer is not as straight forward as the author expected.

Reviewing the literature within this area, reveals much discussion on the premise of Games Based Learning, what it is, and why it is needed. One area that is acknowledged to be problematic is the integration of computer games (be they dedicated educational games or COTS games) into the education system.

Starting with the classroom, there needs to be careful consideration when attempting to introduce games into the teaching environment. As demonstrated by Novak & Nackerud's (2011) 'RCIPR Model', the selection of COTS games can be fraught with difficulty. COTS games by their very nature will not be suited for educational use 'out of the box', and will therefore require extensive configuration (or 'modding') before they can be used. This activity in itself can be quite time consuming and assumes that a member of staff has the prerequisite skills.

The literature documents a few examples of how COTS games can be used within the classroom (Bourgonjon *et al.* 2010, Demirbilek & Tamer 2010, Watson, Mong & Harris 2011, Lim, Nonis & Hedberg 2006, Ney, Emin & Earp 2012), and it becomes apparent from these examples that there are certain recurring themes:

- Keeping pupils focused on the educational aspects of the chosen game (i.e. those which relate to the learning outcomes) can be difficult, as this goes against the pupils' natural desire to explore and 'play' the game in general.

- The use of games within the classroom naturally generates excitement amongst pupils, who in turn produce increased levels of noise and move more actively around the classroom, engaging with other pupils.

- Within a GBL classroom environment, teachers change their role to that of a 'facilitator', whose job is to guide pupils in game use and 'facilitate' the learning of the desired lesson outcomes.

- Finally, the process of preparing and then using COTS games within the classroom can be time consuming (on top of traditional teaching preparation).

For the author, the most striking aspect of these game integration examples is the descriptions of the classroom environments during COTS use.

Some researchers acknowledge that the levels of noise generated by enthusiastic pupils (during game play) can interfere with classroom management. However, it occurs to the author that the perception associated with computer games being used within the classroom, is not really considered within the literature. If the documented examples are taken at face value, then upon entering the classroom, any external party or third person will be greeted by the following scene:

- Pupils playing games, some of whom will be shouting over each other's heads.
- Other pupils wandering around the classroom, trying to see how other 'players' are progressing (game wise).
- A facilitator attempting to 'facilitate' the pupils to interact 'educationally' with the game, and not just play it for fun.

In light of recent announcements concerning Ofsted's plans for 'no notice' inspections (Ofsted 2014, Vaughan 2014, Paton 2013, Hodge 2014, BBC 2014a), would any head teacher be comfortable with the above classroom session taking place, given the possibility of an unannounced visit?. While it could be argued, that what has been witnessed is 'learning for the GBL generation', Ofsted inspectors might perceive the above situation differently.

Looking at the 'bigger picture', it could be argued that the integration of gaming into the classroom could learn a lot from the past.

Discussing the history of I.T. use within British schools, Hammond *et al*. (2009) express the view that the use of computers in the classroom can create 'creative opportunities', but that this creativity is incompatible with the 'locked down' nature of today's schools and education system. It could be argued that this incompatibility is further exacerbated by the results driven inspection culture that has come to dominate education in recent times (Paton 2013, The Guardian 2011, Perryman *et al* 2011).

In a similar vein, the author would suggest that Games Based Learning also threatens to offer ‘creative opportunities’. In fact, it is the creative, fun and ‘disruptive’ nature of Games Based Learning that advocates, such as Prensky, Shaffer and Gee, argue is necessary in order to ‘save’ the currently ‘broken’ education system. If we apply the (I.T.) experiences documented by Hammond *et al*. to Games Based Learning, then it could be argued that the use of games within the classroom is also fundamentally incompatible with this same ‘locked down’ system. Yet, if we take Prensky, Shaffer and Gee at their word – that GBL will save the ‘broken’ education system – how do we reconcile this with a system that opposes anything that might be regarded as ‘creative’ or might loosen the grip of the current ‘lock down’?

Moving beyond the education system, Games Based Learning will only be truly accepted when it is supported by coherent formal government policy. Yet as we have seen from ‘initiatives’ such as the Computer Literacy Project (Hammond *et al*. 2009), the introduction of Interactive White Boards (Hammond *et al*. 2009, Johnston-Wilder & Pimm 2005) and most recently the ‘Year of Code’ (Cellan-Jones 2014), governments have a history of (well meaning) technology rhetoric, which often falls short when it comes to implementation.

So far within this discussion, the author has referred to the use of COTS games and the difficulties associated with trying to introduce them into the classroom. While the issues of acceptance (by the ‘system’) still apply, an alternative to COTS games is the custom development of computer games, specifically for the purpose of education.

In certain respects, developing specialist educational games may be a more practical approach to game integration, due to the fact that the games can be custom developed for a specific task. While there is some debate (*8.4 Research Question 3*) on the level of graphical fidelity associated with non-commercial educational games, the games could be produced in such a manner as to address the shortfalls associated with COTS games, i.e. designed with only the learning objectives in mind, and no extraneous material that needs to be configured (or ‘modded’) out.

If (for practicality) Games Based Learning travels down this path, we get to the issue of who actually designs and develops the games for use within the education system?

Teachers might be the logical first choice to create games, but do teachers have the prerequisite skills to develop games in the first place? The author would argue that many do not, and point to the fact that the current ‘Year of Code’ campaign includes funding to train teachers in computer programming (Gov.UK 2014, Gibbs 2014), which might be regarded as recognition that a skill shortage exists. Of course, history would suggest that simply ‘throwing money at a problem’ does not necessarily solve it, as many failed government I.T. projects have demonstrated (Savage 2010, BBC 2011a, Ballard 2013, Syal 2013, BBC 2013a).

As an alternative to being provided with funding, academia could (in theory) develop collaborative partnerships with the games development industry. While there are a few documented examples of this occurring within the literature (i.e. Blanchfield 2009, Bowland Maths 2014), they seem to be few and far between – this might be due to a perception that there is little profit to be made in educational games, when compared to commercial ones.
The aforementioned ‘Year of Code’ may help counter this problem (in some respects), as the campaign has partnered up with commercial organisations such as Google and Wired Magazine – however it could be argued that these partnerships are either genuinely charitable or savvy public relations arrangements, rather than profit driven commercial ones.

An alternative approach to industrial collaboration would be to incorporate some form of game development training into pre-service teacher training courses or developing specialist GBL teacher training courses, in a similar vein to existing ICT themed PGCE courses currently available (University of East London 2014, University of Huddersfield 2014, Canterbury Christ Church University 2013, Newman University 2014).

Historically, I.T./ICT support within teacher training has been seen to be lacking, despite the presence and use of ICT in schools since the BBC's Computer Literacy Project in the early 1980's (Hammond *et al.* 2009, Becker 2007, Abrams 2011, Condie *et al.* 2007, Watson, Mong & Harris 2011). The author's experience, as a student, on a teacher training course also reflects this criticism. The author can remember undertaking an 'ICT module' which was taught by teacher trainers who openly admitted to being 'luddites'. Their interpretation on the use of ICT (within the classroom), was the ability of the teacher to save a Microsoft Word document into a web page (HTML) format, which could then be viewed in a web browser (such as Internet Explorer).

Returning to the original research question, the author feels that he can now provide an answer (of sorts), as to whether Games Based Learning can be practically used within the education system.

The short answer to this research question might be 'no', if viewing GBL exclusively from the likes of Prensky, Shaffer and Gee's point of view – GBL will probably never fulfil a prominent role within the education system for the reasons discussed previously:

- Practical difficulties in implementing GBL within an educational establishment (preparation time, technical issues, lack of appropriate hardware resources etc.)
- Poor social perceptions of GBL – would any school risk 'facilitating' game playing sessions (during school time, as opposed to afterhours clubs), with the knowledge that Ofsted could be paying them a 'no-notice' visit at any given time?
- The 'creativity' inherent in GBL could be considered incompatible with the currently 'locked down' education system.
- Finally, a lack of formal, coherent government policy to guide the use of GBL within the education system.

If the author were to give a more considered answer, then the answer might be 'yes', Games Based Learning can be used within the education system, but not in the way that most GBL advocates would envisage. At the time of writing, the author would argue that the UK education system is going through a period of change. While some commentators (not unreasonably) criticise the vision of Prensky, Shaffer and Gee, there is a shared view that education – and especially ICT – is in genuine need of change (Douglas 2011, Shepherd 2011, BBC 2011b, Scott 2012, Wakefield 2012, Coughlan 2013, Bradshaw, Twining & Walsh 2012).

It would be tempting to promote Games Based Learning as a solution to effect this change, but the author adopts a more pragmatic view and would suggest that although GBL has a role to play; it will not be the prominent role as favoured by GBL advocates. The agents of educational change can be seen through various developments:

- The new 2014 National Curriculum, which re-introduces computer science, and the teaching of computer programming (DfE 2013b).
- The 'Year of Code' campaign.
- The recognition that the games industry needs additional computer scientists in order to grow and prosper (Livingstone 2011).
- The foundation of the UK's first GBL 'Free School' / Academy (Lee 2014b).
- The increasing popularity of the 'Raspberry Pi' computer, with its inclusion of the 'Scratch' game programming environment (Raspberry Pi Foundation 2013, MIT Media Lab 2014, Harvard Graduate School of Education 2013, Everard 2013, Andrews 2012b).
- And finally, the rumours that the BBC may launch a new Computer Literacy Project, potentially based on the aforementioned Raspberry Pi (Andrews 2012a, Parslow 2012, Lang 2012).

By examining these 'agents of change', a common theme of 'computer gaming' can be seen to emerge. While it may be speculation on the author's part, the future of Games Based Learning – rather than replacing the 'broken down' education system – may lay within the current 'locked down' system, and through pupils 'coding' of games (in 'Scratch') on Raspberry Pi's, provided by (potentially) the BBC's new Computer Literacy Project.

8.5.1 Conclusion

With hindsight, the author experienced difficulty with this research question, finding it to be too narrowly focused on the national curriculum. As a consequence, the question was broadened to apply to the education system as a whole in order to be able to address the question in greater depth.

So, can Games Based Learning be practically used within the education system?

Using COTS games within the classroom requires careful selection and additional time (in terms of preparation), there is also the issue of perception – pupils ‘playing games’ may carry a stigma that schools may wish to avoid – especially on an Ofsted inspection day. Then there is the argument that Games Based Learning, as with ICT before it, may be incompatible with a ‘locked down’ education system that does not encourage ‘creativity’.

Developing educational games may address some of the COTS game criticisms, but also raises the issue of who actually develops the games? Commercial collaboration with the games industry is one possible solution, but rarely seems to have been explored within the literature. Inevitably, there are suggestions that teachers are best placed to create educational games, but this suggestion rarely takes into account teaching workloads or whether teachers have the prerequisite game development skills. Two approaches to this skills shortage may be the government backed ‘Year of Code’ campaign and the introduction of game development within pre-service teacher training.

The author addresses this question by postulating that Games Based Learning can be used practically within the education system, but not in the way that GBL advocates envisage it – namely through a mishmash of commercial (game industry) pressures, government initiatives and the sudden resurgence of interest in home computing through the Raspberry Pi computer.

8.6 Research Question 5

How can the current barriers, preventing the mainstream adoption of Games Based Learning, be addressed?

During the literature review process (*Chapter 2* / *Chapter 3*), the author discovered a series of gaps within the current literature that might be broadly classified as relating to the future mainstream adoption of Games Based Learning.

Within the literature review, the author encountered both positive and critical views of Games Based Learning. These views ranged from questioning its pedagogic value, to extolling its virtues as the saviour of the education system. As discussed during the addressing of Research Question 4, the author holds a more pragmatic view – suggesting that GBL may play a role within education, but perhaps not the one of prominence that GBL advocates would prefer.

At the current time, it is the author's view that Games Based Learning is still evolving and that as a result, its future adoption and implementation has yet to be concretely defined. However, if one assumes that GBL has a positive future within the education system, what will it look like? What steps will need to be taken next, in order to move GBL from the research labs and into practical use within the UK education system?

Over the following sections, the author will address the identified gaps within the literature, in what should be considered a new synthesis of existing knowledge.

8.6.1 Defining the Research Question

As with Research Question 4, this question proved to be challenging to define and its focus changed during, and after the literature review process was completed.

Initially, the motivation for this question was the belief that the real world implementation of Games Based Learning would require a formal policy or ‘framework’ in order to guide it. As the literature review progressed, it became apparent that the evolving nature of GBL was such, that it is still too early to formulate formal policies for its use within the education system.

However, before formal policies can be devised, there still needs to be support for Games Based Learning at the institutional level, and there remains a number of practical barriers that need to be overcome before GBL can enjoy mainstream adoption. With this view in mind, the initial research question (relating to frameworks) was re-phrased/refocused on how to address the issues of institutional support and the more practical issues currently preventing GBL’s mainstream adoption.

8.6.2 Identifying Gaps within the Literature

If the author takes a positive (but still pragmatic) view of Games Based Learning, it would be that GBL is still an evolving area of research which offers potential for those organisations (private and public sectors) that wish to utilise it. However, assuming that this view comes to fruition, the author postulates (based on the literature) that there has been limited ‘real world’ consideration of how Games Based Learning will actually be utilised outside of the research labs. This is not a single gap within the literature, but a collection of smaller gaps or question marks, that the literature has currently not addressed. These gaps can be represented as two recurring themes:

- The lack of Institutional support for Games Based Learning, and
- Practical issues relating to the implementation of Games Based Learning (within the education system).

8.6.2.1 Institutional Level Support for Games Based Learning

The literature describes the theory of Games Based Learning and the use of Serious Games, as well a limited number of practical (academic) implementations. Assuming that over the passage of time, GBL 'proves' itself and is adopted on a wider scale (especially within the education sector), there is currently still a lack of government guidelines promoting or guiding the best practice use of GBL.

Related to this, is the question as to who funds the development and use of Games Based Learning, especially within the education sector?

8.6.2.2 Practical Implementation Issues

At the 'shop floor' level, there are several questions relating to Games Based Learning that the literature has yet to address. It is true, that some of these questions have been asked, but rarely is a realistic (perhaps pragmatic) answer actually provided. The author classifies these current gaps within the literature as follows.

- There is justifiable concern that many schools do not have the appropriate resources (hardware, technical support and skills) to support the implementation of Games Based Learning.

- There is a limited amount of practical 'best practice' advice on how to use computer games (COTS or explicitly educational) within the classroom, and no common repository for teachers to obtain advice on specific games that can be used. While the literature contains some practical examples of game use, the author views this gap in more practical terms – if the author were a teacher wanting to utilise GBL within the classroom next week, where would he go to obtain best practice advice, sample lesson plans and ideally the game(s) themselves?

- It is the author's view, that much of the literature presumes that teachers will have a prominent role in the development of educational games, yet the author would argue that this presumption is flawed. This leads to the question of who exactly will develop the next generation of educational games to be used as part of a Games Based Learning strategy?

8.6.3 Lack of Institutional Level Support for GBL

To some extent, the issues discussed within this area are intertwined, and could be classed as relating to the political will and support that is realistically required if Games Based Learning is to succeed (in any meaningful way) within the education system. It is the author's view, that despite the ongoing research into the area of Games Based Learning, it has not yet reached a level of maturity that will see it formally adopted by the education system and at the government policy level.

This lack of maturity is reflected in the opposing views that can be found within the literature:

- At one extreme, is the view that Games Based Learning offers no educational benefit to learners, and that Prensky's concept of the 'Digital Native' is without any academic merit.
- At the other extreme, there are those who passionately advocate the use of Games Based Learning (such as Prensky, Shaffer and Gee) and considerable research has been dedicated to developing this area of learning (the work of de Freitas and Kiili, for example).

While remaining open-minded, the author is of the view that while the divide between the extremes exists, Games Based Learning will not be perceived seriously at the institutional level. Until this perception changes, it is doubtful whether Games Based Learning will take a prominent role within education, and as a result, it could be argued that there is currently no need (nor will) for formal government policies or guidelines. Ironically, the government funded organisations and policies that might have been helpful in this respect, have been discontinued as part of the first wave of the UK government's austerity cuts i.e. BECTA, and the 'Building Schools for the Future' programme (Cellan-Jones 2010b, Simpson 2011, Cellan-Jones 2010a, Curtis 2010).

Finally, in these austere times, there is the thorny issue of funding. Assuming that the disagreements over its validity can be resolved, and that institutional support falls into place, who actually funds the implementation of a Games Based Learning policy?

8.6.4 Addressing the Lack of Institutional support

8.6.4.1 Creation of a UK Centric GBL Trade Body

While trying to avoid the ‘doom and gloom’ that is often associated with a downturn in the economy, it is an inescapable fact that the UK (at the time of writing) is still within the grips of austerity. This has seen the UK government introduce many financial cuts over the past few years, including the dropping of flagship educational I.T. policies (such as the ‘Building Schools for the Future’ programme) and the ending of funding for I.T. organisations, such as BECTA.

Amidst this climate, the author cannot think of a more inopportune time to promote yet another I.T. based educational concept such as Games Based Learning. While the virtues of GBL might be apparent to its advocates, the author suspects that the government will take another, less favourable view. While some might argue that you should not have to ‘sell’ or ‘spin’ the benefits of Games Based Learning, the reality of our modern (social) media society is such that many self-interested groups or organisations (including the ‘traditional’ games industry) frequently create trade bodies or appoint spokespeople to promote their interests in positive ways.

The creation of an industry trade body serves two purposes. The first purpose is to promote the virtues of the given industry to key players and those who may be supportive of the industry, e.g. the games industry lobbying the UK government for tax breaks (Meer 2011, Stuart 2012, BBC 2012a). The second purpose is to ‘manage’ the image of the trade body members (or the industry as a whole), in such a way as to minimise any negative publicity that occasionally arises, e.g. (In reference to the energy sector) the publicity surrounding energy price rises (Hawkes & Gosden 2013, Donovan 2014, Mason 2013).

Therefore it seems logical to recommend the foundation of a UK centric Games Based Learning trade body which will promote the industry's interests, and admittedly, manage the occasional negative publicity occasionally associated with computer games (Vincent 2014, Tassi 2014, Etchells 2013, Lee 2014a). Although controversial, political public relations (i.e. lobbying) may potentially help the GBL industry to overcome its 'maturing' image and in turn influence the government that in these austere times, the industry should be taken seriously through the creation of formal educational policies and/or national guidelines.

While the author suspects that a Games Based Learning trade body will not enjoy the same level of influence that the games industry trade body does (TIGA), it still has the potential to influence those who shape the government's education policies. The author is not so naïve as to suggest that political lobbying will magically end over thirty years of flawed government education I.T. policies, but it does have the potential to positively influence their future.

The proposed creation of a UK GBL trade body will also address a gap within the industry itself. Currently, the most prominent trade bodies that could fill this role are TIGA (The Independent Games Developers Association) and the SGA (Serious Games Association). TIGA represents the UK/European (non-Serious) games industry, while SGA describes itself as "*an international trade organization serving the entire serious games industry*" (Serious Game Association 2014).
An Internet search for a UK centric GBL/Serious Games trade body reveals ANGILS (Alliance for New Generation Interactive Leisure and Simulations) to be the most prominent. Unfortunately, press releases for ANGILS do not seem to appear online beyond 2008 and attempts to access their official website (http://www.angils.org/) results in a 'web site failed to load' web browser error.

8.6.4.2 Alternative Approaches to Funding

Games Based Learning, by its very nature, will require funding if it is to be successfully implemented.

It may well be that some educational establishments have the appropriate hardware and software resources, and therefore implementation may not be as a significant issue. But, what if a school or college does not have the latest computing technology? How do they provide and implement a Games Based Learning policy or strategy?

Assuming that additional funding cannot be sourced from traditional sources, and that current budgets do not allow for additional expenditure, an educational establishment will need to seek alternative sources of income. This is of course easier said than done, but one approach that could be utilised is the increasing popularity of 'crowdfunding' (Nesta 2014a) as an alternative method of raising finance.

Crowdfunding is essentially the request for, and then subsequent pooling of, financial donations towards a given project. In return for funding the given project, investors receive some form of 'profit'. For example, if the project is funding a new business, then the investor receives equity in that business – effectively making them a share holder (Squareknot 2014). If the project is an actual product, then investors (depending on how much they pledge) may receive the first production versions of that product or discounts on the purchase of the subsequent retail versions.

A number of crowdfunding 'platforms' have appeared over the past year or so (Nesta 2014b, Caldwell 2013, Nesta 2014c, Clawson 2014), but probably the most well-known example is considered to be Kickstarter, with one of its most notable crowdfunded projects (to date) being the Ouya games console (Kickstarter Inc 2014a).

While the majority of its projects are entertainment based, an increasing number of organisations are turning to Kickstarter as a source of funding for educational projects. These include funding for educational magazines (Kickstarter Inc 2014c), school construction projects (Kickstarter Inc 2014b) and educational software and games (Kickstarter Inc 2014d).

The crowdfunding market is still in its infancy, and therefore the author would advise caution in utilising this method as a way of funding Game Based Learning projects, especially as there are concerns that the existence of so-called 'academic crowdfunding' could be used as an excuse by the government to further cutback research spending (Parr 2014).

However, in recognition of its increasing financial significance, the UK Financial Conduct Authority (FCA) has recently published regulatory policies designed to safeguard would-be investors (BBC 2014c, FCA 2014). Additionally, despite its infancy, the crowdfunding market already has its own UK trade body to represent its interests to the wider world (UKCFA 2014), reinforcing the author's earlier argument that the Games Based Learning sector/market should follow suit with their own trade body.

An alternative approach to crowdfunding would be the shrewd manipulation of the (admittedly limited) opportunities for I.T. funding within the current education system.
For example, while there may not be the political will or funding available for promoting Games Based Learning explicitly, there is (currently) political will and funding initiatives to encourage computer programming, as witnessed through the 'Year of Code' campaign.
It could be argued that the purpose of this campaign is not so much training teachers to 'code', but to train teachers so that they are in a position to deliver the computer science (i.e. programming) component of the new 2014 national curriculum.

This provides the opportunity (if used shrewdly) to train teachers in programming, who can in turn teach pupils how to ‘code’ through the medium of games programming, for example, using ‘GameMaker’ or MIT’s ‘Scratch’ to program simple games. While this may not be the same as ‘playing’ educational games, it is one possible implementation of Games Based Learning that will be compatible, maybe even approved of, by the current government.

8.6.5 Practical Implementation Issues

The previous section discussed the gaps within the literature, relating to the lack of institutional level support for Games Based Learning.

This section examines issues of a more practical nature which will also need to be addressed if Games Based Learning is to be practically, and successfully, integrated into the classroom. While these issues are often discussed, the gaps within the literature derive from the lack of pragmatic or practical solutions designed to address these issues. Broadly, these issues can be categorised as follows:

- Technical Issues that affect the ‘shop floor’ implementation of Games Based Learning, primarily the lack of appropriate I.T. resources.
- The lack of a centralised resource, which can aid teachers in their delivery of GBL within the classroom.
- Who should actually develop educational games? Teachers and/or the Games Industry?

8.6.5.1 Lack of I.T. Support / Resources

One of the recurring issues identified within the literature as being problematic, is the level of technical support available to ensure the successful implementation of Games Based Learning. This issue is not unique to GBL, and in theory all educational establishments (be they schools, colleges or universities) should have an adequate level of technical support for their I.T. resources. Idealistically, in terms of Games Based Learning, there may be a need for additional specialist (game related) support skills, but this is of little use if core (conventional) technical support is lacking.

A related issue, both within the literature and encountered through personal experience with the Prototyping Pilot/Main Study, is that of having the appropriate I.T. resources. In order to successfully run modern computer games, there is a requirement for (relatively) modern computers, supporting 3D graphics and, in the case of multiplayer games, a connection to a fast local area network.

8.6.5.2 Lack of Centralised GBL Resources

Reviewing the literature, it becomes apparent that the evolving nature of Games Based Learning has resulted in a (current) lack of formal GBL standards, and this in turn manifests itself in a number of ways.

There is currently a lack of official guidance or a centralised source of information where teaching staff can obtain relevant information on the suitability of COTS/educational games for use within the classroom. While there have been attempts to create COTS selection methodologies (i.e. Novak & Nackerud’s (2011) RCIPR Model) and there is an abundance of general ‘best practice’ advice available, little of it is ‘officially’ standardised (or perhaps ‘sanctioned’ would be a better term) and the advice is frequently fragmented (for example, do you follow the work of Prensky (2001), Gee (2007) or others?).

Similarly, while the criteria for selecting a COTS game may be straightforward (will the game run on the school’s computer hardware?, is the game age appropriate?), there is currently a lack of official ‘educational’ criteria dictating the educational suitability of a given game – at what Key Stage is the game aimed at? Which objectives does the game assist in teaching?

8.6.5.3 Who Develops Educational Games?

Another deficiency that affects the implementation of Games Based Learning is the lack of appropriate skills or expertise within the area of games development.

The author would suggest that there are very few people within the teaching profession who have the prerequisite skills in order to develop educational computer games. In the author's case, even with experience in general software development, the process of developing computer games (for the purposes of the Main Study) was challenging and fraught with problems (*Chapter 9*).

There are potentially two approaches to addressing this issue:

The first approach would be to train teachers in game development, thereby giving them the ability (with the appropriate software) to develop educational games. Of course, this approach raises the issues of who provides the training in the first instance, and who pays for it?

The second approach involves forming a partnership, or collaboration, between both the education sector and the games industry. This arrangement offers the best of both worlds, by taking advantage of the pedagogic knowledge of educationalists and mixing it with the game design and implementation skills of the games industry. In theory, this partnership should lead to the development of commercial quality educational games that are both 'fun' to play, and educational at the same time. As with the first approach, there is still the issue of finance – how are the resulting games ultimately funded or paid for? And by whom?

8.6.6 Addressing Practical Implementation Issues

8.6.6.1 Hire ‘Gaming’ Technicians and Eschew 3D Graphics

In the 21st century, it is difficult to imagine any publicly funded organisation without some form of formal I.T. or technical support policy.

However, during the preparation and implementation of the Prototyping Pilot/Main Study, it was the author’s perception that technical support at the primary school level is not as formalised as it is with larger educational establishments, such as colleges and universities. During the primary school selection process (*4.7.1 Selecting a Primary School*), it was apparent from the Department of Education data, that the availability of I.T. technicians was not always consistent. Some schools employed technicians on a part-time basis, but a considerable proportion seemingly employed no technicians or stated that they were fractional (< 0.5).

Stating the obvious, educational establishments should utilise an appropriate level of technical support for their needs and resources. However, if implementing a Games Based Learning strategy there may be a need for additional technical support, above the standard provision.

This additional support might take the form of employing technicians with ‘gaming’ knowledge and experience of computer networking, specifically in the context of setting up and using multiplayer COTS games over a computer network. This situation might also serve as a good opportunity (perhaps in the form of an afterhours school club) for pupils to obtain ‘work experience’ in I.T. by, for example, assisting in the process of installing computer games and acquiring the knowledge required to configure multiplayer games or set up game servers.

In terms of resources, some researchers express the view (mirroring the author's experience during the pilot/study) that many schools do not have the appropriate computer hardware to utilise Games Based Learning (*2.9.2 Education Barriers*). The most obvious solution to this problem would be to obtain access to additional funding in order to purchase newer I.T. resources – however this should not necessarily be the first option. As a starting point, schools or colleges should consider re-evaluating their existing equipment with a view to utilising it for Games Base Learning activities.

As implied whilst addressing Research Question 4, if advocates can re-define their preferred vision of how Games Based Learning should be implemented, then I.T. resource barriers can be potentially surmounted. There are opposing views (within the reviewed literature) as to the importance of using high fidelity graphics within educational computer games, but taking the Main Study results into account, the author would suggest that utilising 'aesthetically pleasing' graphics within a game is more important than whether the graphics are actually '2D' or '3D'. If advocates' can accept this premise, then the main barrier to using educational games (i.e. the requirement for high specification computers with 3D graphic cards) can be removed.

Of course, by adopting this approach, the range of COTS/educational games that could be introduced into the classroom is limited to either new (graphically simple) games, or older 'classic' games (which due to their age feature less demanding 'retro' graphics). This approach also fits nicely with the use of game development packages, such as 'GameMaker' or 'Scratch', which focus on producing graphically simplistic games. By removing the requirement for the high fidelity 3D graphics, existing hardware could be re-utilised, allowing pupils to 'play' the aforementioned games and in turn reducing the need for financial expenditure on new I.T. resources.

Based on the experience obtained through the Main Study, the author only applies this argument to the use of educational games at the primary school level. At higher education levels (i.e. secondary/high school, college, university) the author suspects that student expectations of graphical fidelity will be considerably higher, than that of primary school pupils. However, as discussed whilst addressing Research Question 3, the general commercial success of ‘aesthetically pleasing’ retro-styled games such as ‘Flappy Birds’ and ‘MineCraft’ could be interpreted as dispelling this higher education argument.

To some extent, all of this discussion might be considered a moot point. Given that Microsoft’s support for its Windows XP Operating System (OS) has officially ended (Ward 2014, McDonald 2014a), many businesses and organisations (including the education sector) may have already completed the process of switching over to newer versions of Microsoft’s OS, which in many cases will probably necessitate the purchase of newer (and probably more game playing capable) hardware.

8.6.6.2 Creation of an Education 'App Store'

Contained within the literature, is a limited range of 'best practice' suggestions as to how to utilise Games Based Learning within an educational environment. However, there currently seems to be a lack of formal standards or guidance to aid this process, especially in terms of selecting the appropriate educational or COTS games for use within the classroom.

For example, when attempting to select a game for inclusion within a teaching session, a teacher might ask themselves the following questions:

- Is the game, especially if it is a COTS game, suitable for use within the classroom environment? (For example, does it contain violence? Is it age appropriate for the target learners?).

- Does the game teach the desired educational concept? Or (in the case of COTS games) *can* the game be used to teach the desired educational concept?

- At which educational level is the game suitable or aimed?

- If an educational game, can it be used to teach specific objectives?

- Have any other teachers used this game before? Do they have any advice/experience on how to use the game within the classroom?

- Is there any support material associated with this game – examples of best practice or lessons plans?

At present, when attempting to answer these questions, the aforementioned teacher would have to turn to a number of resources:

- The PEGI (Pan European Game Information) game rating system (Figure 8.3) provides guidance on computer game suitability (age range, content), but focuses on rating non-educational games for their general content, rather than their pedagogic value.

- With the exception of Novak & Nackerud's (2011) RCIPR Model, selecting a COTS game for educational use relies heavily on the individual teacher's common sense, coupled with guidance sourced from fragmented academic literature, and potentially from the books of Prensky, Shaffer and Gee.

- In terms of the COTS games themselves, the teacher would have to confer with appropriate technical support staff as to the suitability of the chosen game for use with the school's I.T. resources. COTS games typically state both minimum and recommended computer system specifications, which are required in order to install and successfully play the game. However, in the author's experience, these specifications can be on the optimistic side (in order to not deter potential purchasers with low specification computers) and are therefore not the most reliable indicator of compatibility with a school's I.T. resources.

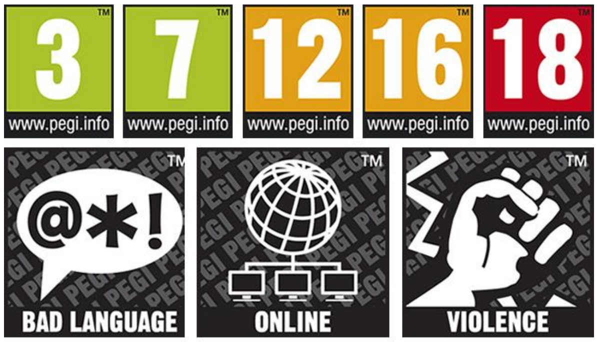


Figure 8.3: PEGI Ratings (PEGI 2014, VSC 2014, BBC 2012b)

While the answers to these (and other) questions can be found eventually (through research), it would be more convenient if there was a single ‘one stop shop’ location where a teacher could go to find all of the relevant information. The author would suggest that the solution to this ‘one stop shop’ can be found in the contemporary ‘App Store’ model, as pioneered by Apple Computers and Google (iTunes and Google Play Store, respectively).

Generically, the App Store approach allows users to visit a central location (i.e. the ‘App Store’ or a ‘Software Manager’, Figure 8.4 / Figure 8.5) to download software directly to their device (e.g. Computer, Tablet or Mobile phone). In addition to the software itself, most ‘stores’ will also provide supporting information, such as (Figure 8.6):

- The system specification (i.e. is it compatible with your device).
- A ‘What’s New’ paragraph (stating any ‘bug’ fixes or new features within the software).
- Access to user reviews, posted by other users of the software.
- A description of the software, accompanied by a picture or ‘screenshot’.
- An overall rating (typically out of 5 ‘stars’), based on user submitted ratings (i.e. Very Good, Good….Very Bad).

From a Games Based Learning perspective, the author proposes that a similar model be adopted for educational and COTS game selection.

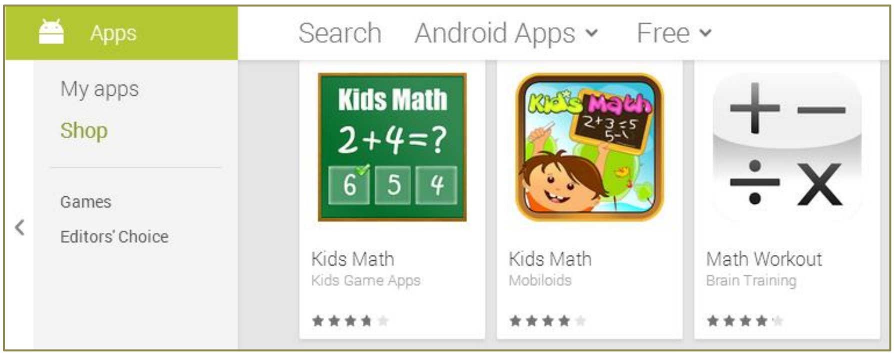


Figure 8.4: Google Play App Store

Figure 8.5: Linux Mint Software Manager

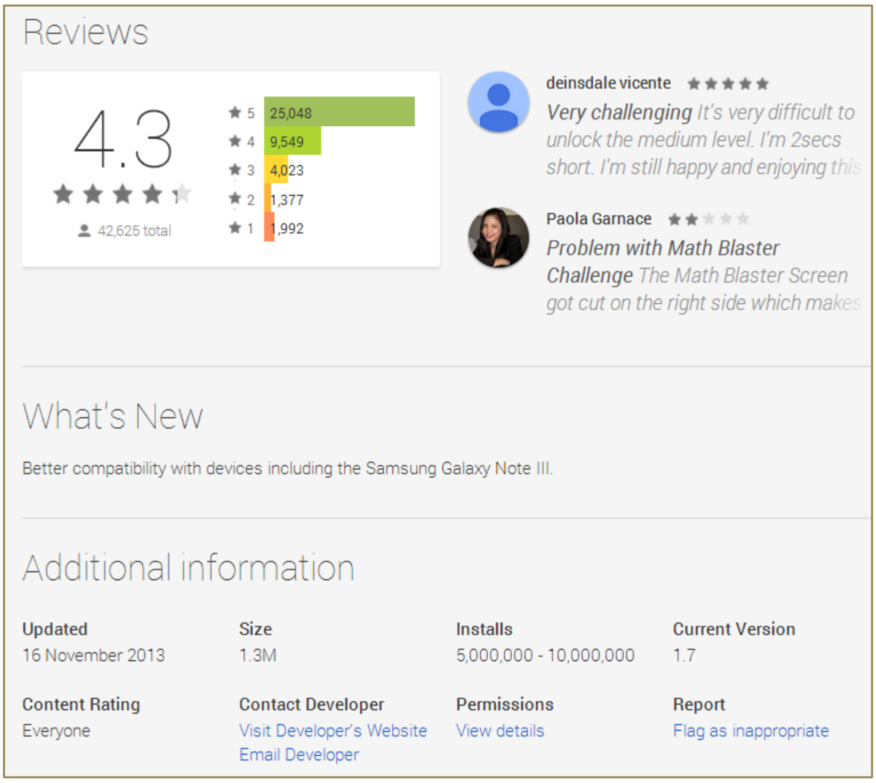


Figure 8.6: Google Play App Description (Math Workout)

Rather than having to locate information from numerous disparate sources, a teacher could theoretically visit an 'Educational App Store' (or 'EduApp Store'), and browse or search the available software by desired criteria, such as System Type (PC, Tablet.), Subject Area (Maths, Biology) or Educational Level (KS1, KS2, KS3). From a list of results, the teacher could then choose to review a particular game, based on ratings, user reviews (both submitted by teachers and subsequently peer reviewed) or by using the aforementioned educational criteria (subject or level). Assuming that the reviewed game meets the teacher's requirements, they can then click on the 'Download' button to download and install the software to their preferred device.

For each game listed within the 'EduApp Store', the author suggests that a range of information is included in order to aid the teacher in their selection process (Table 8.4).
The aspects that distinguish this proposed 'EduApp Store' from the non-educational variety, is the use of peer reviewing and the inclusion of 'best practice' advice ('Support Material', Table 8.4) that aims to provide guidance on how to actually use a specific game within a classroom context, preferably as part of a greater GBL strategy.

While conventional 'App Stores' such as Apple's 'iTunes' or Google's 'Play Store' are tied to a specific platform (i.e. iOS/Android), the author suggests that an 'EduApp Store' should be platform-agnostic i.e. accessible over the Internet from any web-enabled device. Ideally, the 'App's themselves would also be platform-agnostic, but the author pragmatically accepts that this might not be possible given the variety of platforms available on the market today (e.g. iOS, Android, Linux, Microsoft Windows).

While conceding that the 'EduApp Store' concept needs considerable refinement, the author would argue that it provides a starting point for the centralised promotion of GBL best practice.

Name / Title of Game
Self-Explanatory
Introductory Paragraph
This field could be used to present a small synopsis of the game or a ‘What’s New’ paragraph, stating any new features or ‘bugs’ that may have been fixed.
System Specification
This field would contain information relating to the type of device and software required in order to run this specific game This could include the type or class of device (i.e. PC, Tablet or Mobile Phone) and the required operating system/platform (i.e. Android, iOS, Linux, Windows). It is suggested that there should actually be two specifications – an ‘official’ specification (provided by the game developer) and an unofficial specification, as submitted by teachers/users based on practical real world use. This second specification would provide a more realistic and accurate indication of how well the software will run on the teacher’s available hardware.
Subject Area
i.e. Maths, English, Physics etc.
Educational Level
This field will refer to the educational level that the game is aimed at. This could be a generic reference, i.e. the age range of the learner (9 – 12) or the type of institution (Primary School, College, University) Alternatively, this level may be more geographically explicit i.e. referring to a specific education system: KS2/KS3 (UK), K-6/K-12 (US).
Educational Objectives
Overlapping with the ‘Educational Level’, any specific educational objectives might also be specified within this field. As with ‘Educational Level’, these objectives may be generic (i.e. double digit multiplication, single digit division) or relate to a specific geographic curriculum.
Game Description
A fuller, more detailed description of the game, potentially accompanied by ‘screenshots’ and any additional pertinent information. This field might possibly overlap with the ‘Support Material’ field (below).

Table 8.4: Suggested ‘Typical’ EduApp Game Listing (Influenced by Serious Games Directory 2014, Serious Game Classification 2014, EduGameLab 2013, Linux Education Packages 2014)

Rating
Ideally located at the top of each game listing (potentially next to the 'Introductory Paragraph') would be an overall rating, accompanied by the total number of users who have actually submitted a rating. These teacher submitted ratings will typically consist of 1 to 5 Stars, equating with Very Good, Good….Very Bad. Additionally, an official PEGI game rating (along with associated visual logo (Figure 8.9) might also be included, especially if the game is a commercial release.
Review (General)
Ideally, accompanying the Rating (above) will be a review of the game. This might include the following: An 'official' review, provided by administrator's associated with the Educational App Store, or User reviews, submitted by those teachers who have used the game. Ideally, this 'review' will be relatively short and limited to commenting on the game in general.
Review (Educational)
In addition to the general review, this field could be used to give a more pedagogical review of the game, focusing on whether it achieves its stated aims (as included within the Educational Level, Educational Objectives and Game Description). Ideally, comments within this field would be (where practical) peer reviewed in order to ensure consistent professional quality.
Support Material
This field will provide direct/indirect access to 'best practice' material. This may be provided by the game's developers and might include supplementary material such as promotional flyers, crib sheets (explaining the game control mechanisms) or user / help documentation not already included within the game. Ideally though, this field will include teacher-submitted 'best practice' advice derived from actual game use within the classroom. This might take the form of practical examples of use or sample lesson plans that fellow teachers can potentially utilise within their teaching.
Price
Can the game be downloaded for free or is this a paid for commercial product?

Table 8.4: Suggested 'Typical' EduApp Game Listing (Cont.)

Download
Idealistically, this field will actually be represented by a 'Download' button, which if 'clicked', will in turn download and install the software to the current device. In practical terms, how 'elegant' this process appears to the end user will be dependent on the underlying platform, and whether the game is open source or commercial. In the event of a commercial game, additional steps would need to be taken (i.e. accepting payment) before the installation process can successfully complete.
Developer/Publisher Information
Contact details of the game developer/publisher.

Table 8.4: Suggested 'Typical' EduApp Game Listing (Cont.)

8.6.6.3 Education/Industrial GBL Collaboration

Throughout the reviewed literature, there seems to be a presumption that teachers will be at the forefront of implementing Games Based Learning in the classroom, frequently in the context of developing educational games.

The author is of the opinion that given the average teacher's workload, it would be unrealistic to expect them to undertake any substantial game development activities. This assumes of course that teachers have the prerequisite game development skills in the first instance, which the author would suggest will be unlikely for the majority of teachers.
To some extent, the issue of having the relevant skills may be partially addressed through the current initiatives to train teachers in computer programming (Gov.UK 2014, Gibbs 2014, McDonald 2014b). However, this training relates to generic computer programming, and not necessarily game development.

An alternative approach may be to incorporate the appropriate training into pre-service teacher training courses, replacing or supplementing current ICT content. Unfortunately, this approach also presumes that the teacher trainers have the prerequisite game development skills to actually teach the subject to trainee teachers.

A more pragmatic approach to this problem would therefore be collaborations with the games industry, acknowledging that teachers have the pedagogic knowledge and the industry has the game development skills (Tan 2010). There are limited examples of academic/commercial collaboration within the literature (i.e. Blanchfield 2009, Charles *et al.* 2012), but one of the more prominent examples is that of Coventry University's Serious Game Institute (SGI) (Coventry University 2014). However, a review of the SGI website reveals that the majority, although not all, of their projects have a business-centric focus, rather than helping schools implement Games Based Learning (SGI 2014a, SGI 2014b, SGI 2014c).

Future collaborations could, in theory, be facilitated by the proposed UK centric GBL trade body, as discussed in the previous section (*8.6.4.1 Creation of a UK Centric GBL Trade Body*).

8.6.7 Conclusion

During the literature review process, the author identified a series of gaps broadly relating to the future mainstream adoption of Games Based Learning within the education system.

The author addresses these gaps, through a new synthesis of existing knowledge and new contributions to the existing pool of Games Based Learning knowledge.

The identified gaps relate to the lack of institutional support of GBL and the more practical issues associated with implementing a GBL based strategy. The author addresses these gaps, by proposing the following:

In terms of institutional support, the author proposes the foundation of a UK centric GBL trade body. The trade body would be responsible for promoting Games Based Learning to a wider audience and the government (i.e. Department for Education). Additionally, it is envisaged that the trade body could take a central role in facilitating collaborative projects between schools/academia and the games software industry. Given the limited public funding available at the present time, the author argues that shortfalls in GBL funding could be addressed through non-traditional methods, such as 'academic crowdfunding'.

In practical implementation terms, a number of deficiencies have been identified (within the literature) that currently prevent the mainstream adoption of GBL, including the lack of compatible I.T. resources, the absence of a central GBL resource for teachers and finally the issue of who actually designs and develops educational games. Addressing these ‘practical’ gaps, the author proposes:

- The hiring of technical support staff with ‘gaming’ experience.
- Eschewing games with high fidelity 3D graphics, for ‘aesthetically pleasing’ graphics, which in turn are more likely to be compatible with older hardware resources.
- The creation of an ‘Educational App Store’ (inspired by the Apple/Google ‘AppStore’ model) to act as a central repository for GBL ‘Best Practice’, supplementary material (i.e. lesson plans) and ideally, the educational games themselves.
- Finally, the author argues that the most practical and realistic approach to educational game development is through a collaboration between the education and game development sectors, theoretically facilitated by the proposed UK centric GBL trade body.

8.7 Conclusion

Within this penultimate chapter, the author formally addresses the research questions, as identified at the beginning of the thesis (*1.4 Defining the Thesis Research Questions*).

Research Question 1 chronicles the experiences of the author as a mechanism for exploring the practicalities of a teacher developing 'fun' educational computer games. The experience proved to be challenging, and was marked by overambitious enthusiasm and the author's lack of game design skills. Based on feedback (observation and questionnaire) from the Main Study, the author is confident in stating that his developed games could be considered 'fun'. Therefore, the author regards this question as having been addressed. However, the author would also caution that while it may be possible for a teacher to create 'fun' educational games, it may not be the most practical or preferred approach to delivering GBL into the classroom (based on the author's documented experiences).

Research Question 2 proved to be a challenging experience and the author regards this question as having only been partially addressed. The author was only able to source limited literature on the subject of game genre, and this area was not adequately reflected within the Main Study. However, based on the literature, the author would suggest that most researchers (within the field) exhibit a slight bias towards the (3D) simulation genre.

Based on the review of the literature, and the results of the Main Study questionnaires, the author is confident that Research Question 3 has been addressed. While there are scenarios where high-fidelity graphics are regarded as important (i.e. training simulations), the feedback from the Main Study would suggest that computer games can utilise low fidelity graphics and can still be used successfully within an educational environment.

Research Question 4 proved to be a challenging question, and due to its initial narrow focus, was subsequently broadened. When discussing whether GBL can be practically used within the education system, the author postulates two views:

1. GBL is unlikely to be successful (in the manner envisaged by its advocates (i.e. Prensky, Shaffer, Gee) due to a number of factors, including practical difficulties, poor social perception, incompatibility with a 'locked down' education system, lack of a coherent government policy and finally, issues related to who develops and pays for educational games.

2. GBL could be successful, but not in the manner envisaged by its advocates. GBL may ultimately find itself interweaved with the 'agents of change' currently passing through the education system, specifically within the promotion of computer programming as per the new 2014 curriculum and the 'Year of Code'.

As part of addressing Research Question 5, the author has identified and addressed a number of gaps within the current literature. These gaps broadly relate to barriers preventing the mainstream adoption of Games Based Learning. The author proposes to address these gaps in the following ways:

- At the institutional level, the author argues that there is a need for a UK centric GBL trade body to promote the interests of GBL to the wider audience and at the government level. Additionally, the author suggests that 'academic crowdfunding' could be used as a non-traditional form of finance for future GBL development.

- At a practical level, the author argues that a lack of I.T. support/resources could be addressed through the hiring of technicians with 'gaming' experience and the re-utilisation of existing hardware (by eschewing high-fidelity 3D graphics). The creation of an 'Educational App Store' could potentially centralise (and therefore make more accessible) GBL resources and related software. There is an implied view (within the reviewed literature), that teachers are the best placed to develop educational games, the author would argue that this might not always be practical and that an alternative approach could be through collaboration with the games industry, facilitated by the proposed UK centric GBL trade body.

In the final chapter (Chapter 9), the author concludes the thesis by discussing its contributions, limitations and future research, before reflecting on the thesis 'journey' itself.

Chapter 9 – Conclusions and Reflections

9.1 Introduction

In this final chapter, the author draws the thesis to a close, through both discussion and reflection.

In the first half of the chapter, the author discusses the thesis contributions and findings, closely followed by its (educational and institutional) implications. The author concludes with a discussion on the thesis limitations and suggestions for future research.

The second part of the chapter presents the author’s reflections on the thesis ‘journey’. These reflections fall into three areas:

- Reflection on addressing the thesis research questions.
- Reflection on the author’s journey developing educational games, as a non-game developer.
- And finally, a brief personal reflection on the author’s thesis journey.

9.2 Thesis Contributions

9.2.1 Redefining the Need for High Fidelity Graphics

Within the literature, there has been discussion on the role of graphical fidelity within educational computer games. The author holds the view that at the higher levels of education, the target audience (i.e. students) have a greater, more sophisticated, expectation of computer games in terms of their graphical fidelity. Additionally, the author will concede that certain classes of ‘games’ (such as training simulators) are strongly enhanced by the use of realistic, high-fidelity graphics.

However, there is a counter argument – In the days before ‘high fidelity’, there was ‘low fidelity’.

Malone & Lepper’s seminal work on the motivational properties of computer games was originally conducted in the early to mid 1980’s – an era that was still dominated by the first generation of videogame consoles, with their primitive (by today’s standards) rudimentary graphics. Around the same time, Atari Corporation converted their 1980 arcade game ‘Battlezone’ into a military simulator (‘The Bradley Trainer’) at the bequest of the US Army.

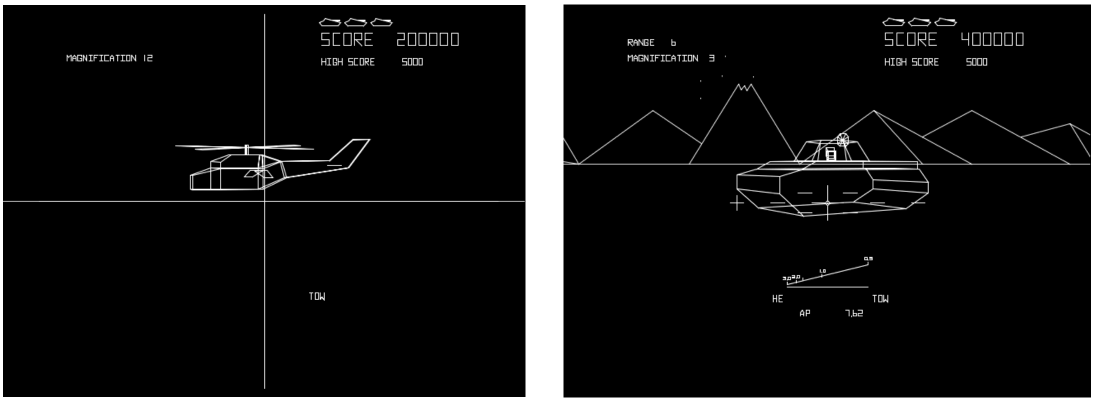


Figure 9.1: Bradley Trainer / Military ‘Battlezone’ (1981) (AtariAge 2014)

Despite the graphical crudeness of the games used by Malone & Lepper within their research, they were still viewed as having motivational properties. Viewing the ‘Bradley Trainer’ today (Figure 9.1), one might think that it would be difficult to be genuinely immersed in a simulation with such crude and unrealistic graphics – yet this did not seem to deter the US Army from commissioning the trainer in the first place.

In terms of the Main Study, the author had anticipated that his authored games would receive at best, a lukewarm reception, and at worst, that they would repel the sample group with their graphical crudeness (specifically in relation to the ‘low fidelity’ games). Yet, against the author’s expectations, both ‘low fidelity’ games (‘Block Panic’ / ‘1982’) were well received by the sample group (based on observational data and questionnaire feedback).

As previously discussed (*8.2 Research Question 1*), there could have been external factors regulating the popularity of these games, including the prospect of game playing (in general) being more appealing than the alternative activities that the sample group could have participated in, in place of the ‘Funky Friday’ programme.

However, the author asserts that there is some limited evidence (based on the study data) to suggest that, at a primary school level at least, educational computer games do not need high-fidelity graphics in order to be used successfully within an educational environment. The author regards this finding as significant, as it contradicts a section of the literature which frequently (and uncritically) places a greater emphasis on educational games which utilise high-fidelity graphics.

Additionally, this finding contributes to the addressing of one of the frequently cited criticisms of Games Based Learning – namely that schools require high specification '3D capable' hardware in order to successfully deliver GBL within the classroom. The results from the Main Study suggest that it is possible to successfully utilise low-fidelity games (running on low resource computing facilities, such as netbooks) and therefore the lack of expensive high specification computer hardware need not be a barrier to the implementation of GBL within the school sector.

9.2.2 'Real World' GBL Development / Usage

During the literature review, the author discovered a limited number of articles documenting the development and piloting of games within an educational environment. Frequently, these articles would focus on the final developed games or the results from the piloting itself, neglecting the game development process and the preparation required in order to pilot the games in the first place.

In terms of game development, the author (despite a software development background) found the process of developing the thesis games to be both time consuming and technically challenging, yet much of the aforementioned literature fails to discuss this aspect, despite it being a significant part of the GBL delivery process. Of significance was the author's fall into the 'Shavian Reversal' trap, which led to both educational versions of 'Pac-Man' and 'Bombjack' being generally poor games i.e. neither fun to play nor educational.

With hindsight, what the author has learnt from this experience is that some game genres are not (practically) suited for use as the basis of educational games design. In the case of ‘Pac-Man’ / ’Bombjack’, had the author altered the original game designs (to incorporate educational content); the result might have been educational, but would have probably not been fun to play. Unfortunately, the author took the alternative approach and blended the educational content behind the mechanics of the original game designs, resulting in fun games, but with (easily) avoidable educational content.

In terms of the Main Study, the primary school’s use of netbook computers (in place of a dedicated ICT suite) added a degree of complication to the classroom preparation process i.e. the need to transport netbooks between classrooms, as part of every (Main Study) session. However, the author still encountered additional (unexpected) issues that resulted in lengthy classroom preparation times. These issues included erratic wireless network connectivity, the need to silence every netbook’s audio output prior to the start of each session, the general slowness of both netbook startup and network logon, and finally the time consuming process of pre-loading an initial game (on every netbook) in order to expedite the start of each session. As with the process of game development, the author regards (GBL) classroom preparation to be an equally significant part of the GBL delivery process, yet this aspect is also rarely documented within the literature.

For the author, the delivery of the Prototyping Pilot and the Main Study was an informative experience, which the literature review failed to prepare him for. This ‘real world’ experience – the development, classroom preparation and delivery of GBL within a live school environment – could be considered of value to those teachers who also wish to introduce GBL into the classroom. Therefore, the author would argue that his (practical) experience represents a significant contribution to the currently limited pool of existing knowledge within this area.

9.3 Thesis Findings

The findings of the thesis, in terms of addressing the research questions and thesis hypotheses (*1.4 Defining the Thesis Research Questions* / *1.5 Thesis Hypotheses*), are summarised below, and are the subject of a wider discussion within Chapter 8.

Research Question 1 asks whether it is possible for a teacher (as a non-game developer) to create ‘fun’ educational computer games. The author regards this question as having been addressed, and his hypothesis proven. However, the author would state that having a teacher develop educational games may not always be the most practical or preferred approach given the difficulties encountered by the author (such as falling into the trap of ‘Shavian Reversal’).

Research Question 2 (type, format or genre most suited to GBL) proved to be a challenging experience and the author regards this question as only having been partially addressed, therefore, the author’s hypothesis has not been proven. Within the literature, the discussions on the subject of genre were mainly descriptive (or based on researcher opinion) and not adequately reflected within the study conducted by the author. However, based on the literature, the author would suggest that most researchers (within the field) exhibit a slight bias towards the (3D) simulation genre.

Based on the review of the literature, and the results from the Main Study, Research Question 3 (quality of computer graphics) has been addressed, but the author’s hypothesis has been disproven. The feedback from the study would suggest that computer games can utilise low-fidelity graphics and can still be used successfully within an educational environment.

Research Question 4 proved to be a challenging question, and due to its initial narrow focus, was subsequently broadened. When discussing whether GBL can be practically used within the education system, the author postulates two views:

1. GBL is unlikely to have a practical role, as envisaged by its advocates (Prensky, Shaffer, Gee), due to a number of factors, including: practical difficulties, poor social perception, incompatibility with a 'locked down' education system, lack of a coherent government policy and finally, issues related to who develops and pays for educational games.

2. GBL could have a practical role, but not as envisaged by its advocates. GBL may ultimately find itself interweaved with the 'agents of change' currently passing through the education system, specifically within the promotion of computer programming as per the new 2014 school curriculum.

The author is of the view that he has addressed this question and proven his hypothesis (with caveats).

As part of addressing Research Question 5, the author has identified and addressed a number of gaps within the current literature. These gaps broadly relate to barriers preventing the mainstream adoption of Games Based Learning. By reference to non-GBL literature, the author proposes to address these gaps in the following ways:

- At the institutional level, the author argues that there is a need for a UK centric GBL trade body to promote the interests of GBL to the wider audience and at the government level. Additionally, the author suggests that 'academic crowdfunding' could be used as a non-traditional form of finance for future GBL development.

- At a practical level, the author argues that a lack of I.T. support/resources could be addressed through the hiring of technicians with 'gaming' experience and the re-utilisation of existing hardware (by eschewing high-fidelity 3D graphics). The creation of an 'Educational App Store' could potentially centralise (and therefore make more accessible) GBL resources and related software. There is an implied view (within the reviewed literature), that teachers are the best placed to develop educational games, the author would argue that this might not always be practical and that an alternative approach could be through collaboration with the games industry, facilitated by the proposed UK centric GBL trade body.

The author is of the view that he has addressed this question and proven his hypothesis.

9.4 Implications

Within this section, the author summarises the implications of his thesis research, which can be divided into two areas: Educational Implications and Institutional Implications.

Educational Implications

Within the literature, many researchers advocate the design of educational games based on recognised educational theory, yet even by their own admission, there exists few examples of where this 'best practice' has been followed. As a result, the literature is dominated by educational game design based (directly and indirectly) on the work of Malone & Lepper.

In order to address this current deficiency, the research community needs to undertake not only additional research, but more practical research.

The author would postulate that additional research needs to be conducted into whether existing learning theories can be aligned with the design of educational games, and then to develop practical 'proof of concept' games to validate this research. The author also notes that much of the research previously conducted within this area (*3.8.4 Learning Theories*), is based upon established learning theories from the early to mid-20th century, rather than upon more recently developed theories (i.e. late-20th century onwards). While the author accepts that this situation is probably due to the accepted academic rigour associated with established theories, this should not (in the author's opinion) completely preclude research involving newer (but admittedly, less established) learning theories.

In addition to academic research, and as postulated by Tan (2010), research within this area could be enhanced through collaboration with the games industry, which is better placed to advise on the non-pedagogic aspects of game development.

Institutional Implications

As discussed within Chapter 8 (*8.6.3 Lack of Institutional Level Support for GBL*), it is the author's view that institutional support for Games Based Learning (as envisaged by GBL advocates) is currently lacking. The education system will naturally focus on delivering the current national curriculum in a manner deemed most appropriate for learners, and in preference to implementing the advice of GBL advocates (such as the use of games to teach). Equally (in the author's view), it is unlikely that the government will give consideration to the recommendations of GBL advocates, unless there is a strong political motivation to do so.

If Games Based Learning is to realise its full potential, there needs to be a pragmatic meeting of minds. The government should take the argued benefits of GBL seriously, and potentially incorporate its principles into the education system. Likewise, GBL advocates need to take a more pragmatic view of how GBL can help (if not necessarily 'fix') the education system, accommodating the pressing issues (such as hardware resource shortages or funding) and helping to resolve them where possible.

9.5 Thesis Limitations

The main limitations of the thesis can be found within the Main Study.

The sample group was kept to a manageable size. This was a practical consideration, and (with the benefit of hindsight) was a wise decision, allowing the author to successfully complete the Prototyping Pilot and Main Study with the minimum of unanticipated issues.

The author regards Research Question Two (Type, Format or Genre of game) as having been only partially addressed. Aside from the documented issues, the Main Study (with hindsight) would have benefited from a larger number of games, representing a wider range of genres. However, the author is of the opinion that had the study utilised an increased number of games, this may have made the study less manageable, contradicting supervisorial advice.

To some extent, the previously stated limitations also apply to Research Question Three (Quality of Graphics). While the author regards this question as having been addressed, the author’s confidence in the results would have been increased further through the use of a larger sample size and additional games reflecting a wider graphical diversity.

Reflecting back upon the study, the author would have preferred to have developed additional 3D (first person perspective) maths games for use within the study, complementing the existing maze games (‘Block Panic’, ‘Pyramid Panic’ and ‘Space Maze Panic’). While the ‘GameMaker’ software allows for the creation of such 3D games, the author is not currently confident that his limited proficiency in games development would have led to the successful implementation of this type of game.

9.6 Future Research

During the literature review process, the author identified three Games Based Learning related research areas which exceeded the scope of the thesis research questions. The author regards these areas to be of interest, and feels that they would merit additional research beyond the present thesis. The author considers there to be two major gaps within the current literature, one relating to the public perception of GBL, and the other relating to the lack of GBL based/aligned learning theories. A third area of interest is that of ‘Gamification’.

In addition to these three general research areas, the author also identifies possible future research specific to the thesis, namely in the areas of game genre (Research Question 2) and the graphical fidelity of educational computer games (Research Question 3).

9.6.1 Perceptions of Games Based Learning

Reviewing the literature, it is apparent that many advocates see virtue in the use of Games Based Learning, while at the other end of the debate, critics question the validity of the 'Digital Native' and whether games can truly be of any educational benefit. However, neither advocates nor critics seem to have considered how the population (outside the field of research) actually perceive the concept of Games Based Learning. One of the roles of the proposed UK centric GBL trade body (*8.6.4.1 Creation of a UK Centric GBL Trade Body*) would be to re-address this current situation.

While advocates might extol the virtues of GBL, it will not be of any relevance if the general public and politicians alike have a poor perception of educational computer games ('a bunch of kids just playing games when they should be learning' or 'an excuse for lazy teachers to avoid teaching').

The author can imagine at least two hypothetical scenarios (below) which could damage the perception of Games Based Learning, unless placed within the 'right' context by well-informed individuals aware of the general issues surrounding GBL.

E.g.

- The sight of pupils 'playing games' in school might still be associated (in certain eyes) with 'mindless' play and not learning. This in turn leads to the inevitable criticism that educational games are just being used by 'lazy teachers' to fill up teaching time. An Ofsted inspector, for example, might interpret 'learning' the digital native way (e.g. pupils running around, raised voices) as poor classroom management, rather than actual learning.

- Imagine a teacher utilising one of the early *Call of Duty* games, in order to teach the history of the Second World War. In the author's view, this might be considered a suitable game for use within a discussion on the key battles of the conflict, as seen from multiple (opposing) points of view (i.e. German, Russian and Allied Forces). Alternatively, the game (unless carefully presented) might also be regarded as wholly inappropriate for use within the classroom due to its depiction of violence against European citizens, regardless of their individual nationalities.

9.6.2 Learning Theory Research

There is a debate within the reviewed literature as to how educational games should be designed.

There are those who argue that game design should be founded on recognised learning theories, while others cite the seminal work of Malone & Lepper as a template for motivational game design. Many researchers, however, concede that many documented examples of 'educational' games ignore both arguments and seem to be based on the principles of traditional (non-educational) game design instead. Given these different arguments, the author is surprised that more research has not been conducted within the area of learning theory based game design.

The author's personal view is that it is more practical to add education to an existing 'fun' game, than it is to add 'fun' to a strictly educational game. Perhaps educational researchers also share this viewpoint, which in turn might explain the dearth of learning theory based game design methodologies?

9.6.3 Gamification

An alternative approach to the implementation of Games Based Learning is that of 'gamification' (Tobias, Fletcher & Wind 2014, Kim & Lee 2013, Whitton 2012, Bekebrede, Warmelink & Mayer 2011, de Freitas & Liarokapis 2011, Abrams 2011).

In short, gamification is the application of 'game like' principles to conventional education or training. As with the term 'game' itself, there is slightly differing opinion on what gamification is, and how it is implemented.

One view, perhaps influenced by the work of Malone & Lepper, is that the mechanics (or principles) found within computer games should be applied in non-game contexts in order to make a given activity more appealing, for example, design the activity to be challenging, foster curiosity and provide rewards. Another view is that gamification leverages a learner's gaming interest, in order to make a non-gaming activity more relevant or 'authentic' to that particular learner (similar in concept to situated learning).

A more pragmatic interpretation of gamification, is that it allows the use of gaming within the classroom without actually having to play the games, for example, by playing a pre-recorded video clip from a specific game in order to demonstrate an educational objective. This particular interpretation is advocated as a way to circumvent a lack of I.T. resources or the inability of older hardware to play newer COTS games.

Further research within this area may be merited, as the author is of the opinion that the pragmatic interpretation of gamification might be the most practical and realistic implementation of Games Based Learning within the UK's current economically austere climate.

9.6.4 Thesis Research

In terms of future research specific to the thesis, the author has previously identified areas that should be considered limitations of the thesis. It is these limitations that the author would like to address through continued research:

Based on the experience gained during the Main Study, the author is of the opinion that the area of game genre warrants further research. While the author is currently unable to offer any empirical evidence as to which genre of games is most suited for use within Games Based Learning, the experiences of producing both 'Pac-Man' and 'Bombjack' would suggest that there are certain genres that are perhaps unsuited for the basis of educational games. Further research would potentially be based upon the work of Wolf (2002), and involve the piloting of games reflecting a subset of Wolf's forty-two game classifications/genres.

Again, based on the experience gained through the Main Study, the author is of the view that the area of graphic fidelity warrants additional research. Specifically, the author would expand the testing of Research Question 3 (with a greater variety of graphically diverse games) as part of any future studies.

Ideally, any future studies would incorporate the following:

- A larger selection of low-fidelity games.
- A selection of 2D 'aesthetically pleasing' games, which could be considered neither low-fidelity, nor high-fidelity (i.e. 3D).
- A selection of 3D games – ideally these will vary in levels of fidelity, but the author concedes that this will be dependent on the author's development skills. Alternatively, these games may have to be sourced commercially (i.e. pre-existing commercial educational games).

The author is also aware (based on his previous experience), that the increased scope of any future studies would also require a greater level of logistics in terms of delivery and the (larger) volumes of sample data that would be generated.

9.7 Thesis Reflections

9.7.1 Research Questions

In terms of the thesis itself, the author's journey has been as interesting as it has been varied.

Within Research Question 1, and specifically from the software development point of view, the author forgot the old adage/philosophy of 'Keep It Simple, Stupid' – in other words, the importance of reducing complexity in the design and implementation of computer software. As documented in Chapter 4 (*4.6.1 Implementation / Development*), the author's initial game designs were (with hindsight) too ambitious, which in turn led to difficulties during the subsequent software development. This initial mistake was due to the author's enthusiasm to begin designing/recreating the 'classic' games of his childhood (i.e. 'Bombjack', 'Pac-Man', '1942' and 'Gauntlet').

While the author is satisfied with the finished games, somewhere along the journey to implementation the author lost track of both ‘Pac-Man’ and ‘Bombjack’ and how these games would work as educational games. It was not until the results came back from the initial testing pilot (conducted by the author’s supervisors), that the full extent of the problem emerged – namely it was possible to play both games, purely as games, effectively avoiding the educational content. Upon reflection, the author’s mistake was painfully obvious – in both games, the maths content was assigned to the optional bonus aspects of the games.

In an attempt to ensure that the educational content was not too imposing on the game play, the author had over-engineered the games so that the player could easily avoid the maths content with the minimum of penalties. Although familiar with the term, the author had not realised that he had effectively fallen prey to ‘Shavian Reversal’ – the failure to evenly balance ‘fun’ and education in balanced proportions.

While the author ‘feels’ that he achieved the ‘correct’ balance within his remaining games, what does ‘correct’ actually mean? Habgood & Ainsworth (2011) discuss the concept of blending ‘fun’ and education together through what they refer to as ‘intrinsic integration’, which they define as consisting of two aspects:

> “*Intrinsically integrated games deliver learning material through the parts of the game that are the most fun to play, riding on the back of the flow experience produced by the game and not interrupting or diminishing its impact.*
>
> *Intrinsically integrated games embody the learning material within the structure of the gaming world and the player’s interactions with it, providing an external representation of the learning content that is explored through the core mechanics of the gameplay.*”

(Habgood & Ainsworth 2011, p.173).

The author interprets Habgood & Ainsworth’s (2011) definition as suggesting that educational content should be attached or hitched onto the back of the ‘fun’ parts of a game, and that the content should be integrated into the game, rather than presented externally to the game i.e. on top of the game play, as with ‘Math Man’ or ‘Math Explorer 2’ (*6.2.6 Math Man / 6.2.7 Math Explorer 2*).

While the author sees the logic within this approach to integration, he ponders how the first part of this ‘intrinsic integration’ can actually be implemented in real terms? Reflecting upon Habgood & Overmar’s (2006) ‘Pyramid Panic’, the author considers the following question – which parts of this game are actually the ‘fun’ parts? – Is it the element of exploration? Avoiding the Pyramid’s enemies? Reaching the end of level? Or, all of these activities?

The author is of the view that the ‘fun parts’ of ‘Pyramid Panic’ (or any other game) will differ between players and player preferences. This in turn makes it potentially difficult to implement ‘intrinsic integration’ as this requires the game designer to actually assign educational content to specific ‘fun parts’, which may not be universally regarded as ‘fun’ by all of the potential game players.

The game ‘Gauntlet’ posed an interesting development challenge. Inspired by the fidelity of the original, the author attempted to recreate (unsuccessfully) the pseudo-3D graphics for his educational version of this game. After having discarded both ‘Pac-Man’ and ‘Bombjack’, the author was understandably reluctant to have to abandon ‘Gauntlet’ as well. At this point, the author was greatly indebted to the work of Habgood & Overmars (2006) and specifically their game design for ‘Pyramid Panic’.

Upon reading through the design methodology for ‘Pyramid Panic’, the author was again forced to reflect upon his own mistakes. As before, the original design for ‘Gauntlet’ was (with the benefit of hindsight) far too ambitious, and the simplicity associated with implementing ‘Pyramid Panic’s (2D) graphics starkly illustrated to the author that he was simply not experienced enough in game design to begin implementing games with 3D or pseudo-3D graphics.

Attempting to address Research Question 2 has contributed to one of the thesis limitations (*9.5 Thesis Limitations*) and relates to the influence of genre on educational games. With the benefit of hindsight, the results of the literature review into this area should have acted as an initial warning. Of the literature sourced, the author found that genre was frequently referenced in a descriptive manner (merely listing the available types) or characterised by a lack of empirical evidence when citing preferences for one genre or another.

These initial literature findings were compounded by the under-representation of genre within the Main Study and further exacerbated when the author abandoned the games 'Pac-Man' (Maze game genre) and 'Bombjack' (Platform genre), reducing the already limited number of represented genres (within the study) even further. However, post-study, it occurred to the author that addressing Research Question 2 could have gone to the other extreme and fallen foul of the same over ambition that caused the author issues whilst addressing Research Question 1.

If the author had tested this research question to the fullest extent, it would have meant potentially testing for all of Wolf's (2002) forty-two genre classifications, or at least the majority of these classifications. This would have been a considerable undertaking and the author can imagine the potential problems that a study of this scale could have succumbed too (namely being too large and therefore unwieldy to manage). Therefore, on reflection, the author has identified game genre as an area that warrants further research, including additional studies of a balanced and manageable nature.

Reflecting on Research Question 3, the author would have liked to have included games of a greater graphical fidelity within the Main Study. Ideally, this would have included educational games (developed by the author) featuring 3D graphics. During the literature review, the author discovered a tutorial (Overmars 2009) demonstrating how a 3D FPS game could be created within 'GameMaker', utilising the sprites from iD Software's 'Doom'.

The tutorial itself was relatively straightforward to implement and resulted in a small single level 3D maze. While the author was impressed with the end result, there was a degree of complexity involved in creating this single level, and the author was concerned with how this complexity would scale up if the tutorial were to be implemented as a full-blown educational game.

Ironically, given the issue of sourcing quality sprites for the author's games, the tutorial only required relatively simple 'textured' images (wall or floor markings/patterns) in order to create its impressive 3D effect. While intrigued by the challenge of basing a game on this tutorial, the author acknowledged his limited game/graphic design skills (especially after his failed attempt at implementing 'Gauntlet') and felt it prudent to continue using Habgood & Overmars's (2006) work as the guiding influence for the author's games.

One aspect of the Main Study that genuinely surprised the author was the reception (by the sample group) of his low-fidelity games, 'Block Panic' and '1982'. Despite the author's best attempt to make these games as unappealing as possible (the badly drawn 'stick' characters in particular), the sample group reacted quite positively towards them.

While some of the popularity of 'Block Panic' might be credited to the game being perceptively easier to play than the rest of the author's games, this observation does not apply to '1982'. Despite its use of single colour triangles and blocks, '1982's crude graphics did not seem to act as a barrier to the sample group's observed enjoyment, and it occurs to the author that sometimes graphical fidelity can be over promoted as a selling point for (leisure-based) digital games.

Research Questions 4 and 5 presented challenges of a different type in comparison to the earlier research questions. Firstly, both questions were too narrowly focused, and secondly each required an element of (literature based) foresight as to the future development of Games Based Learning. The issue of narrow focus was resolved by widening the scope of the research questions in light of the literature review. However, during the write up of Research Question 5, the author was reminded of his experiences during both his Honours and Masters Degree courses within the discipline of computer science.

When the author started his journey into the world of Games Based Learning, he embarked with an open mind. The initial review of the literature revealed the passion of GBL advocates such as Prensky, Shaffer and Gee, but as the literature review progressed, so did the author's own thinking on the subject. While advocates argue for the use of GBL as a mechanism to save a 'failing education system', the author takes a more pragmatic view. The UK education system is currently undergoing a period of change (as reflected by the new 2014 schools curriculum) and the author is of the view that GBL may well play a role within this change.

It was during the realisation of this view, that the author was reminded of his previous academic studies.

At the end of the 1990's, the author undertook a literature review as part of his Honours Degree final year project. The review reflected the view (at the time) that 'traditional' relational databases were not suited to future data storage/retrieval needs and that the future lay with Object Orientated Databases (OODB). By the mid-2000's, the author undertook a Masters Degree and conducted a similar literature review for a database course module. During the review, the author discovered that the concept of OODB's had faded in prominence, giving way to the newer 'XML Database' – again promoting itself as a replacement for the 'traditional' relational database.

Yet towards the end of the Masters Degree, subsequent literature reviews revealed that XML Databases were also starting to fade in prominence within the literature, with seemingly no obvious (non-relational) database replacement. The author later discovered that the major database companies (i.e. Oracle and Microsoft) had responded to the 'threat' of OO/XML database developments by incorporated both concepts (as 'features') into their respective relational databases.

The author is of the view that a parallel analogy can be drawn when discussing both the current, and future, development of Games Based Learning. While the author can discuss current developments within GBL with a degree of rigour (with references to academic literature), attempting to discuss the 'future' development and adoption of GBL is more problematic. What will the future hold for Games Based Learning? Will it be everything that the likes of Prensky, Shaffer and Gee hope for? Or will it be a more pragmatic implementation as postulated by the author?

Referring back to the evolution of the OO/XML database, the author is reasonably confident that whatever the future holds for Games Based Learning, the end result may not ultimately reflect Prensky, Shaffer, Gee or even the author's own postulations.

9.7.2 The Practicalities of Educational Game Development

Reviewing the literature, the author was struck by the different examples of game development within an educational environment.

A number of journal articles were of a practical nature, and documented academics developing experimental 'Serious Games' for use within their teaching. Despite the high level of skills required, these academics appeared to make the games development process seem almost effortless. However, the author acknowledges that within these articles, the development process was considered secondary to the main objective of trying to ascertain whether a computer game could increase the possibilities of successful learning.

Other articles generally focused on the principles of Games Based Learning, primarily advocating its use within the school environment. These articles differed slightly in how proposed educational games would be produced. In some cases, the articles would presume (without comment) that teachers would somehow create these games, in other articles the opinion was more explicit – teachers would develop these games and would, in one example, enlist pupils to help test them. However, a significant gap within the literature was the opposite viewpoint – how does a teacher (or anyone else for that matter), actually go about creating educational games? Neither of the aforementioned articles discusses the practical process of (educational) game development undertaken by the non-game developer.

The author's experience of this process (within the context of the thesis) contributes to addressing this gap within the literature, and represents a new contribution to the existing pool of knowledge and experiences within the area of Games Based Learning.

The author regards himself as a non-game developer, and feels that the experiences encountered during the thesis game development phase can be applied to that of teachers, who may find themselves at the forefront of educational game development. Despite holding degrees in the area of computer science, and having some experience of (non-game) software development, the author still found the game development process to be genuinely challenging.

One difficulty was the gradual learning and understanding of the ‘GameMaker’ software. While the author is in no doubt that ‘GameMaker’ facilitates more accessible game development for the novice developer, it still requires a certain level of skill and experience to develop games. As a result, the author relied heavily on the work of Habgood and Overmars (2006), and their experiences of game development. Their guidance took the form of using tried and tested ‘classic’ game designs as a template for teaching game development. As a non-game designer, being able to relate the theory of game mechanics to well known, practical examples of games design, aided the author’s development journey and probably prevented the author from digging too many ‘holes’ for himself in the early development process.

While the ‘GameMaker’ software has considerable supporting documentation, the knowledge acquired by the author had to be partially gained through experience – some knowledge cannot be simply obtained through reading a book. It was this aspect that allowed the author to appreciate the importance of Internet communities. On several occasions, the author utilised the ‘GameMaker’ forums, in order to ask questions and seek the knowledge that was simply not available within the online help or within the books of Habgood & Overmars (2006) and Habgood, Nielsen & Rijks (2010). The sharing of experiences between fellow (novice) developers proved to be invaluable in the shaping of the author’s understanding of the ‘GameMaker’ development process.

Related to the game development process itself was the sourcing of the multimedia material (graphics and audio) for use within the author's games. While there was the occasional consideration within the literature, that teachers would require technical (i.e. programming) skills in order to develop computer games, there appears to be limited appreciation of the creative skills required. The author suspects that many teachers, including the author himself, do not necessarily have the creative skills needed to create computer games. In the author's case, this led to the reliance on the use of third party multimedia material, which in turn tested the author's technical skills (i.e. editing the multimedia for inclusion within the author's games).

This aspect brought about the realisation that while teachers can teach, it is the game designers that actually creatively 'create'. It would seem obvious to state that games designers do not automatically have the skills and ability to teach, and on this basis, the author would also argue that teachers do not automatically have the creative skills needed to create games, in addition to the required technical and pedagogic skills. Teachers might be capable (technically) of creating games, but without the creative skills, the resulting games may not actually be any 'good' i.e. aesthetically pleasing to look at, and fun to play.

Another lesson that the author learnt (after development was completed) was that not all game genres or formats lend themselves to being 'educationalised'. With the benefit of hindsight, the author considers his developed games, 'Bombjack' and 'Pac-Man', to be very poor educationally. While the games played well from a leisurely point of view, the ability to play the games while avoiding the maths content rendered their educational use null and void. This discovery proved frustrating at the time, as the author had spent considerable time developing the games, only to have to drop them prior to the Prototyping Pilot.

From a personal point of view, the process of developing the thesis games was a challenging adventure, but also a rewarding one. Despite their relative lack of sophistication, the author's games were better received (at the primary school level) than the author had anticipated. However, the author will concede that his games will not be winning any awards for originality nor aesthetic appeal. Additionally, outside of the primary school domain, the games might be regarded by older (and more sophisticated) players as being somewhat amateurish.

The author would argue that the experiences documented within this section are not unique to the author, but can also be applied to teachers (in general) attempting to develop educational games for use within the school environment.

9.7.3 Personal Reflection

At the beginning of the thesis 'journey', the author was working in the Kingdom of Saudi Arabia, not quite out in the middle of the desert, but not far from it. After formally enrolling onto the research degree, the author had the opportunity to meet his supervisors for the first time. While the granular details of that first meeting have diminished over time, the author remembers being told that he was the first 'distance learning PhD student' at the Centre for Education, and that the ensuing 'journey' would be (relatively) uncharted.

In contrast to the author's Honours/Masters degree experiences, the remoteness of the author's location was not without challenge. Sitting within a university library pouring through books and journal articles was not always a practical option in the author's (then) geographical location, and therefore the existence of Athens (the electronic journal retrieval system) proved to be an invaluable tool for studying from within the desert. Supervision was also an interesting experience, but one which was constrained by time zones and lengthy international travel.

The author has also encountered a few personal challenges. During this time, the author's mother passed away and it is with some regret that she will not be able to witness her son complete his 'doctoral' journey. Job redundancy and subsequent relocation also proved to be a stressful experience for the author and a disruptive one considering the international nature of his employment.

However, throughout the stages of this journey, the author has appreciated the support of his supervisors who have steered him in the right direction, especially when the author (occasionally) wandered off track. The author has also been enthused and derived personal satisfaction throughout the writing of this thesis, sometimes, over indulgently, to the exclusion of everything else.

Finally, the author would like to thank his wife whom he met and married during the 'journey', and whom has had faith in the author's abilities, especially during those times when the author's faith stalled.

9.8 Conclusion

This final chapter draws the thesis to a close, through both discussion and reflection.

In terms of thesis contributions, the author has demonstrated (through the Main Study) that educational computer games do not require high-fidelity graphics in order to be successfully used within an educational environment. The author also documents his 'real world' experience of delivering GBL, arguing that his development, classroom preparation and delivery of educational games (through both the Prototyping Pilot and the Main Study) represent a significant contribution to the literature within this area.

With the exception of Research Question 2, the author has addressed the thesis research questions, and proven his hypotheses .However, while Research Question 3 has been addressed, the author has disproven his hypothesis by establishing (thorough the Main Study) that educational computer games can utilise low-fidelity graphics and still be used successfully within an educational environment.

There are two main implications that stem from the thesis research. The first implication relates to the dearth of learning theory based game design methodologies, an area which warrants additional research. The basis of the second implication is that if Games Based Learning is to realise its full potential (within the education system) there needs to be a pragmatic meeting of minds, between the government (i.e. the DfE) and GBL advocates.

The author acknowledges the limitations of the thesis, which centre on the implementation of the Main Study – the use of a small sample size, under-representation of genre and the lack of graphically diverse computer games within the study.

Future research is classified into two areas, general research, and research specific to the thesis. In terms of general future research, the author has identified three areas that fall out of the current scope of the thesis – Perceptions of GBL (how do those outside of the research community view GBL?), Learning Theory Research (pedagogic game design) and 'Gamification' (applying 'game like' principles to training/education). In terms of the thesis itself, the author argues that future research should include additional pilots/studies which incorporate games from a wider variety of game genres and with greater graphical diversity (low-fidelity, 'aesthetically pleasing' and 3D).

Finally, the chapter concludes with the author's reflection upon his thesis journey. This reflection is divided into three areas: Reflection upon addressing the research questions, the process of educational game development and finally, an element of personal reflection.

References

(Formatted in accordance with Warwick University Bibliographic Citation and Referencing Guide: http://www2.warwick.ac.uk/services/library/using/guidance-training/referencing)

4Mation. (2014a, June 08). *Retro Granny's Garden*. [Online]. (URL http://www.4mation.co.uk/retro/retrogranny.html). UK: 4Mation Educational Resources Ltd. (Accessed 15 December 2014).

4Mation. (2014b, May 04). *Granny's Garden*. [Online]. (URL http://www.4mation.co.uk/cat/granny.html). UK: 4Mation Educational Resources Ltd. (Accessed 15 December 2014).

Abbot, C. (2000). *ICT: Changing Education*. UK: Routledge.

Abrams, S.S. (2011). Video Games in the Classroom, *In*: Khine, M.S. ed(s). *Playful Teaching, Learning Games: New Tool for Digital Classrooms*. NL: Sense Publishers, pp. 39-49.

Acorn Electron World. (2013 Maths with a Story: 1. [Online]. (URL http://www.acornelectron.co.uk/info/electron/bbcsoft/Maths_With_A_Story_1.html). UK: BBC. (Accessed 15 December 2014).

Admiraal, W., Huizenga, J., Akkerman, S., Dam, G. T. (2011). The concept of flow in collaborative game-based learning. *Computers in Human Behavior*, **27**(3), pp. 1185-1194.

Ahmad, I., Jaafar, A. (2012). Computer Games: Implementation into Teaching and Learning. *Procedia-Social and Behavioral Sciences*, **59**, pp. 515-519.

Allen, M. (2006). Retroinspection: Commodore 64. *Retro Gamer*, **30**, pp. 18-23.

Allen, M. (2008). Retroinspection: VIC-20. *Retro Gamer*, **46**, pp. 34-37.

Altmann, J. (1974). Observational study of behavior: sampling methods. *Behaviour*, pp. 227-267.

Ambleside Primary School. (2011). *Table Trees*. [Online]. (URL http://www.amblesideprimary.com/ambleweb/mentalmaths/tabletrees.html). UK: Ambleside Primary School. (Accessed 17 October 2011).

Amory, A., Naicker, K., Vincent, J., & Adams, C. (1999). The use of computer games as an educational tool: identification of appropriate game types and game elements. *British Journal of Educational Technology*, **30**(4), pp. 311-321.

Amory, A. (2007). Game object model version II: a theoretical framework for educational game development. *Educational Technology Research & Development*, **55**(1), pp. 51-77.

Amory, A., Molomo, B., Blignaut, S. (2011). The Game Object Model and expansive learning: Creation, instantiation, expansion, and re-representation. *Perspectives in Education*, **29**(4), pp. 87-98.

Anderson, A.R. (2014, February 27). *Keeping It Simple Doesn't Mean You're Stupid*. [Online]. (URL http://www.forbes.com/sites/amyanderson/2014/02/27/keeping-it-simple-doesnt-mean-youre-stupid/). US: Forbes.com LLC. (Accessed 24 June 2014).

Andrews, S. (2012a, February 17). *BBC Micro may return to the classroom*. [Online]. (URL http://www.pcpro.co.uk/news/education/372853/bbc-micro-may-return-to-the-classroom). UK: Dennis Publishing. (Accessed 10 March 2014).

Andrews, S. (2012b, September 14). *Write your own Raspberry Pi game*. [Online]. (URL http://www.pcpro.co.uk/tutorials/376858/write-your-own-raspberry-pi-game). UK: Dennis Publishing. (Accessed on 14 March 2014).

Annetta (Ed.), L.A. (2008). *Serious Educational Games – From Theory to Practice*. NL: Sense Publishers.

Annetta, L. (2010). The "I's" have it: A framework for serious educational game design. *Review of General Psychology*, **14**(2), pp. 105-112.

Annetta, L. A., Folta, E., Klesath, M. (2010). The power of serious games in education and why we are at a critical crossroads in distance education. *V-Learning*. NL: Springer Netherlands, pp. 25-34.

Annetta, L. A., Lamb, R., Stone, M. (2011). Assessing Serious Educational Games. *Serious Educational Game Assessment: Practical Methods and Models for Educational Games, Simulations and Virtual Worlds*. US: SensePublishers, pp. 75-93.

Aponte, M. V., Levieux, G., Natkin, S. (2011). Measuring the level of difficulty in single player video games. *Entertainment Computing*, **2**(4), pp. 205-213.

Apperley, T. H. (2006). Genre and game studies: Toward a critical approach to video game genres. *Simulation & Gaming*, **37**(1), pp. 6-23.

Armstrong, T. (2009). Multiple Intelligences in the Classroom. 3rd Edition. US: ASCD.

Arnab, S., Berta, R., Earp, J., de Freitas, S., Popescu, M., Romero, M., Stanescu, I., Usart, M. (2012). Framing the Adoption of Serious Games in Formal Education. *Electronic Journal of e-Learning*, **10**(2), pp. 159-171.

Arnab, S., Brown, K., Clarke, S., Dunwell, I., Lim, T., Suttie, N., de Freitas, S. (2013). The development approach of a pedagogically-driven serious game to support Relationship and Sex Education (RSE) within a classroom setting. *Computers & Education*, **69**, pp. 15-30.

Arnab, S., Lim, T., Carvalho, M. B., Bellotti, F., Freitas, S., Louchart, S, De Gloria, A. (2014). Mapping learning and game mechanics for serious games analysis. *British Journal of Educational Technology*, **2014**, pp. 1-21.

Ashworth, F., Brennan, G., Egan, K., Hamilton, R. Saenz, O. (2004). Learning Theories and Higher Education. *Level 3*, **2**, pp. 1-17.

AtariAge. (2013a). *Atari VCS*. [Online]. (URL http://atariage.com/2600/archives/consoles.html). (Accessed 25 January 2014).

AtariAge. (2013b). *Basic Math*. [Online]. (URL http://atariage.com/software_page.html?SoftwareLabelID=14). (Accessed 25 January 2014).

AtariAge. (2013c). *Brain Games*. [Online]. (URL http://atariage.com/software_page.html?SoftwareLabelID=48). (Accessed 25 January 2014).

AtariAge. (2013d). *Math Gran Prix*. [Online]. (URL http://atariage.com/software_page.html?SoftwareLabelID=290). (Accessed 25 January 2014).

AtariAge. (2013e). *Alpha Beam with Ernie*. [Online]. (URL http://atariage.com/software_page.html?SoftwareLabelID=987). (Accessed 25 January 2014).

AtariAge. (2013f). *Basic Math - Atari 2600 Screenshots*. [Online]. (URL http://atariage.com/screenshot_page.html?SoftwareLabelID=989&ItemTypeID=SCREENSHOT). (Accessed 25 January 2014).

AtariAge. (2013g). *Math Gran Prix - Atari 2600 Screenshots*. [Online]. (URL http://atariage.com/screenshot_page.html?SoftwareLabelID=290&ItemTypeID=SCREENSHOT). (Accessed 25 January 2014).

AtariAge. (2013h). *BreakOut - Atari 2600 Screenshots*. [Online]. (URL http://atariage.com/screenshot_page.html?SoftwareLabelID=53&ItemTypeID=SCREENSHOT). (Accessed 10 February 2014).

AtariAge. (2014). *Bradley Trainer Support in MAME*. [Online]. (URL http://www.atariage.com/news/Bradley/). (Accessed 18 April 2014).

AtariMania. (2012). *Atari 800XL Trivial Pursuit*. [Online]. (URL http://www.atarimania.com/game-atari-400-800-xl-xe-trivial-pursuit_5522.html). (Accessed 26 January 2014).

ATM. (2014). *L - a Mathemagical Adventure - Single User Licence*. [Online]. (URL http://www.atm.org.uk/Shop/L---a-Mathemagical-Adventure---Single-User-Licence/sof073). UK: Association of Teachers of Mathematics. (Accessed 15 December 2014).

Auman, C. (2011). Using Simulation Games to Increase Student and Instructor Engagement. *College Teaching*, **59**(4), pp. 154-161.

Ayiter, E. (2008). Integrative art education in a metaverse: ground<c>. *Technoetic Arts: A Journal of Speculative Research*, **6**(1), pp. 41-53.

Baldwin-Evans, K. (2006). Key steps to implementing a successful blended learning strategy. *Industrial and Commercial Training*, **38**(3), pp. 156-163.

Ballard, M. (2013, May 31). *Pull out and keep our guide to UK gov IT failures*. [Online]. (URL http://www.computerweekly.com/blogs/public-sector/2013/05/pull-out-and-keepyour-guide-to.html). UK: TechTarget (Accessed 10 March 2014).

Bandura, A. (1997). *Self Efficacy: The Exercise of Control*. US: Worth Publishers.

Barendregt, W., Bekker, M.M. (2004). Towards a Framework for Design Guidelines for Young Children's Computer Games. *Lecture Notes in Computer Science*, **3166**, pp. 365-376.

BBC. (1981). *BBC - Continuing Education Television Computer Literacy Project*. [Online]. (URL http://www.computinghistory.org.uk/pdf/acorn/BBC-Computer-Literacy-Project.pdf). (Accessed 01 October 2013).

BBC. (2011a, September 20). *Failed fire project wasted £469m, says committee of MPs*. [Online]. (URL http://www.bbc.co.uk/news/uk-14974552). UK: BBC. (Accessed 10 March 2014).

BBC. (2011b, December 14). *ICT 'poor in secondary schools', Ofsted says*. [Online]. (URL http://www.bbc.co.uk/news/education-16157519). UK: BBC. (Accessed 10 March 2014)

BBC. (2012a, March 21). *Budget 2012: Tax breaks for games industry*. [Online]. (URL http://www.bbc.co.uk/news/technology-17464478). UK: BBC. (Accessed 12 April 2014).

BBC. (2012b, May 10). *Video Standards Council to take over games age ratings*. [Online]. (URL http://www.bbc.co.uk/news/technology-18017385). UK: BBC. (Accessed 12 April 2014).

BBC. (2013a, September 18). *NHS IT system one of 'worst fiascos ever', say MPs*. [Online]. (URL http://www.bbc.com/news/uk-politics-24130684). UK: BBC. (Accessed 10 March 2014).

BBC. (2013b, December 27). *Internet Archive puts classic 70s and 80s games online*. [Online]. (URL http://www.bbc.co.uk/news/technology-25527786). (Accessed 01 February 2014).

BBC (2014a, January 31). *Ofsted cracks down on classroom behaviour*. [Online]. (URL http://www.bbc.co.uk/news/education-25984167). UK: BBC. (Accessed 01 March 2014).

BBC. (2014b, February 28). *Minecraft film 'set to hit silver screen'*. [Online]. (URL http://www.bbc.co.uk/news/technology-26387798). UK: BBC. (Accessed 02 March 2014).

BBC. (2014c, March 06). *Crowdfunding new regulations anger start-up industry*. [Online]. (URL http://www.bbc.co.uk/news/business-26464551). UK: BBC. (Accessed 12 April 2014).

BBC. (2014d). S*killswise*. [Online]. (URL http://www.bbc.co.uk/skillswise/maths/games). UK: BBC. (Accessed 15 December 2014).

BCS. (2012, September). *BBC Micro: past, present and future*. [Online]. (URL http://www.bcs.org/content/conWebDoc/47859). (Accessed 01 October 2013).

Becker, K. (2007). Digital game-based learning once removed: Teaching teachers. *British Journal of Educational Technology*, **38**(3), pp. 478-488.

Bekebrede, G., Warmelink, H.J.G., Mayer, I.S. (2011). Reviewing the need for gaming in education to accommodate the net generation. *Computers & Education*, **57**(2), pp. 1521-1529.

Bele, J.L., Rugelj, J. (2007). Blended Learning – A Opportunity to Take the Best of Both Worlds. *International Journal of Emerging Technologies in Learning*, pp. 29-33.

Bennett, S., Maton, K., & Kervin, L. (2008). The ‘digital natives’ debate: A critical review of the evidence. *British journal of educational technology*, **39**(5), pp. 775-786.

BERA. (2011). Ethical Guidelines For Educational Research. UK: BERA.

Beuke, C. (2011, August 13). *Keep it Simple Stupid – Should you being focusing more on the basics?*. [Online]. (URL http://www.psychologytoday.com/blog/youre-hired/201108/keep-it-simple-stupid). US: Sussex Publishers, LLC. (Accessed on 24th February 2014).

Belanich, J., Orvis, K. L., Sibley, D. E. (2013). PC-based Game Features that Influence Instruction and Learner Motivation, *Military Psychology*, **25**(3), pp. 206-217.

Belland, B.R. (2012). The Role of Construct Definition in the Creation of Formative Assessments in Game-Based Learning. *In*: Ifenthaler, D., Eseryel, D., Ge, X. ed(s). *Assessment in Game-Based Learning: Foundations, Innovations, and Perspectives*. US: Springer Science+Business Media New York, pp. 29-42.

Bellotti, F., Ott, M., Arnab, S., Berta, R., de Freitas, S., Kiili, K., Gloria, A.D. (2011). Designing Serious Games for Education: From Pedagogical Principles to Game Mechanisms*. Proceedings of the European Conference on Games Based Learning*, pp. 26-34.

Bevan, M. (2008). Retroinspection: Atari 800XL. *Retro Gamer*, **47**, pp. 72-75.

Birch, A. (2004). Sega Ages. *Retro Gamer*, **05**, pp. 29-34.

Blair, D.V. (2009). Learner agency: To understand and to be understood. *British Journal of Music Education*, **26**(2), pp 173-187.

Blanchfield, P. (2009). Using Educational Game Design to Teach Software Engineering. *Proceedings of the European Conference on Games Based Learning*, pp. 24-29.

Blyth, T. (2012). The Legacy of the BBC Micro: effecting change in the UK's cultures of computing. UK: NESTA.

Bowland Maths. (2014). *Bowland small project grants 2014*. [Online]. (URL http://www.bowlandmaths.org.uk/about/grants.html). UK: Bowland Charitable Trust. (Accessed 25 June 2014).

Bradshaw, P., Twining, P., Walsh, C. S. (2012). The Vital Programme: Transforming ICT Professional Development. *American Journal of Distance Education*, **26**(2), pp. 74-85.

Brace, N., Kemp, R., Snelgar, R. (2012). *SPSS for Psychologists*. 5th Edition. UK: Palgrave Macmillan.

Bruner, J. (1966). *Studies in cognitive growth : A collaboration at the Center for Cognitive Studies*. US: Wiley & Sons.

Bruner, J. (1974). *Toward a theory of instruction*. US: Harvard University Press.

Bodrova, E. (1997). Key Concept of Vygotsky's Theory of Learning and Development. *Journal of Early Childhood Teacher Education*, **18**(2), pp. 16-22.

Bourgonjon, J., De Grove, F., De Smet, C., Van Looy, J., Soetaert, R., Valckea, M. (2013). Acceptance of game-based learning by secondary school teachers. *Computers & Education*, **67**(2013), pp. 21-35.

Bourgonjon, J., Valcke, M., Soetaert, R., Schellens, T. (2010). Students' perceptions about the use of video games in the classroom. *Computers & Education*, **54**(2010), pp. 1145-1156.

Bourgonjon, J., Van Looy, J. (2012). Digital games in the classroom? A contextual approach to teachers' adoption intention of digital games in formal education. *Computers in Human Behavior*, **28**(2012), pp. 2023-2033.

Bufe, J., Krömker, D. (2010). Case study of FISS: digital game based learning for a broad range of ages. *In*: Pan, Z, Cheok, A.D., Müller, W., Zhang, X. ed(s). *Transactions on edutainment IV*. DE: Springer Berlin Heidelberg, pp. 56-67.

Buckleitner, W. (2008, June 12). *So Young, and So Gadgeted*. [Online]. (URL http://www.nytimes.com/2008/06/12/technology/personaltech/12basics.html?_r=0). US: The New York Times Company. (Accessed 15 May 2014).

Burgos, D., Tattersall, C., Koper, R. (2007). Re-purposing existing generic games and simulations for e-learning. *Computers in Human Behavior*, **23**(2007), pp. 2656-2667.

Busch, C., Conrad, F., Steinicke, M. (2011). Using Digital Games to Teach the **Hero's** Journey as a Model for Change and Innovation Management. *Proceedings Of The European Conference On Games Based Learning*, pp. 740-744.

Business Performance. (2003). *Instructional Systems Design (ISD)*. [Online] (URL http://www.businessperform.com/workplace-training/addie_model.html). (Accessed 8 January 2011).

Boyle, E., Connolly, T. M., Hainey, T. (2011). The role of psychology in understanding the impact of computer games. *Entertainment Computing*, **2**(2), pp. 69-74.

Caldwell, K. (2013, November 11). *Which are the best 'crowdfunding' websites?*. [Online]. (URL http://www.telegraph.co.uk/finance/personalfinance/investing/10435276/Which-are-the-best-crowdfunding-websites.html). UK: Telegraph Media Group Limited. (Accessed 12 April 2014).

Campbell, J. (2008). *The Hero with A Thousand Faces (Collected Works of Joseph Campbell)*. 3rd ed. CAN: New World Library.

Campbell, S. (2008). The Definitive 194X. *Retro Gamer*, **48**, pp. 30-35.

Campbell-Kelly, M. (2006). *The EDSAC Simulator*. [Online]. (URL http://www.dcs.warwick.ac.uk/~edsac/). (Accessed 12 November 2013).

Canon. (2003). Canon creates a successful blend with e-learning. *Development and Learning in Organizations*, **17**(1), pp. 23- 26.

Carolyn Yang, Y. T., Chang, C. H. (2013). Empowering students through digital game authorship: Enhancing concentration, critical thinking, and academic achievement. *Computers & Education*, **68**, pp. 334-344.

Carroll, M. (2008). Retroinspection: Best of British. *Retro Gamer*, **49**, pp. 54-57.

Castagnolo, C. (2002). *The ADDIE model: Systematic learning explained*. [Online] (URL http://www.helium.com/items/840696-the-addie-model-systematic-learning-explained). (Accessed 8 January 2011).

Cellan-Jones, R. (2010a, March 03). *Are we building schools for the future?*. [Online]. (URL http://www.bbc.co.uk/blogs/thereporters/rorycellanjones/2010/03/are_we_building_schools_for_th.html). UK: BBC. (Accessed 11 October 2013).

Cellan-Jones, R. (2010b, May 24). *Becta: Does it deserve to die?*. [Online]. (URL http://www.bbc.co.uk/blogs/thereporters/rorycellanjones/2010/05/becta_does_it_deserve_to_die.html). UK: BBC. (Accessed 11 October 2013).

Cellan-Jones, R. (2014, 12 February). *Year of Code - PR fiasco or vital mission?*. [Online]. (URL http://www.bbc.co.uk/news/technology-26150717). UK: BBC. (Accessed 08 March 2014).

Centre for Computing History. (2013). *Acorn BBC Micro Model B*. [Online]. (URL http://www.computinghistory.org.uk/det/182/acorn-bbc-micro-model-b/). (Accessed 25 January 2013).

Champsas, I., Leftheris, I., Tsiatsos, T., Terzidou, T., Mavridis, A. (2012). OpenGames: A Framework for Implementing 3D Collaborative Educational Games in OpenSim. *Proceedings of the European Conference on Games Based Learning*, pp. 82-92.

Charles, D., Hanna, C., Paul, R., Charles, T. (2012). Rapid Development of Games Inspired Metacognitive Learning Experiences Using Moodle and Gamemaker. *Proceedings of the European Conference on Games Based Learning*, pp. 93-101.

Charles, M., Bustard, D., Black, M. (2009). Game inspired tool support for e-learning processes. *Electronic Journal of e-Learning*, **7**(2), pp. 101-110.

Che Pee, N. (2011). *Computer games use in an educational system*. PhD thesis. University of Nottingham.

Chee, Y.S. (2007). Embodiment, embeddedness, and experience: game-based learning and the construction of identity. *Research and Practice in Technology Enhanced Learning*, **2**(1), pp. 3-30.

Chen, Z. H., Hsu, Y. C., Chan, T. W. (2010). Review of Game-based Learning - from the Design Perspective. In: *CCCE 2010 : Global Chinese Conference on Computers in Education*, Singapore, June 1-4 2010, pp. 20-23.

Cheng, Y. M., Kuo, S. H., Lou, S. J., Shih, R. C. (2012). The construction of an online competitive game-based learning system for junior high school students. *The Turkish Online Journal of Educational Technology*, **11**(2), pp. 214-227.

Chew, E., Jones, N., Turner, D. (2008). Critical review of the blended learning models based on Maslow's and Vygotsky's educational theory. *In*: Fong, J., Kwan, R., Wang, F.L. ed(s). *Hybrid learning and education*. DE:Springer Berlin Heidelberg, pp. 40-53.

Clawson, T. (2014, January 09). *A 'Defining Moment' For UK Crowdfunding*. [Online]. (URL http://www.forbes.com/sites/trevorclawson/2014/01/09/a-defining-moment-for-uk-crowdfunding/). US: Forbes LLC. (Accessed 12 April 2014).

Claypool, K., Claypool, M. (2005). Teaching software engineering through game design. *ACM SIGCSE Bulletin*, **37**(3), pp. 123-127.

Clearwater, D. (2011). What defines video game genre? Thinking about genre study after the great divide. *Loading…The Journal of the Canadian Game Studies Association*, **5**(8), pp. 29-49.

Clyde, J., Thomas, C. (2008). Building an information literacy first-person shooter. *Reference Services Review*, **36**(4), pp. 366-380.

Cohen, L., Manion, L. and Morrison, K. (2008). *Research Methods in Education*. 6th Edition. UK: Routledge.

Condie, R., Munro, B., Seagraves, L., Kenesson, S. (2007). *The impact of ICT in schools – a landscape review*. Glasgow: Quality in Education Centre (University of Strathclyde).

Connolly, T.M., Stansfield, M., McLellan, E. (2006). Using an Online Games-Based Learning Approach to Teach Database Design Concepts. *The Electronic Journal of e-Learning*, **4**(1), pp. 102-110.

Conole, G., Dyke, M., Oliver, M., Seale, J. (2004). Mapping pedagogy and tools for effective learning design. *Computers & Education*, **43**(1-2), pp. 17-33.

Coughlan, S. (2013, July 08). *Curriculum changes 'to catch up with world's best'*. [Online]. (URL http://www.bbc.co.uk/news/education-23222068). UK: BBC. (Accessed 10 March 2014).

Coulter, M.A. (1990). A Review of Two Theories of Learning and their Application in the Practice of Nurse Education. *Nurse Education Today*, Vol. 10, pp. 333-338.

Coventry University. (2014). *Serious Games Institute | Coventry University*. [Online]. (URL http://www.coventry.ac.uk/research/research-directory/computer-science/serious-games-institute/). UK: Coventry University. (Accessed 18 April 2014).

Cozby, P.C., Bates, S.C. (2007). *Methods in Behavioral Research*. 9th Edition. US: McGraw-Hill.

Crookes, D. (2006). Retroinspection: Amstrad CPC 464. *Retro Gamer*, **25**, pp. 48-51.

Crookes, D. (2013). Inside the BBC Micro. *Retro Gamer*, **116**, pp. 42-47.

Cross, C. (2009). Making games seriously: Creating a peer designed video game for use in library promotion and instruction. *Library Review*, **58**(3), pp. 215-227.

Csapó, B., Lörincz, A., Molnár, G. (2012). Innovative Assessment Technologies in Educational Games Designed for Young Students. *In*: Ifenthaler, D., Eseryel, D., Ge, X., ed(s). *Assessment in Game-Based Learning: Foundations, Innovations, and Perspectives*. US: Springer Science+Business Media, pp. 235-254.

Csikszentmihalyi, M. (1975), Play and Intrinsic Rewards, *Journal of Humanistic Psychology*, **15**(3), pp. 41-63.

Csikszentmihalyi, M. (1997). Happiness and Creativity: Going with the Flow. *The Futurist*, Sept-Oct 1997, pp. 8-12.

Curtis, P. (2010, July 05). *School building programme scrapped in latest round of cuts*. [Online]. (URL http://www.theguardian.com/education/2010/jul/05/school-building-programme-budget-cuts). UK: Guardian News and Media Limited. (Accessed 11 October 2013).

Cusick, D. (2004). Hola Amiga!. *Retro Gamer*, **09**, pp. 18-24.

Dana Foundation. (1999, October 01). *A Debate on "Multiple Intelligences"*. [Online]. (URL http://www.dana.org/Cerebrum/Default.aspx?id=39332). US: The Dana Foundation. (Accessed 16 September 2014).

Day, A. (2007). Retroinspection: Amiga 500. *Retro Gamer*, **39**, pp. 34-39.

Davies, L. (2014, January 20). *Advice on branding – keep it simple, stupid*. [Online]. (URL http://www.designweek.co.uk/industry-voice/advice-on-branding-keep-it-simple-stupid/3037815.article). UK: Centaur Communications Ltd. (Accessed on 24th February 2014).

Dawson, C. (2009). *Introduction Research Methods*. 4th Edition. UK: How To Books Ltd.

Deci, E. L., Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behaviour*. US: Springer-Verlag.

Deci, E. L., & Ryan, R. M. (2000). The" what" and" why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological inquiry*, **11**(4), pp. 227-268.

Deci, E. L., Ryan, R. M. (Eds.). (2013). *Handbook of self-determination research*. US:University Rochester Press.

de Freitas, S., Earp, J., Ott, M., Kiili, K., Ney, M., Popescu, M., Romero, M., Usart, M., Stanescu, I. (2012). Hot Issues in Game Enhanced Learning: the GEL Viewpoint. *Procedia Computer Science*, **15**, pp. 25-31.

de Freitas, S., Liarokapis, F. (2011). Serious Games: A New Paradigm for Education?. *In*: Ma, M., Oikonomou, A., Jain, L.C. ed(s). *Serious Games and Edutainment Applications*. UK: Springer-Verlag London. pp. 9-23.

de Freitas, S., Rebolledo-Mendez, G., Liarokapis, F., Magoulas, G., Poulovassilis, A. (2010). Learning as immersive experiences: Using the four-dimensional framework for designing and evaluating immersive learning experiences in a virtual world. *British Journal of Educational Technology*, **41**(1), pp. 69-85.

de Freitas, S., Routledge, H. (2013). Designing leadership and soft skills in educational games: The e-leadership and soft skills educational games design model (ELESS). *British Journal of Educational Technology*, **44**(6), pp. 951-968.

del Blanco, Á., Torrente, J., Marchiori, E. J., Martínez-Ortiz, I., Moreno-Ger, P., Fernández-Manjón, B. (2012). A Framework for Simplifying Educator Tasks Related to the Integration of Games in the Learning Flow. *Educational Technology & Society*, **15**(4), pp. 305-318.

Demirbilek, M., Tamer, S.L. (2010). Math teachers' perspectives on using educational computer games in math education. *Procedia Social and Behavioral Sciences*, **9**(2010), pp. 709-716.

Demirbilek, M. (2014). The 'Digital Natives' Debate: An Investigation of the Digital Propensities of University Students. *Eurasia Journal of Mathematics, Science & Technology Education*, **10**(2), pp. 115-123.

Dempsey, J.V., Haynes, L.L., Lucassen, B.A., Casey, M.S. (2002). Forty Simple Computer Games and What They Could Mean to Educators. *Simulation Gaming*, **33**(2), pp. 157-168.

Denis, G., Jouvelot, P. (2005). Motivation-driven educational game design: applying best practices to music education. *In*: *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology*. Valencia, Spain, ACM, pp. 462-465.

Denning, S. (2012, March 29). *What Maslow Missed*. [Online]. (URL http://www.forbes.com/sites/stevedenning/2012/03/29/what-maslow-missed/). US: Forbes LLC. (Accessed 18 September 2014).

DeVary, S., (2008). Educational Gaming. *Distance Learning*, **5**(3), pp. 35-44.

DfE. (2010). *Department for Education, Education and Skills In Your Area*. [Online]. (URL http://www.education.gov.uk/inyourarea/schools/lea_890_schools.shtml). UK: Department for Education. (Accessed 04 November 2013).

DfE (2011, November 25). Mathematics: Ma2 Number and algebra. [Online]. (URL http://www.education.gov.uk/schools/teachingandlearning/curriculum/primary/b00199044/mathematics/attainment/ma2). (Accessed 15 July 2013).

DfE (2013a, June 14). Assessing without levels. [Online]. (URL http://www.education.gov.uk/schools/teachingandlearning/curriculum/nationalcurriculum2014/a00225864/assessing-without-levels). (Accessed 15 July 2013).

DfE. (2013b, August 05). *ICT*. [Online]. (URL http://www.education.gov.uk/schools/teachingandlearning/curriculum/secondary/b00199065/ict). UK: Department for Education. (Accessed 14 October 2013).

Dickey, M. D. (2005). Engaging by design: How engagement strategies in popular computer and video games can inform instructional design. *Educational Technology Research and Development*, **53**(2), pp. 67-83.

Dickey, M. D. (2007). Game design and learning: A conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. *Educational Technology Research and Development*, **55**(3), pp. 253-273.

Dietrich, T., Balli, S. J. (2014). Digital Natives: Fifth-Grade Students' Authentic and Ritualistic Engagement with Technology. *International Journal of Instruction,* **7**(2), pp. 21-34.

Dietz C. (2004, October). *Mihaly Csikszentmihalyi's theory of flow*. [Online]. (URL http://www.teachingexpertise.com/articles/mihaly-csikszentmihalyis-theory-of-flow-1674). (Accessed 17 October 2010).

Dille, F., Zuur Platten, J. (2006). *The Ultimate Guide to Video Game Writing and Design*. US: Lone Eagle Publishing Company.

Djaouti, D., Alvarez, J., Jessel, J-P., Rampnoux, O. (2011). Origins of Serious Games. *In*: Ma, M., Oikonomou, A., Jain, L. ed(s). *Serious Games and Edutainment Applications*. UK: Springer London, pp. 25-43.

Dondi, C., Moretti, M. (2007). A methodological proposal for learning games selection and quality assessment. *British Journal of Educational Technology*, **38**(3), pp. 502-512.

Dondlinger, M.J. (2007). Educational Video Game Design: A Review of the Literature. *Journal of Applied Educational Technology*, **4** (1), pp. 21-31.

Donner, E.J., Csikszentmihalyi, M. (1992). Transforming Stress to Flow. *Executive Excellence*, **9**(2), pp. 16-77.

Donovan, N. (2014, January 03). *Complaints to Energy Ombudsman double*. [Online]. (URL http://www.bbc.co.uk/news/business-25593469). UK: BBC. (Accessed 12 April 2014).

Douglas, T. (2011, August 26). *Google's Eric Schmidt criticises education in the UK*. [Online]. (URL http://www.bbc.co.uk/news/uk-14683133). UK: BBC. (Accessed 10 March 2014).

Driscoll, Dr. M. (2002). Blended Learning – Let's get beyond the hype. *E-learning Magazine*, March 2002, pp. 54.

Drury, P. (2011). The Making Of Computer Space. *Retro Gamer*, **93**, pp. 26-33.

Dublin, L. (2004). The nine myths of e-learning implementation: ensuring the real return on your e-learning investment. *Industrial and Commercial Training*, **36**(7), pp. 291-294.

Dunn, L. (2002). *Theories of learning*. UK Oxford Centre for Staff and Learning Development, Oxford Brookes University.

Dunwell, I., de Freitas, S., Jarvis, S. (2011). Four-dimensional consideration of feedback in serious games. *Digital games and learning*, pp. 42-62.

Eastwood, J.L., Sadler, T.D. (2013). Teachers' implementation of a game-based biotechnology curriculum. *Computers & Education*, **66**(2013), pp. 11-24.

Education Scotland. (2014). *Research summary - multiple intelligences*. [Online]. (URL http://www.journeytoexcellence.org.uk/resourcesandcpd/research/summaries/rsmultipleintelligences.asp). UK: Education Scotland. (Accessed 16 September 2014).

EduGameLab. (2013). *EduGameLab*. [Online]. (URL http://edugamelab.hosting.his.se/sgdb/). UK: Serious Games Institute. (Accessed 18 April 2014).

Echeverría, A., Barrios, E., Nussbaum, M., Améstica, M., Leclerc, S. (2012). The atomic intrinsic integration approach: A structured methodology for the design of games for the conceptual understanding of physics. *Computers & Education*, **59**(2), pp. 806-816.

Ekanayake, H., Backlund, P., Ziemke, T., Ramberg, R., Hewagamage, K. (2011). Assessing Performance Competence in Training Games. *In*: D´Mello, S., Graesser, A., Schuller, B., Martin, J-C., ed(s). *Fourth International Conference, ACII 2011, Memphis,TN, USA, October 9-12 2011*, pp. 518-527.

Elliott, L., Golub, A., Ream, G., Dunlap, E. (2012). Video game genre as a predictor of problem use. *Cyberpsychology, Behavior, and Social Networking*,**15**(3), pp. 155-161.

Erhel, S., Jamet, E. (2013). Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. *Computers & Education*, **67**, pp. 156-167.

Eseryel, D., Ifenthaler, D., Ge, X. (2011). Alternative Assessment Strategies for Complex Problem Solving in Game-Based Learning Environments. *In*: Ifenthaler, D., Spector, J.M., Kinshuk, Isaias, P., Sampson, D.G., ed(s). *Multiple Perspectives on Problem Solving and Learning in the Digital Age*. Springer Science+Business Media, pp. 159-178.

Etchells, P. (2013, September 19). *What is the link between violent video games and aggression?*. [Online]. (URL http://www.theguardian.com/science/head-quarters/2013/sep/19/neuroscience-psychology). UK: Guardian News and Media Limited. (Accessed 12 April 2014).

Everard, B. (2013, July 17). *Build your first game using Scratch on the Raspberry Pi*. [Online]. (URL http://www.techradar.com/news/software/applications/build-your-first-game-using-scratch-on-the-raspberry-pi-1164882). UK: Future Publishing Limited. (Accessed on 14 March 2014).

Eynon, R. (2010). Supporting the'Digital Natives': What is the Role of Schools?. *In*: Dirckinck-Holmfeld, L., Hodgson, V., Jones, C., de Laat, M., McConnell, D., Ryberg, T. ed(s). *Proceedings of the 7th International Conference on Networked Learning*. UK: Lancaster University, pp. 851-858.

Fang, J. (2012). *The Use of a Game-Based Project in Engineering Education: An Examination of the Academic Learning, Engagement and Motivation of First Year Engineering Students.* Ph.D. thesis. Purdue University.

Faiola, A., Newlon, C., Pfaff, M., Smyslova, O. (2012). Correlating the effects of flow and telepresence in virtual worlds: Enhancing our understanding of user behavior in game-based learning. *Computers in Human Behavior*, **29**, pp. 1113-1121.

Faure, C., Ray, B., (2011). Game Time! Justifying the Use of Wii Fit Plus in the Early Elementary Physical Education Classroom. *Journal of Technology Integration in the Classroom*, **3**(1), pp. 91-98.

FCA. (2014, April 09). *PS14/4: The FCA's regulatory approach to crowdfunding over the internet, and the promotion of non-readily realisable securities by other media*. [Online]. (URL http://www.fca.org.uk/news/firms/ps14-04-crowdfunding). UK: Financial Conduct Authority. (Accessed 12 April 2014).

FCO (2014). *Foreign travel advice Saudi Arabia*. [Online]. (URL https://www.gov.uk/foreign-travel-advice/saudi-arabia/local-laws-and-customs). UK: GOV.UK. (Accessed 19 June 2014).

Field, A. and Hole, G. (2008). *How to Design and Report Experiments*. UK: SAGE Publications Ltd.

Fildes, N. (2013, July 12). *Millions more log out from desktop PCs*. [Online]. (URL http://www.thetimes.co.uk/tto/business/industries/technology/article3814489.ece). (Accessed 12 November 2013).

Foster, A. (2012). Assessing Learning Games for School Content: The TPACK-PCaRD Framework and Methodology. *In*: Ifenthaler, D., Eseryel, D., Ge, X., ed(s). *Assessment in Game-Based Learning: Foundations, Innovations, and Perspectives*. US: Springer Science+Business Media, pp. 201-215.

Friese, K. I., Herrlich, M., Wolter, F. E. (2008). Using Game Engines for Visualization in Scientific Applications. *In*: Ciancarini, P., Nakatsu, R., Rauterberg, M., Roccetti, M. ed(s). *New Frontiers for Entertainment Computing*. US:Springer, pp. pp. 11-22.

Furió, D., González-Gancedo, S., Juan, M., Seguí, I., Rando, N. (2013). Evaluation of learning outcomes using an educational iPhone game vs. traditional game. *Computers & Education*, **64**, pp. 1-23.

Gage, N.L., Berliner, D.C. (1998). *Educational psychology*. 6th Edition. US: Houghton Mifflin.

Gagné, R. (1985). *The Conditions of Learning and the Theory of Instruction*. 4th ed. US: Thomson Learning.

Gardner, H. (1993). *Frames of Mind: The Theory of Multiple Intelligences*. 2nd ed (10th Anniversary). US: Basic Books.

Garris, R., Ahlers, R., Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & gaming*, **33**(4), pp. 441-467.

Gee, J.P. (2007). *What video games have to teach us about learning and literacy*. US: Palgrave Macmillan.

Gibbs, S. (2014, 04 February). *Year of Code scheme offers £500,000 fund for computing teachers*. [Online]. (URL http://www.theguardian.com/technology/2014/feb/04/government-year-of-code-500000-fund-computing-teachers). UK: Guardian News and Media Limited. (Accessed 08 March 2014).

Glaser, R. (1962). Programmed Instruction – A Behavioral View. *The American Behavioral Scientist*, November 1962, pp. 46-51.

Goldberg, D., Larsson, L. (2013). *Minecraft: The Unlikely Tale of Markus 'Notch' Persson and the Game That Changed Everything*. US: Seven Stories Press.

Goldberg, M. (2012a). Before Videogames. *Retro Gamer*, **108**, pp. 30-35.

Goldberg, M. (2012b). Inside the Atari 2600. *Retro Gamer*, **103**, pp. 26-33.

Goodwin, S. (2007). Retroinspection: BBC Micro. *Retro Gamer*, **42**, pp. 58-64.

Google Play (2014). Top Selling in Games. [Online]. (URL https://play.google.com/store/apps/category/GAME/collection/topselling_paid). (Accessed 19 October 2014).

Gov.UK. (2014, 04 February). *Year of Code and £500,000 fund to inspire future tech experts launched*. [Online]. (URL https://www.gov.uk/government/news/year-of-code-and-500000-fund-to-inspire-future-tech-experts-launched). UK: Gov.UK. (Accessed 08 March 2014).

Gredler, M. E. (2004). Games and simulations and their relationships to learning. *Handbook of research on educational communications and technology*, **2**, pp. 571-581.

Griffiths, M. (1999). Violent video games and aggression: A review of the literature. *Aggression and Violent Behavior*, **4**(2), pp. 203-212.

Gros, B. (2007). Digital Games in Education: The Design of Games-Based Learning Environments. *Journal of Research on Technology in Education*, **40**(1), pp. 23-38.

Gu, X., Zhu, Y., Guo, X. (2013). Meeting the "Digital Natives": Understanding the acceptance of technology in classrooms. *Journal of Educational Technology & Society*, **16**(1), pp. 392-402.

Gulliksen, J., Göransson, B., Boivie, I., Blomkvist, S., Persson, J., Cajander, Å. (2003). Key principles for user-centred systems design. *Behaviour and Information Technology*, **22**(6), pp. 397-409.

Gunter, G., Kenny, R., Vick, E. (2006). A Case for a Formal Design Paradigm for Serious Games. *The Journal of the International Digital Media and Arts Association*, **3**(1), pp. 1-19.

Gunter, G.A., Kenny, R.F. and Vick, E.H. (2008). Taking educational games seriously: using the RETAIN model to design endogenous fantasy into standalone educational games. *Educational Technology Research & Development*, 56, pp. 511-537.

Habgood, J., Nielsen, N., Rijks, M. (2010). *The Game Maker's Companion – Game Development: The Journey Continues*. US: Apress.

Habgood, J., Overmars, M. (2006). *The Game Maker's Apprentice: game development for beginners*. US: Apress.

Habgood, M.P.J., Ainsworth, S., Benford, S. (2005a). Intrinsic fantasy: motivation and affect in educational games made by children. *In*: *2005 AIED workshop on motivation and affect in educational software*, Amsterdam.

Habgood, M. P. J., Ainsworth, S. E., Benford, S. (2005b). Endogenous fantasy and learning in digital games. *Simulation & Gaming*, **36**(4), pp. 483-498.

Habgood, M. P. J., Ainsworth, S. E. (2011). Motivating Children to Learn Effectively: Exploring the Value of Intrinsic Integration in Educational Games. *Journal of the Learning Sciences*, **20**(2), pp. 169-206.

Hainey, T., Connolly, T., Boyle, L. (2010). A Refined Evaluation Framework for Games-Based Learning. *Proceedings of the European Conference on Games Based Learning*, pp. 97-105.

Hainey, T., Westera, W., Connolly, T.M., Boyle, L., Baxter, G., Beeby, R.B., Soflano, M. (2013). Students' attitudes toward playing games and using games in education: Comparing Scotland and the Netherlands. *Computers & Education*, **69**(2013), pp. 474-484.

Hammond, M., Reynolds, L., Ingram, J. (2011). How and why do student teachers use ICT?. *Journal of Computer Assisted Learning*, **27**(3), pp. 191-203.

Hammond, M., Younie, S., Woollard, J., Cartwright, V., Benzie, D. (2009). *What does our past involvement with computers in education tell us? A view from the research community*. Coventry: Centre for New Technologies Research in Education (University of Warwick).

Handby, S. (2012). Virtual Blockbuster. *Computer Shopper*, February 2013, 300, p124.

Harris, J. (2010). *Game Design Essentials: 20 Atari Games*. [Online]. (URL http://www.gamasutra.com/view/feature/132076/game_design_essentials_20_atari_.php?page=20). (Accessed 27 February 2012).

Harris, K.R., Graham, S. (1994). Constructivism: Principles, Paradigms, and Integration. *The Journal of Special Education*, **28**(3), pp. 233-247.

Harteveld, C., Guimarães, R., Mayer, I., Bidarra, R. (2007). Balancing Pedagogy, Game and Reality Components Within a Unique Serious Game for Training Levee Inspection. *In*: Hui, K-C., Pan, Z., Chung, R.C-K., Wang, C.C.L., Jin, X., Göbel, S., Li, E.C-L. ed(s). *Second International Conference*, Edutainment 2007, Hong Kong, China, June 11-13, 2007. UK: Springer, pp. 128-139.

Harvard Graduate School of Education. (2013). *Hour of Code with Scratch*. [Online]. (URL https://scratched.gse.harvard.edu/hoc/). US: Harvard Graduate School of Education. (Accessed on 14 March 2014).

Hawkes, S., Gosden, E. (2013, October 18). *Energy secretary demands British Gas meeting over 'unjustifiable' energy price rise*. [Online]. (URL http://www.telegraph.co.uk/finance/personalfinance/consumertips/household-bills/10389937/Energy-secretary-demands-British-Gas-meeting-over-unjustifiable-energy-price-rise.html). UK: Telegraph Media Group Limited. (Accessed 12 April 2014).

Hays, R. T. (2005). *The effectiveness of instructional games: A literature review and discussion*. US: Naval Air Warfare Center Training Systems Division. (Technical Report 2005-004).

Hauge, J. B., Riedel, J. C. (2012). Evaluation of Simulation Games for Teaching Engineering and Manufacturing. *Procedia Computer Science*, **15**, pp. 210-220.

Heffner, C.L. (2011, November 29). Research on Humanistic Theory. [Online]. (URL http://allpsych.com/personalitysynopsis/index.html). US: Heffner Media Group Inc. (Accessed 08 November 2014).

Hirumi, A., Appelman, B., Rieber, L., Van Eck, R. (2010). Preparing Instructional Designers for Game-Based Learning: Part III. *Game Design as a Collaborative Process. TechTrends: Linking Research & Practice to Improve Learning*, **54**(5), pp. 38-45.

Hirumi, A., Stapleton, C. (2009). Applying Pedagogy during Game Development to Enhance Game-Based Learning. *In*: Miller, C.T. ed(s). *Games: Purpose And Potential In Education*, UK: Springer Science+Business Media, pp. 127-162.

Hodge, K. (2014, January 31). *Ofsted rolls out plans for surprise behaviour inspections in schools.* [Online]. (URL http://www.theguardian.com/teacher-network/2014/jan/31/ofsted-surprise-visits-schools-behaviour-issues). UK: Guardian News and Media Limited. (Accessed 01 March 2014).

Hofmann, J., Miner. N. (2008). Real Blended Learning Stands Up. *Training &Development*, September 2008, pp. 54.

Hong, J.C., Cheng, C.L., Hwang, M.Y., Lee, C.K., Chang, H.Y. (2009). Assessing the educational values of digital games. *Journal of computer assisted learning*, **25**(5), pp. 423-437.

Hopper, B. and Hurry, P. (2000). Learning the MI Way: The Effects on Students' Learning of Using the Theory of Multiple Intelligences. *Pastoral Care*, December 2000, pp. 26-32.

Hou, J., Nam, Y., Peng, W., Lee, K. M. (2012). Effects of screen size, viewing angle, and players' immersion tendencies on game experience. *Computers in Human Behavior*, **28**(2), pp. 617-623.

Hsieh, Y. H., Lin, Y. C., Hou, H. T. (2013). Exploring the role of flow experience, learning performance and potential behavior clusters in elementary students' game-based learning. *Interactive Learning Environments*, pp. 1-16.

Hsu, C-Y., Tsai, C-C., Wang, H-Y. (2012). Facilitating Third Graders' Acquisition of Scientific Concepts through Digital Game-Based Learning: The Effects of Self-Explanation Principles. *The Asia-Pacific Education Researcher*, **21**(1), pp. 71-82.

Hu, J. (2010). *An investigation into designing online language learning materials to support the academic reading of international Masters degree students*. PhD thesis. University of Warwick.

Hubbub. (2014). *Hubbub - Crowdfunding for the education community*. [Online]. (URL https://hubbub.net/). UK: Hubbub. (Accessed 12 April 2014).

Huitt, W. (2009). *Humanism and open education*. [Online]. (URL http://www.edpsycinteractive.org/topics/affect/humed.html). (Accessed 08 November 2014).

Husain, L., (2011). *Getting Serious about Math: Serious Game Design Framework & an Example of Educational Game*. PhD thesis. Lunds Universitet.

Hwang, G-J., Sung, H-Y., Hung, C-M., Huang, I., Tsai, C-C. (2012). Development of a personalized educational computer game based on students' learning styles. *Education Technology Research and Development*, **60**(4), pp. 623-638.

Ibáñez, B.C., Marne, B., Labat, J. (2011). Conceptual and Technical Frameworks for Serious Games. *Proceedings of the European Conference on Games Based Learning*, pp. 81-87.

Ibáñez, M.B., Crespo, R.M., Kloos, C.D. (2010). Assessment of Knowledge and Competencies in 3D Virtual Worlds: A Proposal. *In*: Reynolds, N., Turcsányi-Szabó, M., ed(s). *FIP TC 3 International Conference, KCKS 2010, Held as Part of WCC 2010*, Brisbane, Australia, September 20-23 2010, pp. 165-176.

Ice, P., Burgess, M., Beals, J., Staley, J. (2012). Aligning Curriculum and Evidencing Learning Effectiveness Using Semantic Mapping of Learning Assets. International Journal of Emerging Technologies in Learning, **7**(2), pp. 26-31.

Ifenthaler, D., Eseryel, D., Ge, X. (2012). Assessment for Game-Based Learning. *In*: Ifenthaler, D., Eseryel, D., Ge, X. ed(s). *Assessment in Game-Based Learning: Foundations, Innovations, and Perspectives*. UK: Springer Science+Business Media New York, pp. 1-8.

IMDB. (2013a). *BMX Bandits (1983)*. [Online]. (URL http://www.imdb.com/title/tt0085204/). (Accessed 26 January 2014).

IMDB. (2013b). *Back to the Future (1985)*. [Online]. (URL http://www.imdb.com/title/tt0088763/). (Accessed 26 January 2014).

Instructional Design. (2011). *ADDIE Model*. [Online] (URL http://www.instructionaldesign.org/models/addie.html). (Accessed 8 January 2011).

International Arcade Museum. (2013a). *WhacAMole*. [Online]. (URL http://www.arcade-museum.com/game_detail.php?game_id=10421). (Accessed 01 October 2013).

James-Clarke IV, D. (2006). Blended Learning v2.0: Multi-Sensory Solutions. *Chief Learning Officer*, January 2006, pp. 44-48.

Jary, S. (2014, November 13). *The best maths apps for children - iPhone, iPad and Android apps for kids*. [Online]. (URL http://www.pcadvisor.co.uk/features/software/3380559/best-maths-apps-for-children/). UK: IDG UK. (Accessed 15 December 2014).

Jayakanthan, R., 2002, Application of computer games in the field of education, The Electronic Library, Vol.20, Number 2, 2002, pg 98 – 102, UK: MCP UP Limited.

Jennett, C., Cox, A. L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T., Walton, A. (2008). Measuring and defining the experience of immersion in games. *International Journal Of Human-Computer Studies*, **66**(9), pp. 641-661.

Jensen, K. T. (2012a, January 30). *Worst Educational Games*. [Online]. (URL http://www.ugo.com/games/worst-educational-games). (Accessed 5 March 2012).

Jeong, E. J., Biocca, F. A., Bohil, C. J. (2012). Sensory realism and mediated aggression in video games. *Computers in Human Behavior*, **28**(5), pp. 1840-1848.

Johnston-Wilder, S., Pimm, D. (2005). *Teaching Secondary Mathematics with ICT*. 1st Edition. UK: MPG Books Ltd.

Jong, M. S., Shang, J., Lee, F. L., Lee, J. H. (2008). Harnessing computer games in education. *International Journal of Web-Based Learning and Teaching Technologies*, **3**(3), pp. 54-61.

Jordan, J., Carlile, O., Stack, A. (2009). *Approaches to Learning – A Guide for Teachers*. UK: McGraw-Hill Education.

Kaur, A. (2013). Maslow's Need Hierarchy Theory: Applications and Criticisms. *Global Journal of Management and Business Studies*, **3**(10), pp. 1061-1064.

Kay, R. (2014, February 26). *Flappy Bird Illustrates Why Microsoft Should Spin Off Consumer*. [Online]. (URL http://www.forbes.com/sites/rogerkay/2014/02/26/flappy-bird-illustrates-why-microsoft-should-spin-off-consumer/). US: Forbes LLC. (Date Accessed 01 March 2014).

Ke, F. (2008). Alternative goal structures for computer game-based learning. *Computer-Supported Collaborative Learning*, **3**(1), pp. 429-445.

Ke, F., Grabowski, B. (2007). Gameplaying for maths learning: cooperative or not?. *British Journal of Educational Technology*, **38**(2), pp. 249-259.

Kearney, P. (2007). Cognitive assessment of game-based learning. *British Journal of Educational Technology*, **38**(3), pp. 529-531.

Keith, D. (2006, October 21). *Who wants to be a Mathionaire*. [Online]. (URL http://www.subtangent.com/maths/mathionaire.php). (Accessed 17 October 2011).

Keller, J. M. (2010). *Motivational Design for Learning and Performance: The ARCS Model Approach*. US: Springer.

Kennedy, D. M., Fox, B. (2013). 'Digital natives': an Asian perspective for using learning technologies. *International Journal of Education and Development using Information and Communication Technology*, **9**(1), pp. 64-79.

Ketelhut, D.J., Schifter, C.C. (2011). Teachers and game-based learning: Improving understanding of how to increase efficacy of adoption. *Computers & Education*, **56**(2011), pp. 539-546.

Khalili, N., Sheridan, K., Williams, A., Clark, K., Stegman, M. (2011). Students Designing Video Games about Immunology: Insights for Science Learning. *Computers in the Schools*, **28**(3), pp. 228-240.

Kickmeier-Rust, M.D. (2012, December 12). Balancing on a high wire: Adaptation and balancing are key to educational success. [Online]. (URL http://www.galanoe.eu/index.php/home/472-balancing-on-a-high-wire-adaptation-and-balancing-are-key-to-educational-success). EU: Games And Learning Alliance. (Accessed 16 September 2014).

Kickmeier-Rust, M. D., Hillemann, E., Albert, D. (2011). Tracking the UFO's Paths: Using Eye-Tracking for the Evaluation of Serious Games. In: Shumaker, R., ed(s). *Virtual and Mixed Reality-New Trends*. DE: Springer Berlin Heidelberg, pp. 315-324.

Kickmeier-Rust, M. D., Peirce, N., Conlan, O., Schwarz, D., Verpoorten, D., Albert, D. (2007). Immersive digital games: the interfaces for next-generation e-learning?. *In*: Stephanidis, C. ed(s). *Universal Access in Human-Computer Interaction. Applications and Services*. DE:Springer Berlin Heidelberg, pp. 647-656.

Kickstarter Inc. (2014a). *OUYA: A New Kind of Video Game Console*. [Online]. (URL https://www.kickstarter.com/projects/ouya/ouya-a-new-kind-of-video-game-console). US: Kickstarter Inc. (Accessed 12 April 2014).

Kickstarter Inc. (2014b). *Levey Day School Community Garden*. [Online]. (URL https://www.kickstarter.com/projects/782506972/levey-day-school-community-garden?ref=search). US: Kickstarter Inc. (Accessed 12 April 2014).

Kickstarter Inc. (2014c). *Let's get Education Outside School Magazine into print!*. [Online]. (URL https://www.kickstarter.com/projects/eosmagazine/lets-get-education-outside-school-magazine-into-pr?ref=search). US: Kickstarter Inc. (Accessed 12 April 2014).

Kickstarter Inc. (2014d). Educational game «Learn Spanish Fun». [Online]. (URL https://www.kickstarter.com/projects/160251268/educational-game-learn-spanish-fun?ref=search). US: Kickstarter Inc. (Accessed 12 April 2014).

Kiili, K. (2005a). Digital game-based learning: Towards an experiential gaming model. *Internet and Higher Education*, **8**, pp. 13-24.

Kiili, K. (2005b). Content creation challenges and flow experience in educational games: The IT-Emperor case. *Internet and Higher Education*, **8**(2005), pp. 183-198.

Kiili, K., de Freitas, S., Arnab, S., Lainema, T. (2012). The Design Principles for Flow Experience in Educational Games. *Procedia Computer Science*, **15**, pp.78-91.

Kiili, K., Lainema, T. (2008). Foundation for Measuring Engagement in Educational Games. *Journal of Interactive Learning Research*, **19**(3), pp. 469-488.

Kim, J. T., Lee, W. H. (2013). Dynamical model for gamification of learning (DMGL). *Multimedia Tools and Applications*, August 2013, pp. 1-11.

King, I. (2013, October 10). *PC Shipments Fall 8.6 Percent Amid Tepid Back-to-School Demand*. [Online]. (URL http://www.bloomberg.com/news/2013-10-09/pc-shipments-fall-8-6-percent-amid-tepid-back-to-school-demand.html). (Accessed 12 November 2013).

Klopfer, E., Osterweil, S. (2013). The Boom and Bust and Boom of Educational Games. *Lecture Notes in Computer Science*, **7544**, pp. 290-296.

Kobie, N. (2013, September 12). *Tablet sales to overtake PCs this quarter*. [Online]. (URL http://www.pcpro.co.uk/news/384172/tablet-sales-to-overtake-pcs-this-quarter). (Accessed 12 November 2013).

Koster, R. (2005). *A Theory of Fun for Game Design*. US: Paraglyph Press.

Krauss, S. E. (2005). Research Paradigms and Meaning Making: A Primer. *The Qualitative Report*, **10**(4), pp. 758-770.

Krcmar, M., Farrar, K., McGloin, R. (2011). The effects of video game realism on attention, retention and aggressive outcomes. *Computers in Human Behavior*, **27**(1), pp. 432-439.

Kremer, W., Hammond, C. (2013, September 01). *Abraham Maslow and the pyramid that beguiled business*. [Online]. (URL http://www.bbc.co.uk/news/magazine-23902918). UK: BBC. (Accessed 18 September 2014).

Kurtz, P. (2000). *Humanist Manifesto 2000: A Call for a New Planetary Humanism*. US: Prometheus Books.

Kurzel, F. (2010). Using Game Development as the Focus of Instruction. *Proceedings of Informing Science & IT Education Conference (InSITE) 2010*, Cassino , Southern Italy, June 19-24 2010, pp. 217-226.

Lacey, R. (1982). *The Kingdom*. UK: Fontana Paperbacks.

Lacey, R. (2009). *Inside the Kingdom*. UK: Hutchinson Books.

Lambie, R. (2009). Mod Rule. *Micro Mart*, 1082, pp. 72-77.

Lang, J. (2012, February 15). *The BBC Computer Literacy Project 2012*. [Online]. (URL http://www.raspberrypi.org/forum/viewtopic.php?f=47&t=3102). UK: Raspberry Pi Foundation. (Accessed 10 March 2014).

Lean, J., Moizer, J., Towler, M., Abbey, C. (2006). Simulations and games: Use and barriers in higher education. *Active Learning in Higher Education*, **7**(3), pp. 227-242.

Lee, D. (2014a, April 07). *Aggression from video games 'linked to incompetence'*. [Online]. (URL http://www.bbc.co.uk/news/technology-26921743). UK: BBC. (Accessed 12 April 2014).

Lee, D. (2014b, October 09). *Ian Livingstone applies to create 'gaming' school*. [Online]. (URL http://www.bbc.co.uk/news/technology-29550486). UK: BBC. (Accessed 11 November 2014).

Lepper, M. R., Malone, T. W. (1987). Intrinsic motivation and instructional effectiveness in computer-based education. *In*: Snow, R. E., Farr, M. J. ed(s). *Aptitude, learning and instruction: III. Cognitive and affective process analyses*. US: Lawrence Erlbaum, pp. 255-286.

Libin, A., Lauderdale, M., Millo, Y., Shamloo, C., Spencer, R., Green, B., Donnellan, J., Wellesley, C., Groah, S. (2010). Role-Playing Simulation as an Educational Tool for Health Care Personnel: Developing an Embedded Assessment Framework. *Cyberpsychology, Behavior, And Social Networking*, **13**(2), pp. 217-224.

Lieberman, D.A., Fisk, M.C., Biely, E. (2009). Digital Games for Young Children Ages Three to Six: From Research to Design. *Computers in the Schools*, **26**(4), pp. 299-313.

Lim, C. P., Nonis, D., Hedberg, J. (2006). Gaming in a 3D multiuser virtual environment: Engaging students in science lessons. *British Journal of Educational Technology*, **37**(2), pp. 211-231.

Linden Research (2014). *Second Life Official Site*. [Online]. (URL http://www.secondlife.com/). (Accessed 26 January 2014).

Linux Education Packages. (2014). *Software Portal - Linux Mint Community*. [Online]. (URL http://community.linuxmint.com/software/browse/2). (Accessed 17 April 2014).

Liu, E.Z.F., Lin, C.H. (2009). Developing evaluative indicators for educational computer games. *British Journal of Educational Technology*, **40**(1), pp. 174-178.

Livingstone, I. (2011, November 28). *Ian Livingstone: 'Seismic shift' in computer education*. [Online]. (URL http://www.bbc.co.uk/news/technology-15926871). UK: BBC. (Accessed 10 March 2014).

Loguidice, B., Barton, M. (2009). *Vintage games: an insider look at the history of Grand Theft Auto, Super Mario, and the most influential games of all time*. US: Taylor & Francis.

Lowood, H. (2009). Videogames in computer space: The complex history of Pong. *Annals of the History of Computing, IEEE*, **31**(3), pp. 5-19.

Maciuszek, D., Ruddeck, G., Martens, A. (2010). Component-Based Development of Educational Games: The Case of the User Interface. *Proceedings of the European Conference on Games BasedLearning*, pp. 208-217.

Mack, N., Woodsong, C., Macqueen, K.M., Guest, G., Namey, E. (2005). *Qualitative Research Methods: A Data Collector's Field Guide*. US: Family Health International.

MacKenty, B. (2006a). *Instructional Design and games in education*. [Online]. (URL http://www.mackenty.org/index.php/site/comments/instructional_design_and_games_in_education/). (Accessed 15 June 2010).

MacKenty, B. (2006b). *All Play and No Work*. [Online]. (URL http://www.schoollibraryjournal.com/article/CA6367046.html). (Accessed 8th July 2010).

MacKenty, B. (2008). *The right circumstance for games in education to work*. [Online]. (URL http://www.mackenty.org/index.php/site/comments/the_right_circumstances_for_games_in_education_to_work/). (Accessed 15 June 2010).

Mad4Maths. (2011). *Mad4Maths – Fun Numeracy Games*. [Online]. (URL http://www.mad4maths.com/multiplication_table_math_games/). (Accessed 17 October 2011).

Malone, T. W., Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. *In*: Snow, R. E., Farr, M. J. ed(s). *Aptitude, learning and instruction: III. Cognitive and affective process analyses*. US: Lawrence Erlbaum, pp. 223-253.

Manga High. (2014). *Mangahigh.com – Play Maths, Love Maths*. [Online]. (URL https://www.mangahigh.com/en-gb/). UK: Blue Duck Education Ltd. (Accessed 15 December 2014).

Mann, J. (1999). Behavioral sampling methods for cetaceans: a review and critique. *Marine mammal science*, **15**(1), pp. 102-122.

Marchiori, E.J., Serrano, A., Torrente, J., Martínez-Ortiz, I., Fernández-Manjón, B. (2011). Extensible Multi-platform Educational Game Framework. *Lecture Notes in Computer Science*, **7048**, pp. 21-30.

Marne, B., Wisdom, J., Huynh-Kim-Bang, B., Labat, J. (2012). The Six Facets of Serious Game Design: A Methodology Enhanced by Our Design Pattern Library. *Lecture Notes in Computer Science*, **7563**, pp. 208-221.

Marsh, T. (2011). Serious games continuum: Between games for purpose and experiential environments for purpose. *Entertainment Computing*, **2**(2), pp. 61-68.

Martens, R., Gulikers, J., Bastiaens, T. (2004). The impact of intrinsic motivation on e-learning in authentic computer tasks. *Journal of computer assisted learning*, **20**(5), pp. 368-376.

Martinez, S. (2006).Educational Games: How Attitudes and Markets Influence Design. *Australian Computers in Education Conference*, October 2006.

Maslow, A. H. (1943). A Theory of Human Motivation. *Psychological review*, **50**(4), pp. 370-396.

Maslow, A.H. (1968). Toward a Psychology of Being. US: D.Van Nostrand Company Inc

Mason, R. (2013, October 29). *Energy firms 'overcharge by £3.7bn a year'*. [Online]. (URL http://www.theguardian.com/business/2013/oct/29/energy-firms-overcharge-accusation). UK: Guardian News and Media Limited. (Accessed 12 April 2014).

Mathews, J. (2004, September 07). 21 Years Later, 'Multiple Intelligences' Still Debated - Educator Pushes Appealing to All Types of Learners. [Online]. (URL http://www.washingtonpost.com/wp-dyn/articles/A1337-2004Sep6.html). US: The Washington Post. (Accessed 16 September 2014).

McAlpine, M., van derZanden, L., & Harris, V. (2010). Using Games Based Technology in Formal Assessment of Learning. *Proceedings Of The European Conference On Games Based Learning*, pp. 242-250.

McCally, K. (2010). Self-Determined. *Rochester Review*, **72**(6), pp. 18-21.

McDonald, C. (2014a, April 08). *Microsoft ends XP support – what should users do next?*. [Online]. (URL http://www.computerweekly.com/news/2240217714/Microsoft-ends-XP-support-what-should-users-do-next). UK: TechTarget. (Accessed 12 April 2014).

McDonald, C. (2014b, April 08). *Microsoft invests in teacher training ahead of curriculum change*. [Online]. (URL http://www.computerweekly.com/news/2240217718/Microsoft-invests-in-teacher-training-ahead-of-curriculum-change). UK: TechTarget. (Accessed 18 April 2014).

McMahon, M. T. (2009). *Using the DODDEL model to teach serious game design to novice designers: Proceedings of Ascilite 2009*, Auckland, The University of Auckland: Auckland University of Technology & Australasian Society for Computers in Learning in Tertiary Education.

McLellan, R. (2009). Self-Determination Theory: An overview and identification of Issues of interest to educators. *In*: *Can current theories of motivation inform practice in educational contexts?*, University of Cambridge, 8th May 2009, pp. 16-40.

McVeigh, T. (2013, November 16). *Minecraft: how a game with no rules changed the rules of the game for ever*. [Online]. (URL http://www.theguardian.com/technology/2013/nov/16/minecraft-game-no-rules-changed-gaming). UK: Guardian News and Media Limited. (Accessed 02 March 2014).

Meer, A. (2011, February 21). *Osborne games hope sparks renewed tax breaks lobbying*. [Online]. (URL http://www.gamesindustry.biz/articles/2011-02-21-osborne-games-hope-sparks-renewed-tax-breaks-lobbying). UK: Gamer Network. (Accessed 12 April 2014).

Neher, A. (1991). Maslow's Theory of Motivation A Critique. *Journal of Humanistic Psychology*, **31**(3), pp. 89-112.

Melero, J., Hernández-Leo, D., Blat, J. (2011). A Review of Scaffolding Approaches in Game-Based Learning Environments. *Proceedings Of The European Conference On Games Based Learning*, pp. 717-724.

Mercer, S. (2012). The Complexity of Learner Agency. *Journal of Applied Language Studies*, **6**(2), pp. 41-59.

Merriam-Webster. (2013). *Disequilibrium – Definition*. [Online]. (URL http://www.merriam-webster.com/dictionary/disequilibrium). (Accessed 15 October 2013).

Merz , T. (2014, January 23). *How Minecraft took over the world*. [Online]. (URL http://www.telegraph.co.uk/men/thinking-man/10589721/How-Minecraft-took-over-the-world.html). UK: Telegraph Media Group Limited. (Accessed 02 March 2014).

Michael, D., Chen, S. (2006). *Serious Games – Games that Educate, Train, and Inform*. US: Course Technology/Cengage.

Miller, D., Robertson, D., Hudson, A., Shimi, J. (2012). Signature Pedagogy in Early Years Education: A Role for COTS Game-Based Learning. *Computers in the Schools*, **29**(1), pp. 227-247.

Miller, G. A., Dawood, N. N., Kassem, M. (2012). Building an Emergent Learning Environment for Construction Health and Safety by Merging Serious Games and 4D Planning. *In*: Issa, R.R., Flood, I. ed(s). *Computing in Civil Engineering: Proceedings of the 2012 ASCE International Conference on Computing in Civil Engineering,* Clearwater Beach, Florida, June 17-20, 2012, US: ASCE Publications, pp. 129-136.

Milne, R. (2013). The History of Seventies Home Computers. *Retro Gamer*, **115**, pp. 76-81.

Minović, M., Milovanović, M., & Starcevic, D. (2013). Literature Review in Game-Based Learning. *In*: Lytras, M.D., Ruan, D., Tennyson, R.D., Ordonez De Pablos, P., García Peñalvo, F.J., Rusu, L. ed(s). *Information Systems, E-learning, and Knowledge Management Research*. DE: Springer Berlin Heidelberg, pp. 146-154.

Mirapaul, M. (2003, September 17). *Online Games Grab Grim Reality*. [Online]. (URL http://www.nytimes.com/2003/09/17/arts/online-games-grab-grim-reality.html?src=pm&pagewanted=1). US: The New York Times Company. (Accessed 05 April 2014).

Mislevy, R.J., Behrens, J.T., Dicerbo, K.E., Frezzo, D.C., West. P. (2012). Three Things Game Designers Need to Know About Assessment. *In*: Ifenthaler, D., Eseryel, D., Ge, X., ed(s). *Assessment in Game-Based Learning: Foundations, Innovations, and Perspectives*. US: Springer Science+Business Media, pp. 59-81.

MIT Media Lab. (2014). *Scratch – Imagine, Program, Share*. [Online]. (URL http://scratch.mit.edu/). US: MIT Media Lab. (Accessed on 14 March 2014).

Mojang AB. (2013). *Minecraft*. [Online]. (URL https://minecraft.net/). SE: Mojang AB. (Accessed 05 March 2014).

Molka-Danielsen, J., Deutschmann, M., Panichi, L. (2009). Designing Transient Learning Spaces in Second Life-a case study based on the Kamimo experience. *Designs for Learning*, **2**(2), pp. 22-33.

Monk, A. (2000). User-Centred Design. *In*: Sloane, A., van Rijn, F., ed(s). *Home Informatics and Telematics*. US: Springer Science+Business Media, pp. 181-190.

Moore, J., Price, C. (2009). Development of an Educational Immersive Environment for Primary School Literacy Education. *Proceedings of the European Conference on Games Based Learning*, pp. 271-278.

Moreno-Ger, P., Burgos, D., Martínez-Ortiz, I., Sierra, J. L., Fernández-Manjón, B. (2008). Educational game design for online education. *Computers in Human Behavior*, **24**(6), pp. 2530-2540.

Morris, D. (2009). Learning Design Approaches to Curriculum Redesign: A Case Study. *International Journal of Learning*, **16**(9), pp. 589-596.

Mortera-Gutièrrez, F. (2006). Faculty Best Practices Using Blended Learning in E-Learning and Face-to-Face Instruction. *International Journal on E-Learning*, **5**(3), pp. 313-337.

Moschini, E. (2006). Designing for the smart player: usability design and user centred design in game-based learning. *Digital Creativity*. **17**(3), pp. 140-147.

Muijs, D. (2010). *Doing Quantitative Research in Education with SPSS*. 2nd Edition. UK: SAGE Publications Ltd;

Nadolski, R. J., Hummel, H. G., Van Den Brink, H. J., Hoefakker, R. E., Slootmaker, A., Kurvers, H. J., & Storm, J. (2008). EMERGO: A methodology and toolkit for developing serious games in higher education. *Simulation & Gaming*, **39**(3), pp. 338-352.

Nagowah, L. and Nagowah, S. (2009). A Reflection on the Dominant Learning Theories: Behaviourism, Cognitivism and Constructivism. *International Journal of Learning*, **16**(2), pp. 279-285.

National STEM Centre. (2014a). *SMILE Cards*. [Online]. (URL (2) http://www.nationalstemcentre.org.uk/elibrary/maths/collection/44/smile-cards). UK: The National STEM Centre. (Accessed 15 December 2014).

National STEM Centre. (2014b). *SMILE Wealth of Worksheets*. [Online]. (URL http://www.nationalstemcentre.org.uk/elibrary/resource/675/smile-wealth-of-worksheets). UK: The National STEM Centre. (Accessed 15 December 2014).

Nelson, C. (2008, January 8). *Engagement and Flow*. [Online]. (URL http://secondlanguagewriting.com/explorations/Archives/2007/January/EngagementandFlow.html). (Accessed 17 October 2010).

Nesta. (2014a). *Crowdfunding*. [Online]. (URL http://www.nesta.org.uk/project/crowdfunding). UK: NESTA. (Accessed 12 April 2014).

Nesta. (2014b). *Find a crowdfunding platform*. [Online]. (URL http://www.crowdingin.com/). UK: NESTA. (Accessed 12 April 2014).

Nesta. (2014c). *20 Shades of Startup*. [Online]. (URL http://www.nesta.org.uk/20-shades-startup/). UK: NESTA. (Accessed 12 April 2014).

Ney, M., Emin, V., Earp, J. (2012). Paving the way to Game Based Learning: a question matrix for Teacher Reflection. *Procedia Computer Science*, **15**(2012), pp. 17-24.

Newman University. (2014), *PGCE Secondary Computer Science and ICT*. [Online]. (URL http://www.newman.ac.uk/postgraduate/593/pgce-secondary-ict-qts). UK: Newman University. (Accessed 10 June 2014).

Nintendo Corporation (2014), *Nintendo UK's The Legend of Zelda Hub*. [Online]. (URL http://www.nintendo.co.uk/Games/Nintendo-Characters-Hub/The-Legend-of-Zelda-Hub/Nintendo-UK-s-The-Legend-of-Zelda-Hub-627606.html). (Accessed 23 March 2014).

Novak, K., Nackerud, R. (2011). Choosing a Serious Game for the Classroom: An Adoption Model for Educators. *Serious Games and Edutainment Applications*, **2011**, pp. 291-308.

Obikwelu, C., Read, J.C. (2012). The Serious Game Constructivist Framework for Children's Learning. *Procedia Computer Science*, **15**, pp. 32-37.

O'Neil, H. F., Wainess, R., Baker, E. L. (2005). Classification Of Learning Outcomes: Evidence From The Computer Games Literature, *The Curriculum Journal*, **16**(4), pp. 455-474.

Ofsted. (2014, January 31). *Press release: Ofsted to carry out no notice behaviour inspections in response to concerns of parents*. [Online]. (URL http://www.ofsted.gov.uk/news/ofsted-carry-out-no-notice-behaviour-inspections-response-concerns-of-parents). UK: Ofsted. (Accessed 01 March 2014).

Orvis, K. A., Horn, D. B., Belanich, J. (2008). The roles of task difficulty and prior videogame experience on performance and motivation in instructional videogames. *Computers in Human behavior*, **24**(5), pp. 2415-2433.

Ott, M., Tavella, M. (2009). A contribution to the understanding of what makes young students genuinely engaged in computer-based learning tasks. *Procedia-Social and Behavioral Sciences*, **1**(1), pp. 184-188.

Ott, M., Tavella, M. (2010). Motivation and engagement in computer-based learning tasks: investigating key contributing factors. *World Journal on Educational Technology*, **2**(1), pp. 1-15.

Overmars, M. (2004a). *Game Design in Education*. [Online]. (URL http://www.cs.uu.nl/research/techreps/repo/CS-2004/2004-056.pdf). (Accessed 8 July 2010).

Overmars, M. (2004b). Teaching computer science through game design. *Computer*, **37**(4), pp. 81-83.

Overmars, M. (2009, December 23). A First Person Shooter . [Online]. (URL http://sandbox.yoyogames.com/extras/user/cv/san1/15/76015/gm_tutorial_-_first_person_shooter.pdf). UK: YoYo Games Ltd. (Accessed 19 July 2014).

Overmars, M. (2011). *Designing Successful iPhone and Android Games with GameMaker*. [Online]. (URL www.yoyogames.com/docs/designing_successful_iphone_games.pdf). (Accessed 4 February 2012).

Oxford Dictionaries. (2013). *disequilibrium: definition of disequilibrium in Oxford dictionary (British & World English)*. [Online]. (URL http://oxforddictionaries.com/definition/english/disequilibrium?q=disequilibria). (Accessed 15 October 2013).

Ozcelik, E., Cagiltay, N. E., Ozcelik, N. S. (2013). The effect of uncertainty on learning in game-like environments. *Computers & Education*, **67**, pp. 12-20.

Pailing, M. (2002). E-learning: is it really the best thing since sliced bread?. *Industrial and Commercial Training*, **34**(4), pp. 151-155.

Pannese, L. and Carlesi, M. (2007). Games and learning come together to maximise effectiveness: The challenge of bridging the gap. *British Journal of Educational Technology*, **38**(3), pp. 438-454.

Panoutsopoulos, H., Sampson, D.G., Mikropoulos, T. (2014). Digital Games as Tools for Designing and Implementing Pedagogical Innovations: A Review of Literature. *In*: Gosper, M., Ifenthaler, D., ed(s). *Curriculum Models for the 21st Century: Using Learning Technologies in Higher Education*. US: Springer Science+Business Media, pp. 279-293.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. US: Basic Books.

Papert, S. (1998). Does easy do it? Children, games, and learning. *Game Developer*, **5**(6), pp. 88.

Paras, B., Bizzocchi, J. (2005). Game, motivation, and effective learning: An integrated model for educational game design. *In*: *International DiGRA 2005 Conference*, Vancouver, British Columbia, Canada, June 16-20, 2005.

Parslow, P. (2012, February 15). *BBC Computer Literacy 2012 – one to keep an eye on*. [Online]. (URL http://blogs.reading.ac.uk/digitallyready/2012/02/15/bbc-computer-literacy-2012-one-to-keep-an-eye-on/). UK: University of Reading. (Accessed 10 March 2014).

Parr , C. (2014, January 19). *Crowdfunding 'could threaten government investment'*. [Online]. (URL http://www.timeshighereducation.co.uk/news/crowdfunding-could-threaten-government-investment/2010584.article). UK: TSL Education Ltd. (Accessed 12 April 2014).

Paton, G. (2013, December 11). *Ofsted: schools face 'no-notice' inspections in behaviour crackdown*. [Online]. (URL http://www.telegraph.co.uk/education/educationnews/10511288/Ofsted-schools-face-no-notice-inspections-in-behaviour-crackdown.html). UK: Telegraph Media Group Limited. (Accessed 01 March 2014).

Pavero Software Ltd. (2009, May 27). *Gauntlet 1 - The Map*. [Online]. (URL http://maps.speccy.cz/map.php?id=Gauntlet1&sort=4&part=3&ath=). (Accessed 13 March 2012).

Pavlov, I. P. (1902). *The Work Of The Digestive Glands*. UK: Griffin.

Peariso, J. F. (2008). *Multiple Intelligences or Multiply Misleading: The Critic's View of the Multiple Intelligences Theory*. US: Institute of Educational Sciences.

Pearson, E. M., Podeschi, R. L. (1999). Humanism and individualism: Maslow and his critics. *Adult Education Quarterly*, **50**(1), pp. 41-55.

PEGI. (2014) *PEGI Pan European Game Information - What do the labels mean?*. [Online]. (URL http://www.pegi.info/en/index/id/33/). BE: PEGI S.A. (Accessed 18 April 2014).

Perry, D., DeMaria, R. (2009). *David Perry on Game Design – A Brainstorming Toolbox*. CAN: Course Technology/Cengage.

Perryman, J., Ball, S., Maguire, M., Braun, A. (2011). Life in the Pressure Cooker – School League Tables and English and Mathematics Teachers' Responses to Accountability in a Results-Driven Era, *British Journal of Educational Studies*, **59**(2), pp. 179-195.

Petridis, P., Dunwell, I., Panzoli, D., Arnab, S., Protopsaltis, A., Hendrix, M., de Freitas, S. (2012). Game engines selection framework for high-fidelity serious applications. *International Journal of Interactive Worlds*, **2012**.

Phillips, V., Popović, Z. (2012). More than child's play: Games have potential learning and assessment tools. *Phi Delta Kappan*, **94**(2), pp. 26-30.

Piaget, J. (1972). *The psychology of the child*. US: Basic Books.

Piaget, J. (2007). *The Child's Conception of the World: A 20th-Century Classic of Child Psychology*. US: Rowman & Littlefield Publishers Inc.

Pivec, M. (2007). Editorial: Play and Learn: potentials of game-based learning. *British Journal of Educational Technology*, **38**(3), pp. 387-393.

Pivec, P. (2009). Game-based Learning or Game-based Teaching?. UK: BECTA.

Ponterotto, J. G. (2005). Qualitative Research in Counseling Psychology: A Primer on Research Paradigms and Philosophy of Science. *Journal of Counseling Psychology*, **52**(2), pp. 126-136.

Poremba, C. (2009). JFK Reloaded: Documentary Framing and the Simulated Document. *Loading...*, **3**(4), pp. 1-12.

Prensky, M. (2001). *"Digital Game-Based Learning"*. USA: Paragon House.

Prensky, M. (2006). *"Don't Bother Me Mom – I'm Learning!"*. USA: Paragon House.

Pressman, R. S. (2001). *Software Engineering: A Practitioner's Approach*, 5th Edition. USA: McGraw-Hill.

Preston, J., Morrison, B. (2010). Entertaining Education – Using Games-Based and Service-Oriented Learning to Improve STEM Education. *In:* Pan, Z., Cheok, A.D., Müller, W. ed(s). *Transactions on Edutainment III*. DE: Springer-Verlag Berlin Heidelberg, pp. 70-81.

Primary Games. (2011a). *Wipeout Wall*. [Online]. (URL http://www.primarygames.co.uk/pg7/wwmulti.swf). UK: Primary Games Ltd. (Accessed 01 April 2013).

Primary Games. (2011b). *Table Mountain*. [Online]. (URL http://www.teachingtables.co.uk/tm/tmgame/twopgame.html). UK: Primary Games Ltd. (Accessed 01 April 2013).

Primary Resources. (2011a). *Moon Maths*. [Online]. (URL http://www.primaryresources.co.uk/online/moonmaths.swf). UK: Primary Resources. (Accessed 17 October 2011).

Pring, R. (2004). *Philosophy of Educational Research*. 2nd Edition. UK: Continnuum

Pritchard, A. (2009). *Ways of Learning – Learning Theories and Learning Styles in the Classroom*. Second Edition, UK: Routledge.

Procci, K., Singer, A. R., Levy, K. R., Bowers, C. (2012). Measuring the flow experience of gamers: An evaluation of the DFS-2. *Computers in Human Behavior*, **28**, pp. 2306-2312.

Provo, F. (2007, September 7). Donkey Kong Jr. Math Review. [Online]. (URL http://uk.gamespot.com/donkey-kong-jr-math/reviews/donkey-kong-jr-math-review-6178336/). (Accessed 5 March 2012).

Raessens, J. (2006). Reality play: Documentary computer games beyond fact and fiction. *Popular Communication*, **4**(3), pp. 213-224.

Rapeepisarn, K., Wong, K.W., Fung, C.C., Khine, M.S. (2008). The Relationship between Game Genres, Learning Techniques and Learning Styles in Educational Computer Games. *In*: Pan, Z., Zhang, X., El Rhalibi, A., Woo, W., Li, Y. ed(s). *Third International Conference*, Edutainment 2008, Nanjing, China, June 25-27, 2008, UK: Springer, pp 497-508.

Raspberry Pi Foundation. (2013, January 29). *15,000 Raspberry Pis for UK schools - thanks Google!*. [Online]. (URL http://www.raspberrypi.org/archives/3158). UK: Raspberry Pi Foundation. (Accessed 10 March 2014).

Reed, M. (2010). Retroinspection: Acorn Archimedes. *Videogames Hardware Handbook 1977 to 2001*, Vol. 2, pp. 215-217.

Retro Gamer. (2006a). Retroinspection: Atari 2600. *Retro Gamer*, **21**, pp. 44-47.

Rieber, L. P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational technology research and development*, **44**(2), pp. 43-58.

Rice, J. W. (2007). New media resistance: Barriers to implementation of computer video games in the classroom. *Journal of Educational Multimedia and Hypermedia*, **16**(3), pp. 249-261.

Rigby, B. (2013, October 09). *Lenovo tops PC makers, industry sales decline in quarter*. [Online]. (URL http://www.reuters.com/article/2013/10/09/us-technology-pc-sales-idUSBRE99817Y20131009?feedType=RSS&feedName=technologyNews). (Accessed 12 November 2013).

Rogers, C.R. (1969). *Freedom to Learn*. US: Charles Merrill.

Roodt, S., Joubert, P. (2009). Evaluating Serious Games in Higher Education: a Theory-Based Evaluation of IBMs Innov8. *Proceedings of the European Conference on Games Based Learning*, pp. 332-338.

Rothschild, M. K. (2008). *The instructional design of an educational game: form and function in JUMP*. US: Department of Education.

Royle, K. (2009, July 08). *Computer games and realising their learning potential*. [Online]. (URL http://www.gamebasedlearning.org.uk/content/view/67/60/). UK: Without Frontiers Ltd (Accessed 17 October 2013).

Ryan, R. M., Deci, E. L. (2000a). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology*, **25**(1), pp. 54-67.

Ryan, R. M., Deci, E. L. (2000b). Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American psychologist*, **55**(1), pp. 68-78.

Sandford, R., Ulicsak, M., Facer, K., & Rudd, T. (2006). *Teaching with Games: Using commercial off-the-shelf computer games in formal education*. UK: FutureLab.

Sardone, N. B., Devlin-Scherer, R. (2010). Teacher Candidate Responses To Digital Games: 21st Century Skills Development. *Journal of Research on Technology in Education*, **42**(4), pp. 409-425.

Saunders, M., Lewis, P., Thornhill, A. (2012). *Research Methods for Business Students*. 6th Edition. UK: Prentice Hall

Savage, M. (2010, January 19). *Labour's computer blunders cost £26bn*. [Online]. (URL http://www.independent.co.uk/news/uk/politics/labours-computer-blunders-cost-16326bn-1871967.html). UK: Independent.co.uk. (Accessed 10 March 2014).

Scalise, K., Wilson, M. (2012). Measurement Principles for Gaming. *In*: Ifenthaler, D., Eseryel, D., Ge, X., ed(s). *Assessment in Game-Based Learning: Foundations, Innovations, and Perspectives*. US: Springer Science+Business Media, pp. 287-305.

Scatteia, L. (2005). Space-themed videogames: an effective way to promote space. *The Electronic Library*. **23**(5), pp. 553-566.

Schell, J., (2010). *The Art of Game Design – A Book of Lens*. USA: Morgan Kaufmann Publishers.

Schott, G., Yeatman, B. (2005). *Subverting Game-Play: 'JFK Reloaded' as Performative Space*. *The Australasian Journal of American Studies*, **24**(2), pp. 82-94.

Schrader, P. G., McCreery, M. (2012). Are All Games the Same?. *In*: Ifenthaler, D., Eseryel, D., Ge, X. ed(s). *Assessment in Game-Based Learning: Foundations, Innovations, and Perspectives*. UK: Springer Science+Business Media New York, pp. 11-28.

Scotland, J. (2012). Exploring the Philosophical Underpinnings of Research: Relating Ontology and Epistemology to the Methodology and Methods of the Scientific, Interpretive, and Critical Research Paradigms. *English Language Teaching*, **5**(9), pp. 9-16.

Scott, K. (2012, January 11). *Current ICT curriculum at schools to be scrapped*. [Online]. (URL http://www.wired.co.uk/news/archive/2012-01/11/ict-education-rehaul?page=all). UK: Wired.co.uk. (Accessed 10 March 2014).

Serious Game Association. (2014). *About SGA – Serious Games Association*. [Online]. (URL http://www.seriousgamesassociation.com/about-sga/). (Accessed 20 Oct 2014).

Serious Game Classification. (2014). *Serious Game Classification : Games*. [Online]. (URL http://serious.gameclassification.com/EN/games/index.html?display=thumb). (Accessed 17 April 2014).

Serious Games Directory. (2014). *Serious Games Directory BETA*. [Online]. (URL http://www.seriousgamesdirectory.com/proj/education/). US: Serious Games Association. (Accessed 17 April 2014).

SGI. (2014a). *Serious Games Studio*. [Online]. (URL http://www.seriousgamesinstitute.co.uk/applied-research/default.aspx?section=10&item=146&category=1). UK: Serious Games Institute. (Accessed 18 April 2014).

SGI. (2014b). *BOO-Games*. [Online]. (URL http://www.seriousgamesinstitute.co.uk/applied-research/BOO-Games.aspx). UK: Serious Games Institute. (Accessed 18 April 2014).

SGI. (2014c). *Cluster 2020*. [Online]. (URL http://www.seriousgamesinstitute.co.uk/applied-research/CLUSTER.aspx). UK: Serious Games Institute. (Accessed 18 April 2014).

Shaffer, D.W. (2008). *How Computer Games Help Children Learn*. USA: Palgrave Macmillan.

Sharp, H., Rogers, Y., Preece, J. (2007). *Interaction Design: Beyond Human-Computer Interaction*. 2nd Ed. UK: John Wiley & Sons.

Shepherd, J. (2011, November 28). *Computer lessons are out of date, admits government*. [Online]. (URL http://www.theguardian.com/education/2011/nov/28/computer-lessons-out-of-date). UK: Guardian News and Media Limited. (Accessed 10 March 2014).

Shernoff, D. J., Csikszentmihalyi, M., Shneider, B., Shernoff, E. S. (2003). Student engagement in high school classrooms from the perspective of flow theory. *School Psychology Quarterly*, **18**(2), pp. 158-176.

Sherry, J. L. (2013). Formative Research for STEM Educational Games. *Zeitschrift für Psychologie*, **221**(2), pp. 90-97.

Shute, V.J., Ke, F. (2012). Games, Learning, and Assessment. *In*: Ifenthaler, D., Eseryel, D., Ge, X. ed(s). *Assessment in Game-Based Learning: Foundations, Innovations, and Perspectives*. US: Springer Science+Business Media, pp. 43-58.

Shute, V.J., Masduki, I., Donmez, O. (2010). Conceptual Framework for Modeling, Assessing and Supporting Competencies within Game Environments. *Technology, Instruction, Cognition & Learning*, **8**(2), pp. 137-161.

Simpson, E. (2011, April 01). *Becta, the first quango to be cut, closes its doors*. [Online]. (URL http://www.bbc.co.uk/news/business-12932140). UK: BBC. (Accessed 11 October 2013).

Sisarica, A., Maiden, N. (2013). An Emerging Model of Creative Game-Based Learning. *In*: Ma, M., Fradinho Oliveira, M., Petersen, S., Baalsrud Hauge, J. ed(s). *Serious Games Development and Applications*. DE:Springer Berlin Heidelberg, pp. 254-259.

Skinner, B. F. (1938). *The behavior of organisms: An experimental analysis*. UK: Appleton-Century.

SMILE Centre. (1984). *Micro Smile - The first 30 SMILE programs for the BBC Micro Model 'B'*. UK: SMILE Centre.

Smith, E. (2012). The Digital Native Debate in Higher Education: A Comparative Analysis of Recent Literature. *Canadian Journal of Learning and Technology*, **38**(3), pp. 1-18.

Smith, E. (2013). Are Adult Educators and Learners ‘Digital Immigrants’? Examining the Evidence and Impacts for Continuing Education. *Canadian Journal of University Continuing Education*, **39**(1), pp.1-13

Smith, J.S. (2005). Flow Theory and GIS: Is there a Connection for Learning? *International Research in Geographical and Environmental Education*. **14**(3), pp. 223-230.

Smith, M. (2011). What Computing Students Can Learn by Developing Their Own Serious Games. *In*: Ma, M., Oikonomou, A., Jain, L.C ed(s). *Serious Games and Edutainment Applications*. UK: Springer-Verlag London, pp. 447-480.

Smith, M. K. (2008). *Howard Gardner and multiple intelligences*. [Online]. (URL http://infed.org/mobi/howard-gardner-multiple-intelligences-and-education/). UK: infed.org. (Accessed 16 September 2014).

Sommeregger, P., Kellner, G. (2012). Brief Guidelines for Educational Adventure Games Creation (EAGC). *In*: *Proceedings of the 2012 Fourth IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning*, Takamatsu, Japan, March 27-30 2012. IEEE Computer Society Press, pp. 120-122.

Sommerville, I. (2007). *Software Engineering*. Eighth Edition. UK: Addison-Wesley.

Somyürek, S., Coşkun, B. K. (2013). Digital competence: Is it an innate talent of the new generation or an ability that must be developed?. *British Journal of Educational Technology*, **44**(5), pp. E163-E166.

Song, M., Zhang, S. (2008). EFM: A model for educational game design. *In*: Pan, Z., Zhang, X., El Rhalibi, A., Woo, W., Li, Y. ed(s). *Technologies for e-learning and digital entertainment*. DE: Springer Berlin Heidelberg, pp. 509-517.

Spencer, S. (2004a). A Brief History of Videogames Part 1. *Retro Gamer*, **16**, pp. 60-66.

Spencer, S. (2004b). A Brief History of Videogames Part 2. *Retro Gamer*, **17**, pp. 62-71.

Squareknot. (2014). *Crowdfunding Platform Offering Both Equity & Loan Funding | Squareknot*. [Online]. (URL https://www.squareknot.co.uk/). UK: Squareknot Limited. (Accessed 12 April 2014).

Squire, K.D. (2005). *Changing the game: What happens when videogames enter the classroom?*. [Online]. (URL http://www.innovateonline.info/pdf/vol1_issue6/Changing_the_Game-__What_Happens_When_Video_Games_Enter_the_Classroom_.pdf). (Accessed 8 July 2010).

Squire, K.D. (2013). Video Game-Based Learning: An Emerging Paradigm for Instruction. *Performance Improvement Quarterly*, **26**(1), pp. 101-130.

Squire, K.D., Jan, M. (2007), Mad City Mystery: Developing Scientific Argumentation Skills with a Place-based Augmented Reality Game on Handheld Computers. *Journal of Science Education and Technology*, **16**(1), pp. 5-29.

Stewart, J.M. (2002). A blended e-learning approach to intercultural training. *Industrial and Commercial Training*, **34**(7), pp. 269-271.

Stowell, T., Shelton, B.E. (2008). Challenges, Frustrations and Triumphs of Remixing an Open Source Game Engine for Educational Purposes. *TechTrends: Linking Research & Practice to Improve Learning*, **52**(5), pp. 32-37.

Stuart, K. (2012, March 23). *Video game tax breaks: what does it mean and what happens now?*. [Online]. (URL http://www.theguardian.com/technology/gamesblog/2012/mar/23/video-game-tax-credits). UK: Guardian News and Media Limited. (Accessed 12 April 2014).

Su, C. H., & Cheng, C. H. (2013). 3D Game-Based Learning System For Improving Learning Achievement In Software Engineering Curriculum. *The Turkish Online Journal of Educational Technology*, **12**(2), pp. 1-12.

Syal, R. (2013, September 18). *Abandoned NHS IT system has cost £10bn so far*. [Online]. (URL http://www.theguardian.com/society/2013/sep/18/nhs-records-system-10bn). UK: Guardian News and Media Limited (Accessed 10 March 2014).

Tabachnick, B. G., Fidell, L. S. (2012). *Using Multivariate Statistics*. Sixth Edition. UK: Pearson.

Tan, W.H. (2010). *Game-based learning in formal educational contexts : how subject matter experts and game experts could collaborate to design and develop games*. PhD thesis. University of Warwick.

Tang, S., Hanneghan, M., Carter, C. (2012). A Platform Independent Model for Model Driven Serious Games Development. *Proceedings of the European Conference on Games Based Learning*, pp. 495-504.

Tang, S., Hanneghan, M., El Rhalibi, A. (2009). Introduction to games-based learning. *Games-based learning advancements for multi-sensory human computer interfaces: Techniques and effective practices*. US: IGI Global, pp. 1-17.

Tappeiner, E., Lyons, C. (2008). Selection criteria for academic video game collections. *Collection Building*, **27**(3), pp. 121-125.

Tassi, P. (2014, April 08). *At Long Last, Video Game Aggression Linked To Losing, Not Violence*. [Online]. (URL http://www.forbes.com/sites/insertcoin/2014/04/08/at-long-last-video-game-aggression-linked-to-losing-not-violence/). US: Forbes LLC. (Accessed 12 April 2014).

Thang, S. M., Jaafar, N. M., Nambiar, R., Amir, Z., Wong, F. F. (2014). Are Malaysian undergraduates 'digital natives' in the true sense of the word? A quantitative analysis. *3L: The Southeast Asian Journal of English Language Studies*, **20**(1), pp. 177-191.

The Guardian. (2011, October 03). *Targets and league tables*. [Online]. (URL http://www.theguardian.com/teacher-network/2011/oct/03/targets-league-tables). UK: Guardian News and Media Limited. (Accessed 10 June 2014).

Tobias, S., Fletcher, J.D., Wind, A.P. (2014). Game-Based Learning. *In*: Spector, J.M., Merrill, M.D., Elen, J., Bishop, M.J. ed(s). *Handbook of Research on Educational Communications and Technology*. 4th Edition. US: Springer Science+Business Media, pp. 485-503.

Topologika. (2014). *GIANTKILLER*. [Online]. (URL http://www.r-e-m.co.uk/topologika/?page=./services/freebies/giantkiller.html). UK: Topologika Ltd. (Accessed 15 December 2014).

Tragazikis, P., Kirginas, S., Gouscos, D., Meimaris, M. (2011). Digital Games Evaluation and Educational Assessment - a Review and Proposal for an Open Methodological Framework (OMEGA). Proceedings of the European Conference on Games Based Learning, pp. 604-612.

Tran, C.D., George, S., Marfisi-Schottman, I. (2010). EDoS: An Authoring Environment for Serious Games Design Based on Three Models. *Proceedings of the European Conference on Games Based Learning*, pp. 393-402.

Transum Software. (2011a). *Table Master*. [Online]. (URL http://www.transum.org/software/tablesmaster/tablesmaster.asp). UK: Transum Software. (Accessed 17 October 2011).

Transum Software. (2011b). *Tran Towers*. [Online]. (URL http://www.transum.org/Software/Trantowers/trantowers.asp). UK: Transum Software. (Accessed 17 October 2011).

Trigg, A.B. (2004) Deriving the Engel Curve: Pierre Bourdieu and the Social Critique of Maslow's Hierarchy of Needs, *Review of Social Economy*, **62**(3), pp. 393-40.

Trasler, J. (2002). Effective learning depends on the blend, *Industrial and Commercial Training,* **34**(5), pp. 191-193.

Tsai, F-H., Yu, K-C., Hsiao, H-S. (2012). Exploring the Factors Influencing Learning Effectiveness in Digital Game-based Learning. *Educational Technology & Society*, **15**(3), pp. 240-250.

UKCFA. (2014, April 09). *UK Crowd Funding Association*. [Online]. (URL http://www.ukcfa.org.uk/). UK: UK Crowd Funding Association. (Accessed 12 April 2014).

Ullrich, C. (2008). Descriptive and Prescriptive Learning Theories. *Courseware Generation for Web-Based Learning*, pp. 37-42.

University of Adelaide. (2011). *Instructional design*. [Online] (URL http://www.adelaide.edu.au/clpd/online/designing/instructional/). (Accessed 8 January 2011).

Canterbury Christ Church University. (2013), *PGCE in ICT and Computer Science*, [Online]. (URL http://www.canterbury.ac.uk/courses/prospectus/pgce/courses/11-18-PGCE-computer-science.asp). UK: Canterbury Christ Church University. (Accessed 10 June 2014).

University of East London. (2014), *Primary with ICT and computing, PGCE*. [Online]. (URL http://www.uel.ac.uk/study/courses/prim-ict-com.htm). UK: University of East London. (Accessed 10 June 2014).

University of Huddersfield. (2014), *Teacher Training, Secondary ICT and Computer Science, PGCE with QTS 2014-15*. [Online]. (URL http://www.hud.ac.uk/courses/full-time/postgraduate/teacher-training-secondary-ict-and-computer-science-pgce-with-qts/). UK: University of Huddersfield. (Accessed 10 June 2014).

Usability Professionals' Association. *What is User-Centered Design?*. [Online] (URL http://www.upassoc.org/usability_resources/about_usability/what_is_ucd.html). (Accessed 8 January 2011).

UsabilityNet. (2006). *Key principles of user centred design*. [Online] (URL http://www.usabilitynet.org/management/b_design.htm). (Accessed 8 January 2011).

Van Eck, R. (2006). Digital Game-Based Learning - It's Not Just the Digital Natives Who Are Restless. *EDUCAUSE Review*, March/April 2006, pp. 16-30.

van Lier, L. (2008). Agency in the classroom. *In*: Lantolf, J.P., Poehner, M.E ed(s). *Sociocultural theory and the teaching of second languages*, UK: Equinox.

van Staalduinen, J-P., de Freitas, S. (2010). A Game-based Learning Framework: Linking Game Design and Learning Outcomes. *In*: Khine, M. S. ed(s). *Learning to Play: Exploring the Future of Education with Video Games*. US: Peter Lang Publishing Inc.

Vaughan, N. (2007). Perpectives On Blended Learning in Higher Education. *International Journal on E-Learning*, **6**(1), pp. 81-94.

Vaughan, R. (2014, January 31). *No-notice inspections to start next week in bid to tackle bad behaviour*. [Online]. (URL http://news.tes.co.uk/b/ofsted-watch/2014/01/31/no-notice-inspections-to-start-next-week-in-bid-to-tackle-bad-behaviour.aspx). UK: TSL Education Ltd. (Accessed 01 March 2014).

Vincent, J. (2014, April 08). *Violent video games don't make you aggressive - difficult games do, says new study*. [Online]. (URL http://www.independent.co.uk/life-style/gadgets-and-tech/violent-video-games-dont-make-you-aggressive--difficult-games-do-says-new-study-9246838.html). UK: Independent Print Ltd. (Accessed 12 April 2014).

Vogel, J. J., Greenwood-Ericksen, A., Cannon-Bowers, J., Bowers, C. A. (2006). Using Virtual Reality with and without Gaming Attributes for Academic Achievement. *Journal of Research on Technology in Education*, **39**(1), pp. 105-118.

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research*, **34**(3), pp. 229-243.

Vogler, C. (2007). *Writer's Journey: Mythic Structure for Writers*. 3rd ed. US: Michael Wiese Production.

Von der Heiden, B., Bock, V., Richert, A., & Jeschke, S. (2011). Learning by Playing: Potential of Serious Games to Increase Intellectual Capital. *In*: Jeschke, S., Isenhardt, I., Hees, F., Trantow, S., ed(s). *Enabling Innovation*. DE: Springer Berlin Heidelberg, pp. 375-388.

VSC. (2014). *Parent's and Carer's Guide To Video Games Ratings*. [Online]. (URL http://www.videostandards.org.uk/VSC/games_ratings.html). UK: The Video Standards Council. (Accessed 18 April 2014).

Vygotsky, L. S. (1978). *Mind in society : The development of higher psychological processes*. US: Harvard University Press.

Vygotsky, L. S. (1986). *Thought and language*. US: MIT Press.

Wahyuni, D. (2012). The Research Design Maze: Understanding Paradigms, Cases, Methods and Methodologies. *Journal of Applied Management Accounting Research*, **10**(1), pp. 69-80.

Wakefield, W. (2012, July 20). *How schools will boot up a new ICT curriculum*. [Online]. (URL http://www.bbc.co.uk/news/technology-18687248). UK: BBC. (Accessed 10 March 2014).

Walker, A. and Shelton, B.E. (2008). Problem-Based Educational Games: Connections, Prescriptions, and Assessment. *Journal of Interactive Learning Research*. **19**(4), pp. 663-684.

Wahba, M. A., Bridwell, L. G. (1976). Maslow reconsidered: A review of research on the need hierarchy theory. *Organizational Behavior and Human Performance*, **15**(2), pp. 212-240.

Wang, L. (2007). Socialcultural Learning Theories and Information Literacy Teaching Activities in Higher Education. *Reference & User Services Quarterly*, **47**(2), pp. 149-158.

Waraich, A., Wilson, G. (2005). BMX Bandits: The Design of an Educational Computer Game for Disaffected Youth. *People and Computers XVIII – Design for Life*, pp. 151-163.

Ward, M. (2014, April 08). *Windows XP users face end to Microsoft support*. [Online]. (URL http://www.bbc.com/news/technology-26884167). UK: BBC. (Accessed 12 April 2014).

Warwick IT Services. (2012, Sept 10). *IBM ® SPSS ® Statistics 20 - Documents and Resources*. [Online]. (URL http://www2.warwick.ac.uk/services/its/servicessupport/training/course_cat/teaching_research/spssdocumentsandresources). (Accessed 5 May 2013).

Watson, J. B. (1913). Psychology as the Behaviorist Views it. *Psychological review*, **20**(2), pp. 158-178.

Watson, W. R., Mong, C. J., Harris, C. A. (2011). A case study of the in-class use of a video game for teaching high school history. *Computers & Education*, **56**(2), pp. 466-474.

Wei, T., Li, Y. (2010). Design of educational game: a literature review. *In*: Pan, Z., Cheok, A.D., Müller, W., Zhang, X. ed(s). *Transactions on edutainment IV*. DE: Springer Berlin Heidelberg, pp. 266-276.

Welker, J., Berardino, L. (2005). Blended learning: understanding the middle ground between traditional classroom and fully online instruction. *Journal of Educational Technology Systems*, **34**(1), pp. 33-55.

Wernbacher, T., Pfeiffer, A., Wagner, M., Hofstätter, J. (2012). Learning by Playing: Can Serious Games be fun?. *Proceedings Of The European Conference On Games Based Learning*, pp. 533-541.

Westera, W., Nadolski, R.J., Hummel, H.G.K., Wopereis, I.G.J.H. (2008). Serious games for higher education : a framework for reducing design complexity. *Journal of computer assisted learning*, **24**(5), pp. 420-432.

Westwood, P. (2004). *Learning and learning difficulties: A handbook for teachers*. AUS: ACER Press.

White, J. (2005, December 08). *Multiple intelligence? It's a flaky theory*. [Online]. (URL http://www.independent.co.uk/news/education/education-news/john-white-multiple-intelligence-its-a-flaky-theory-518528.html). UK: Independent Print Ltd. (Accessed 16 September 2014).

Whitton, N. (2012). The place of game-based learning in an age of austerity. *Electronic Journal of e-Learning*, **10**(2), pp. 249-256.

Wideman, H.H., Owston, R.D., Brown, C., Kushniruk, A., Ho, F., Pitts, K.C. (2007). Unpacking the potential of educational gaming: A new tool for gaming research. *Simulation & Gaming*, **38**(1), pp. 10-30.

Williams, R. (2014, February 09). *Flappy Bird 'to be taken down' after 'ruining creator's life'*. [Online]. (URL http://www.telegraph.co.uk/technology/10626852/Flappy-Bird-to-be-taken-down-after-ruining-creators-life.html). UK: Telegraph Media Group Limited. (Date Accessed 01 March 2014).

Williamson, B. (2003, October). *Playing 9/11: The war on taste?*. [Online]. (URL http://archive.futurelab.org.uk/resources/publications-reports-articles/web-articles/Web-Article586). UK: Futurelab. (Accessed 05 April 2014).

Willingham, D.T. (2004). Reframing the Mind: Howard Gardner and the theory of multiple intelligences. [Online]. (URL http://educationnext.org/reframing-the-mind/) Education Next, **4**(3). (Accessed 16 September 2014).

Wilson, K. A., Bedwell, W.L., Lazzara, E.H., Salas, E., Burke, C.S., Estock, J.L., Orvis, K.L., Conkey, C. (2009). Relationships Between Game Attributes and Learning Outcomes: Review and Research Proposals. *Simulation & Gaming*, **40**(2), pp. 217-266.

Wolf, M.J.P. (2002). *The Medium of the Video Game*. 1st Edition. US: University of Texas Press.

Wu, W. H., Chiou, W. B., Kao, H. Y., Alex Hu, C. H., Huang, S. H. (2012). Re-exploring game-assisted learning research: The perspective of learning theoretical bases. *Computers & Education*, **59**(4), pp. 1153-1161.

Wu, W. H., Hsiao, H. C., Wu, P. L., Lin, C. H., Huang, S. H. (2012). Investigating the learning-theory foundations of game-based learning: a meta-analysis. *Journal of Computer Assisted Learning*, **28**(3), pp. 265-279.

Xiao, J. (2014). Learner agency in language learning: the story of a distance learner of EFL in China. *Distance Education*, **35**(1), pp. 4-17.

X-Entertainment. (2003, July 18). *X-Entertainment: Nintendo - Donkey Kong Jr. Math!*. [Online]. (URL http://www.x-entertainment.com/articles/0812/). (Accessed 5 March 2012).

Yap, K.Y.-L., Wong, L.L., Yap, K.Z., Chui, W.K., Yap, J.Y.G., Athreya, U.S. (2013). Gamification of Pharmacy Practices: Learning How to Manage Patients the Fun Way. Technology-enhanced Learning, 7th October 2013, pp. 1-4.

Yoyo Games. (2007, August 03). *MathsBall*. [Online]. (URL http://sandbox.yoyogames.com/games/7943-mathsball). (Accessed 17 October 2011).

Yoyo Games. (2008a, April 03). *Math Magic*. [Online]. (URL http://sandbox.yoyogames.com/games/31401-math-magic). (Accessed 17 October 2011).

Yoyo Games. (2008b, October 04). *Donkey Kong Jr MATH 2*. [Online]. (URL http://sandbox.yoyogames.com/games/58576-donkey-kong-jr-math-2). (Accessed 17 October 2011).

Yoyo Games. (2009a, April 10). *Math Man*. [Online]. (URL http://sandbox.yoyogames.com/games/77550-mathman). (Accessed 17 October 2011).

Yoyo Games. (2009b, May 22). *Math Explorer 2*. [Online]. (URL http://sandbox.yoyogames.com/games/82614-math-explorer-2). (Accessed 5 March 2012).

Yoyo Games. (2009c, October 19). *Math Balls*. [Online]. (URL http://sandbox.yoyogames.com/games/100223-math-balls). (Accessed 17 October 2011).

Yoyo Games. (2010, November 04). *Math Man*. [Online]. (URL http://sandbox.yoyogames.com/games/150568-mathman). (Accessed 17 October 2011).

Appendix A: Questionnaire Based Survey (KSA)

The Questionnaire Based Survey involved the distribution and completion of three different questionnaires relating to computer games and Games Based Learning. The intention of the Survey was to elicit the views on these topics from parents, teachers and school pupils.

This Appendix includes two completed (anonymised) copies for each of the *Pupil*, *Parent* and *Teacher* questionnaires.

Computer Game Playing At School

Do you like computer games? Would you like to see them used in school?
If '**Yes!**', then it would be great if you could answer a couple of questions for me
You could end up designing your own computer game!

Questions About You

1. I am a: Boy ☑ / Girl ○ (Tick one circle)

2. What are your favourite subjects at school? (Numeracy, French, Science etc.)

PE, ICT, Golden time,

3. What are your favourite hobbies? (Sport, TV, DVD, Computers etc.)

Building Lego, running

4. Do you like to use computers at school? And if so, what for?

yes because I like learning about the greecs

Questions About Computer Games

5. Do you like to play computer games? (Tick one circle)

   Everyday ○, Weekly ☑, Monthly ○, Rarely ○

6. Whenever you play games, how many hours will you play the game for? (Tick one circle)

   1 ○, 2 ☑, 3 ○, 4 ○, 5 ○

Pupil Questionnaire (1) - Page 2

Questions About Computer Games (Continued)

7. Do you use a computer (PC) or games console (Xbox, Wii etc.) to play games? (Tick one circle)

   PC ☑, Console ◯, Both ◯, None ◯

8. What type of computer games do you like to play? (tick as many circles as you like)

   Puzzle ◯, Strategy ◯, Driving / Flying ◯, Other ☑

   If you selected '*Other*', Please state which type of game

vilance

9. Why do you like to play these types of game?

because there fun

10. What is your favourite computer game(s) at the moment and Why?

gum drop hop, teach a penguin fly, dan ball

11. What sorts of things make a good computer game?

   (e.g. the story?, playing the game with friends/other players?, the computer graphics?, the music etc.)

funny games

Thank you for filling out this questionnaire!

Pupil Questionnaire (1) - Page 3

Design a Game!

If you could create your own computer game, what would it be about?

My computer game would be about...

a perso with Wings

Who would be in the game (i.e. your friends, family)?

I would have the following characters: (Heroes/Villains etc.)

ningas, orange

What type of game would you design? (Puzzle game, Racing game etc.)

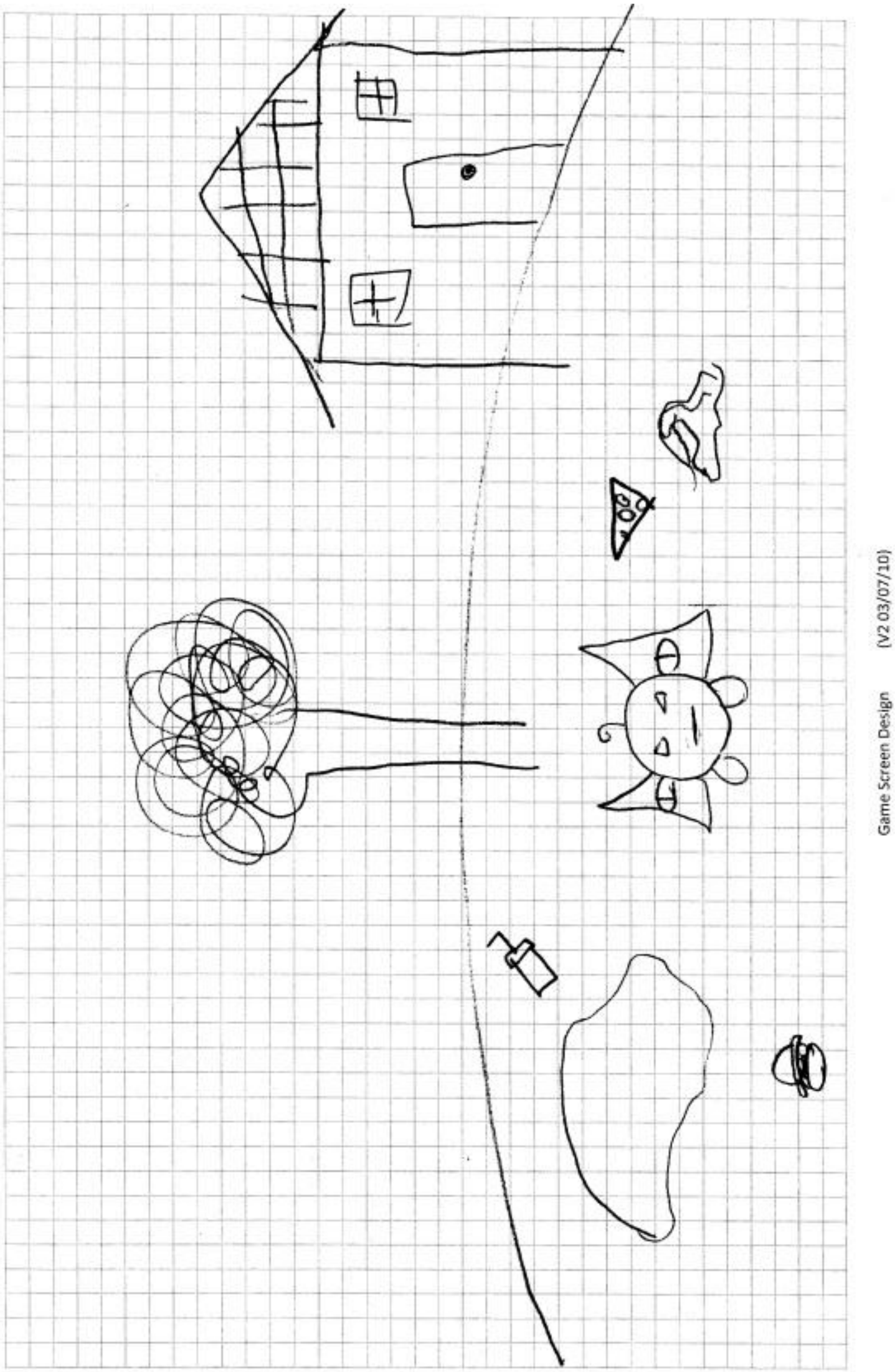
vilance

What would your game *look* like?

If you would like to draw a game screen design, please use the back of this piece of paper!

Thank you for filling out this questionnaire!

Pupil Questionnaire (1) - Page 4



Computer Game Playing At School

Do you like computer games? Would you like to see them used in school?
If '**Yes!**', then it would be great if you could answer a couple of questions for me
You could end up designing your own computer game!

Questions About You

1. I am a: Boy ✓ / Girl ○ (Tick one circle)

2. What are your favourite subjects at school? (Numeracy, French, Science etc.)

Litrace

3. What are your favourite hobbies? (Sport, TV, DVD, Computers etc.)

Sport

4. Do you like to use computers at school? And if so, what for?

for games work maths

Questions About Computer Games

5. Do you like to play computer games? (Tick one circle)

Everyday ✓, Weekly ○, Monthly ○, Rarely ○

6. Whenever you play games, how many hours will you play the game for? (Tick one circle)

1 ○, 2 ✓, 3 ○, 4 ○, 5 ○

Pupil Questionnaire (2) - Page 2

Questions About Computer Games (Continued)

7. Do you use a computer (PC) or games console (Xbox, Wii etc.) to play games? (Tick one circle)

PC ◯, Console ◯, Both ✓, None ◯

8. What type of computer games do you like to play? (tick as many circles as you like)

Puzzle ◯, Strategy ✓, Driving / Flying ◯, Other ◯

If you selected '***Other***', Please state which type of game

9. Why do you like to play these types of game?

because there fun

10. What is your favourite computer game(s) at the moment and Why?

age of war 2 becaus it's what I'm into

11. What sorts of things make a good computer game?

(e.g. the story?, playing the game with friends/other players?, the computer graphics?, the music etc.)

the Adventure, vilonce and Defence

Thank you for filling out this questionnaire!

Pupil Questionnaire (2) - Page 3

Design a Game!

If you could create your own computer game, what would it be about?

My computer game would be about...

age of war

Who would be in the game (i.e. your friends, family)?

I would have the following characters: (Heroes/Villains etc.)

Heroes and villains (chosi

What type of game would you design? (Puzzle game, Racing game etc.)

an Adrentur game

What would your game *look* like?

If you would like to draw a game screen design, please use the back of this piece of paper!

Thank you for filling out this questionnaire!

Pupil Questionnaire (2) - Page 4

Parent Questionnaire (1)

Computer Game Playing At School (Parents)

Hello, as part of my PhD research, it would be a great help if you could fill out this quick questionnaire. Should you have any questions or concerns, please feel free to contact me through the [redacted] School – [redacted] Section.

Thanks in advance!

Brief Introduction to my research area:
Serious Games are educational computer games that try to balance the level of education with the level of 'fun'. Ideally, serious games are neither pure educational games, nor pure (fun) video games. In theory, a good serious game will be fun to play, but educational at the same time.

About You

1. Do you play computer games? (tick one circle)

   Yes ✓, No ○

2. How would you feel (as a learner) about learning by playing a computer game (in addition to more traditional learning, i.e. books, teachers)?

   There needs to be a balance, however, if learning is fun, then more is learnt!

3. Given the opportunity, would you be comfortable with your child/children playing serious (educational) games at school? (tick one circle)

   Yes ✓, No ○

4. Do you think that playing computer games can be beneficial for children (either in terms of leisure or education)?

   Yes. My son plays games at home, but learns from them as well. For example, FIFA World Cup has him asking about the different countries and their location on a map.

5. How important is it for an educational game to be explicitly tied/matched to the English National Curriculum (as used at the [redacted])?

   It ~~is important~~ / ***not important*** (delete applicable) because:

   If it expands knowledge. ENC is not the be all and end all of education!

Thanks for completing this questionnaire!

Parent Questionnaire (2)

Computer Game Playing At School (Parents)

Hello, as part of my PhD research, it would be a great help if you could fill out this quick questionnaire. Should you have any questions or concerns, please feel free to contact me through the [redacted] School – [redacted] Section.

Thanks in advance!

Brief Introduction to my research area:
Serious Games are educational computer games that try to balance the level of education with the level of 'fun'. Ideally, serious games are neither pure educational games, nor pure (fun) video games. In theory, a good serious game will be fun to play, but educational at the same time.

About You

1. Do you play computer games? (tick one circle)

   Yes ✓, No ○

2. How would you feel (as a learner) about learning by playing a computer game (in addition to more traditional learning, i.e. books, teachers)?

   I would happy to play a game provide it was part of a blended solution of traditional learning supplemented by game based learning

3. Given the opportunity, would you be comfortable with your child/children playing serious (educational) games at school? (tick one circle)

   Yes ✓, No ○

4. Do you think that playing computer games can be beneficial for children (either in terms of leisure or education)?

   Anything that makes education fun can only be beneficial

5. How important is it for an educational game to be explicitly tied/matched to the English National Curriculum (as used at the [redacted])?

   It is ~~*important*~~ / *not important* (delete applicable) because:

   Provided there was a genuine learning point to the game that would improve the overall education of children it would be fine to deviate from the English National Curriculum

Thanks for completing this questionnaire!

Computer Game Playing At School (Teachers)

Hello, as part of my PhD research, it would be a great help if you could fill out this quick questionnaire. Should you have any questions or concerns, please feel free to contact me through the [redacted] School [redacted] Section.

Thanks in advance!

Brief Introduction to my research area:
Serious Games are educational computer games that try to balance the level of education with the level of 'fun'. Ideally, serious games are neither pure educational games, nor pure (fun) video games. In theory, a good serious game will be fun to play, but educational at the same time

About You

1. Are you a Specialist or a Primary teacher?

> Primary - though specialise in coordinating ICT within the curriculum. Have also lectured ICT to student teachers.

2. Do you play computer games yourself?

   Yes ☑, No ○

   If '***Yes***', are these games educational or leisure games?

   Educational ○, Leisure ☑

3. Do you use educational (computer or otherwise) games as part of your teaching strategy?

   Yes ☑, No ○

   If '***Yes***' please elaborate on how you use these games in order to teach?

> Simulation games for teaching of History, Geog, Science
> Maths games for practise & mental strategies.

Teacher Questionnaire (1) - Page 2

Educational Games

4. From an educational view, what do you feel makes a good educational computer game?

One which allows pupils to practise skills rather than trying to teach the skills. Must be engaging & purposeful to the child.

5. Are there any positives associated with pupils playing educational games?

Absolutely – vast majority of pupils are hugely motivated by engaging ICT.

6. Are there any negatives associated with pupils playing educational games?

As long as there is a balance with a range of techniques to suit different learning styles – No.

7. How important is it for an educational game to be explicitly tied/matched to the English National Curriculum (as taught at the [redacted])?

It is ***important*** / ***not important*** (delete applicable) because:

E.N.C – is rich and very full – as mentioned, the games need to be purposeful and matched to learning goals.

8. If you were helping your pupils to design a computer game, what as a teacher would you like to see (or not see) in the game?

As above – that the child understands the objective (learning outcome) and that they can discuss what they have learned.

Thank you for completing the questionnaire!

Teacher Questionnaire (2) - Page 1

Computer Game Playing At School (Teachers)

Hello, as part of my PhD research, it would be a great help if you could fill out this quick questionnaire. Should you have any questions or concerns, please feel free to contact me through the [redacted] School [redacted] Section.

Thanks in advance!

Brief Introduction to my research area:
Serious Games are educational computer games that try to balance the level of education with the level of 'fun'. Ideally, serious games are neither pure educational games, nor pure (fun) video games. In theory, a good serious game will be fun to play, but educational at the same time

About You

1. Are you a Specialist or a Primary teacher?

Primary

2. Do you play computer games yourself?

Yes ✓, No ○ not frequently

If '*Yes*', are these games educational or leisure games?

Educational ○, Leisure ✓

3. Do you use educational (computer or otherwise) games as part of your teaching strategy?

Yes ✓, No ○

If '*Yes*' please elaborate on how you use these games in order to teach?

'Adventure' games to develop reading, logic & problem solving strategies.
Assorted interactive whiteboard software to illustrate a concept with greater ease or clarity & give 'practice' opportunities.
Multi-media software to make a topic as 'real' as possible for the children.

Teacher Questionnaire (2) - Page 2

Educational Games

4. From an educational view, what do you feel makes a good educational computer game?

- Matches key learning objectives of curriculum.
- Levelled, to create differentiation within game.
- Graphically eye catching to compete with home experiences.

5. Are there any positives associated with pupils playing educational games?

Enthusiasm to 'do the work'

6. Are there any negatives associated with pupils playing educational games?

Many games don't focus enough on a topic ~~of~~ or learning objective. Some have too much reading or non relevent pages.

7. How important is it for an educational game to be explicitly tied/matched to the English National Curriculum (as taught at the [redacted])?

It is ***important*** / ***not important*** (delete applicable) because:

If it doesn't tie in, we can't justify buying or using it in school.

8. If you were helping your pupils to design a computer game, what as a teacher would you like to see (or not see) in the game?

- Age relevent theme.
- Volume & level of text appropiate to ages.
- Levels built in
- Tied to a specific topic and collection of English curriculum learning objectives.

Thank you for completing the questionnaire!

Appendix B: Generic ADDIE Design

As part of the design process, the author produced a number of ADDIE-based game designs.

Each design consists of the following (ADDIE) stages:

- Analysis
- Design
- Development
- Implementation
- Evaluation

In order to avoid duplication, these designs have been separated into three areas:

- This Appendix (B) includes a generic ADDIE design (which applies to all of the game designs), and generically documents of all of the ADDIE stages (A to E).

- Appendix C presumes the above stages, but documents the *Design* stage in greater detail, due to it being specific to each game design.

- The post-implementation evaluation of the author's games is not documented within an explicit *Evaluation* stage, but is discussed, evaluated and reflected upon within the following thesis sections:

  The author's evaluations/reflections:
  4.6 Game Design / Development
  4.7.2 Pilot / Main Study Game Selection
  9.7 Thesis Reflections

  Prototyping Pilot / Main Study Sample Group Feedback:
  7.5 Prototyping Pilot
  7.6 Main Study

Generic ADDIE Design

Analysis

The Analysis phase describes the educational problem, along with the desired goals and objectives to be achieved. This phase will also seek to identify learners and their learning environment.

Tasks

The tasks/objectives of the author's educational games will be described in greater detail in subsequent sections. However, generically, the author will develop a series of educational games which will allow pupils to practice simple multiplication with one or two digits (i.e. 2 x 3 = 6, 2 x 12 = 24).

Players will gain points through correctly shooting/collecting the correct answers to given multiplication questions. However, should players ignore the mathematical aspect of the game (i.e. shoot or collect items randomly), the scoring system will (through the subtraction of points) penalise the player.

The reasoning behind this dual approach is that if the player plays the game 'correctly' (i.e. mathematically) they will be rewarded point-wise, whereas if they play 'incorrectly' (i.e. ignoring the math content) they will lose points. Whichever approach taken, it is important that the game play / game mechanics are not explicitly interfered with and that the game is still 'fun' to play, regardless of the chosen approach.

Users

The target user of the educational games will be primary school pupils, aged around 8 – 10 years old, studying at Key Stage 2 (Year 3 / 4) in the National Curriculum.

Constraints

The most obvious constraint will be access to the pupils, which will affect when trials/evaluative sessions can be performed. Technological constraints will centre on available ICT resources and access to school computer networks. Additionally, there may be compatibility issues with the games running on the aforementioned ICT resources/computer networks. i.e. network permissions, hardware compatibility etc.

Environment

The local school (currently participating with the author's research) does not contain dedicated ICT rooms/suites, as the current national curriculum advocates the use of 'mobile computing' (i.e. being able to access IT resources irrespective of location). Additionally, the curriculum regards ICT as a discrete subject (being used to support existing core subjects) rather than a dedicated subject in its own right.

It is foreseen that the educational games produced will be tested and ultimately run (on portable netbooks) within a standard classroom environment. The classrooms are well lit (through natural sunlight and florescent lighting) and are fitted with air-conditioning. The tables and chairs are designed for the target age group and the classrooms are colourfully decorated.

Design

The designs for the individual educational games will be detailed within Appendix C, however generically the games do share some design commonality, which is described in this ADDIE stage. Based on an earlier Design Pilot (*Chapter 6*), some initial design decisions have already been taken.

- Players will 'answer' a given math question by selecting, collecting or colliding with the correct/incorrect answer
- The educational game designs will be based on existing 'classic' computer games, but blended with math content.

As a result of the above decisions, a number of 'Classic' arcade games have been selected as the basis for the author's educational game designs.

Goals

The primary goal of the educational games is 'collecting things', in this context it is envisioned that the players will travel around the game play area collecting the answers to a given math question.

Rewards and Penalties

For each of the games there will be some form of scoring system, which it is hoped will encourage players to play. As described in the Analysis section, the scoring system will award points for correct (i.e. mathematical) play, but deduct points for incorrect (i.e. non-mathematical) play,

Additionally, rewards will be given when the player achieves certain objectives (i.e. certain math targets). These rewards will include extra lives/energy, time, points and 'Bonus' opportunities (where the enemies are momentarily paused/slowed down, giving the player a brief upper-hand in the game).

The games will also potentially feature penalty systems, such as limited lives or a countdown timer (hopefully acting as an incentive to the player). In some of the maze-style games, on loss of life, the player's position (within the maze) will be reset back to the beginning of the maze or level.

Game Play

The length/time of game play has been influenced by a number of factors:

- Observations during the Design Pilot (*Chapter 6*) indicated that pupils spent (on average) several minutes playing/exploring each of the piloted games. Typically the time played ranged from 2-3 minutes to 30 minutes.
- Overmars's (2011) recommendations for playing times on similar games being developed for mobile platforms (i.e. Smartphones and Tablet PC's).
- The limited nature of the proposed games (i.e. the set number of 'items' or math answers to collect)

As a result, it is anticipated that typical game play will be sustained for a short to medium period of time (from 2-5 minutes, to 30 minutes).

Tutorials

In the light of the feedback from the Design Pilot, in-game text-based help will be kept to a minimum but will be provided, via a menu option and a (more detailed) printed User Guide, for completeness.

User Interface Design

Given the target age group and the simplistic nature of classic arcade games, it is anticipated that the user interface will be clean and simple, displaying only the relevant amount of information, so as not to detract from the game play itself.

Based on Perry & DeMaria (2009), the majority of this game information (Time, No. of Lives, Health etc.) will be visual in nature and displayed at the top of the screen. Other relevant (textual) information will be displayed at the bottom of the screen. Fortunately, the GameMaker software provides a number of built-in functions for the display of this type of information.

Inspired by traditional arcade games, it is anticipated that the game graphics will be colourful and simplistic with simple sound effects. Additionally, there may be some background music during game play. The (generic) overall design for the proposed educational games is shown in Figure 1.

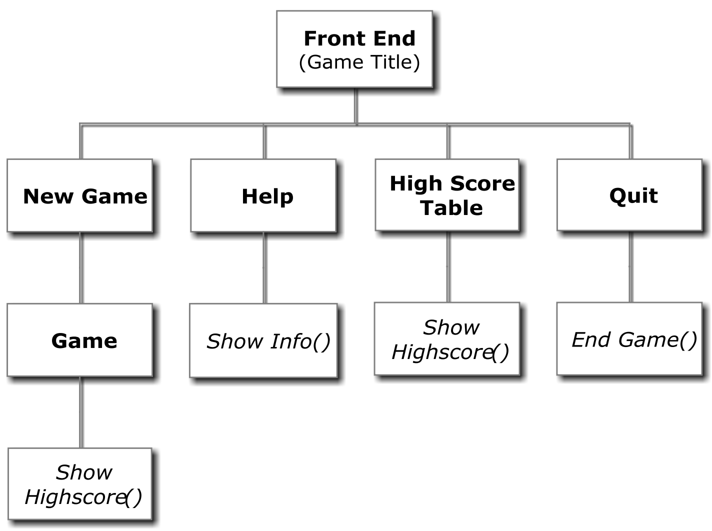


Figure 1: Generic Serious Game Design (GameMaker).

Evaluation Methods / User Feedback

Obtaining user feedback will be performed primarily through three methods

1. Observation of the pupils playing the educational games.
2. Pre and Post diagnostic testing.
3. Questionnaires (on various aspects of the games).

A process of iterative prototyping is envisioned, and it is hoped that this process will provide additional feedback from the pupils, in turn helping to refine the game.

Challenge

It could be argued that challenge is the most difficult aspect of games design, as it is not explicitly implemented, rather it comes about due to the appropriate use of penalties/rewards and various other 'incentives'.

In addition to the aforementioned goals, rewards etc. each game will have a set number of levels (initially 5 to 10), with each level offering an increased level of challenge (including 'harder' math questions).

For simplicity the player will not be offered an explicit option to select the level of difficulty, although the specific times table (used during the game) will be selectable.
There is the possibility of a save option to be incorporated into each game. This may be an option that can be manually selected in game (i.e. press the F12 key) or is automatically performed at certain key points by the game itself (without user intervention).

However, given the limited playtime (2 – 30 minutes) and size of the games (5 – 10 levels), it may not be appropriate to implement a save feature – the development time alone may outweigh the actual use of this feature. Additionally, the school computer network security may prove to be a constraint on whether a save feature would actually work

Design Constraints

In order to keep the development (of the educational games) manageable, a number of practical constraints have been placed on the game implementations.

These constraints include:

- Limitations on the length of game play (i.e. from 2-3 to 30 minutes)
- A limit on the number of game levels (5 to 10 levels, with the option of more if necessary)
- Game simplicity (relative to the target age group, 8 – 9 year olds)
- Limiting the games to a Single Player format

Development

The Development phase, as the name suggests, is concerned with the development of the educational games.

Development will take place using the GameMaker games development package.

It is anticipated that a series of educational games will be created through a rapid prototyping approach, where each prototype generates feedback that will be incorporated into the next (improved) iteration. The ability/frequency of this process will be partially reliant on access to pupils at the selected school.

A possible (future) development on this process will be the use of the next (as yet unreleased) version of GameMaker, which will allow the development of educational games (or ‘Apps’) for both Apple iOS and Google Android systems.

Testing

Testing will take three forms:

1. Local testing by the author during and after the game development.
2. The process of Rapid Prototyping will provide both technical and user test data
3. Group/User testing by the school pupils, in class

Documentation

Documentation will take the form of comments within the coding itself, technical documentation and then some user documentation/guides on the games themselves.
Based on observations during the Design Pilot (*Chapter 6*) textual in-game documentation will be kept to a minimum, but will be provided outside of the actual game play (via an option from the Main Menu).

Implementation

The Implementation (or delivery) phase sees the educational product (in this case, educational computer games) being delivered to the learners, along with appropriate documentation and training. This phase will naturally feed into the final 'Evaluation' stage of the ADDIE methodology.

Due to the use of Rapid Prototyping, this phase may be iterative until the final game(s) are delivered.

Regardless of iteration, authorisation to install the prototype/finished games will need to be obtained from the school before actual installation.

The prototypes/finished games will need to be tested for compatibility with the local school's netbooks and computer network (specifically with the security settings used on the network) and whether additional operating system patches will be needed.

Testing/Observation sessions (within the classrooms) will need to be pre-booked, and there will obviously be (class) time restrictions placed on the sessions themselves.

A CRB (Criminal Records Bureau) Certificate will need to be obtained prior to any access to the school/pupils being granted.

Evaluation

It is anticipated (subject to clearance), that there will be some form of pre and post diagnostic testing in order to establish whether pupils attainment has been influenced through the use of the author's educational games.

Diagnostic testing will take the form of a math quiz before and after the game playing sessions take place. Additionally there will be questionnaires for the pupils to fill in.

In addition to written data, it is hoped that observing the sessions will also yield useful observational data.

Appendix C: Game Specific ADDIE Designs

This Appendix contains the game-specific (ADDIE) *Design* stages for the author's educational games. In order to comply with university regulations on appendix length, only the Design stages for two (of the original four) game designs are included within this Appendix:

- 'Pyramid Panic' (also the basis of 'Space Maze Panic' and 'Block Panic') is a scrolling maze style game. This design originated as a remake of Atari Corporation's arcade game, 'Gauntlet', but due to technical difficulties was later redeveloped as Habgood & Overmars's (2006) 'Pyramid Panic'

- '194X' (also the basis of '294X' and '1982') is a flying plane style game based upon Capcom's arcade game, '1942'

ADDIE Design (194X)

The Analysis, Development, and Information stages of the ADDIE methodology have been generically described in Appendix B. This Appendix covers the (game specific) *Design* stage in more detail.

Design

Background / Game Play

‘194X’ is a proposed amalgamation of a series of games (‘1941’, ‘1942’, ‘1943’, ‘1944’ & ‘19XX’) that were released by the arcade manufacturer Capcom over a period of several years, the last being released in the year 2000 (Campbell 2008).

‘194X’ is an arcade ‘shoot em up’ where you take control of a Second World War bomber plane (Figure 1). The objective of the game is to shoot down waves of enemy aircraft that traverse (vertically and horizontally) across the screen, until you meet the End-Of-Level enemy (also known as the so-called ‘Big Boss’).

Defeating the ‘Big Boss’ leads to the successful completion of the game.

Figure 1: 1942
(From original Capcom arcade game).

Maths Aspect

The educational game implementation of ‘194X’ will remain faithful to the originals that inspired it, but will make the following changes.

As part of the onscreen display (Lives, High Score etc.) a mathematical sum will be displayed

.
In addition to the ‘regular’ enemy planes that the player has to shoot down, there will be a number of ‘Answer Planes’. Each Answer Plane will display a potential answer to the aforementioned sum, but only one will actually be the correct answer. If the player shoots down the ‘correct’ Answer Plane, they will be awarded bonus points. However, if the player shoots down any ‘incorrect’ Answer Planes, they will lose a substantial number of points.

Figure 2 depicts the first rough (hand drawn) design for ‘194X’.

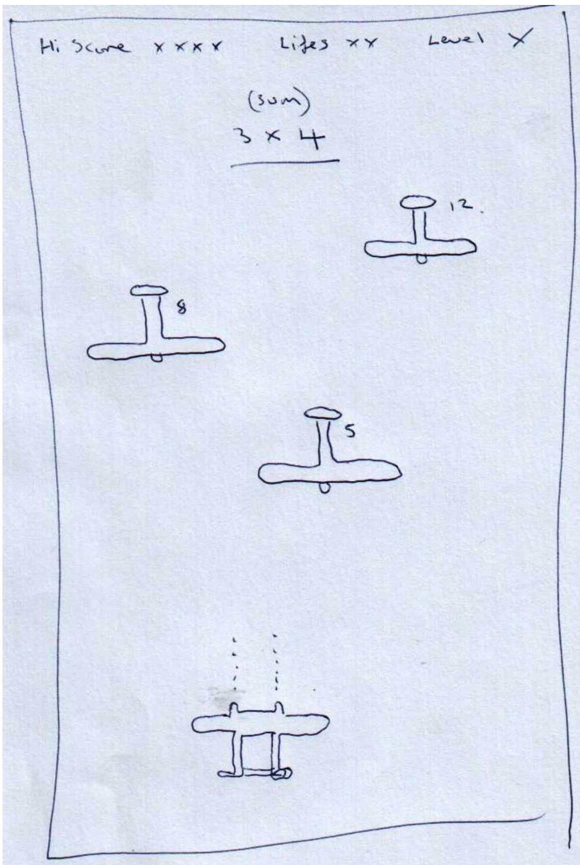


Figure 2: First rough (hand drawn) screen design for 194X.

Characters

Main Player

The player controls a bomber plane (a P-38 Lightning in the Capcom originals, Figure 3) which can be moved in four directions (Up/Down, Left/Right). The Control (Ctrl) Key is used to fire the player's weapon. The player has three lives which can be lost when the player collides with, or is shot by an enemy plane.

Enemies

The enemy consist of 'waves' of small planes that travel vertically and horizontally across the screen (Figure 3).

Player Enemy Planes

Figure 3: Player and Enemy Planes
(From original Capcom arcade game).

Scoring System

Points are allocated in the following way:

Object	Points
Shooting a Standard Plane (No Answer Displayed)	10
Shooting an (Incorrect) Answer Plane	-100
Shooting an (Correct) Answer Plane	50
Shooting End-of-Level 'Boss' Plane	2 Points for every hit (50 hits to destroy) + 400 Point bonus

Table 1: 194X Scoring System.

Level Design

While featuring a 'scrolling' landscape, in reality '194X' is a single screen game (the enemies emerge from either the top or bottom of the screen), and as such there is very little in terms of level design (apart from the number and type of planes featured). Hence additional levels will be a repeat of the initial level, but with potentially different numbers/waves of enemy planes.

In-game Information will be displayed at the top of the game play area and will consist of:

- The current level.
- The player's current score.
- The player's current number of lives.
- A Mathematical Sum (for which the player must shoot the correct Answer Plane)

User Interface Design

The educational game implementation of '194X' will feature a limited front-end menu system. The intention is to allow quick access to the game itself, but provide additional features (such as a High Score Table, or external Game Help/Information) as menu options for those who may wish to access them. The overall game design for '194X' will be based on the generic design, as depicted in Figure 4.

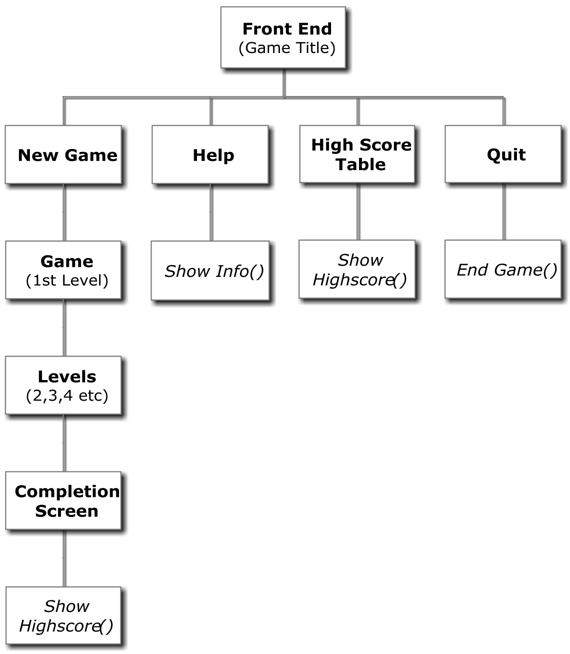


Figure 4: GameMaker '194X' Design.

ADDIE Design (Pyramid Panic / Gauntlet)

The Analysis, Development, and Information stages of the ADDIE methodology have been generically described in Appendix B. This Appendix covers the (game specific) *Design* stage in more detail.

Design

Foreword

Originally, it had been the author's intention to produce an educational game version of the well-known arcade game 'Gauntlet' (Figure 1).

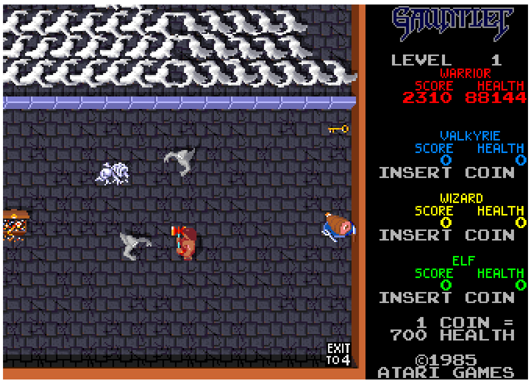


Figure 1: Gauntlet
(From original Atari arcade game).

Figure 2: Early Prototype of Serious Game Gauntlet.

'Gauntlet' was originally released by Atari Games in 1985, and was a multi-player maze game. Although the game was essentially two dimensional in graphical terms, the use of shadows and two-tone colours gave the game graphics, a pseudo 3D effect.

Unfortunately, attempting to reproduce this style of graphics (and associated game logic) proved to be problematic. This was due more to the author's limited experience with the GameMaker product, rather than any technical limitations of the product itself.

Additionally, with the benefit of hindsight, the design for the educational game version of 'Gauntlet' was far too ambitious. As a consequence, a decision was made to abandon the educational game remake (Figure 2), and adopt a simpler (both graphically and technically) maze game format instead.

Using Habgood & Overmars (2006) GameMaker example, 'Pyramid Panic' as a starting point, an educational version (sharing the same name) was produced. The following design documentation has therefore been updated to reflect the mixture of Habgood & Overmars's original 'Pyramid Panic' specifications/graphics, the original 'Gauntlet' design work and the author's (retro fitted) mathematical content.

Background / Game Play

The original 'Pyramid Panic' sees the player travelling around a Pyramid (maze), collecting various treasures. Enemies have elaborate patterns of movement, and can be defeated by collecting *scarabs* that are scattered around the maze. Additionally, various potions can be collected for additional points. For the educational version, the format of the game has been simplified:

- The player must travel around the maze, collecting treasures (diamonds) while avoiding (or shooting) various enemies. Once the player has collected all the diamonds, an Exit/Doorway is unblocked and the player can exit the level.

Maths Aspect

Scattered around the maze are sums and a configuration of (4) blocks, each block displaying a potentially correct/incorrect answer to the given sum (Figure 3). The player could, in theory, avoid these sums and just collect the diamonds. However, by colliding with the block that displays the correct answer (to the sum), the player will gain greater points.

The game can therefore be played for fun (for a set amount of points) or mathematically (for greater levels of points).

Figure 3: Maths question, with four potential answers.
(From the finished 'Pyramid Panic' game).

Characters

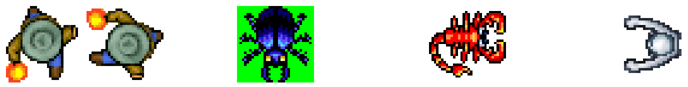
Main Player

The player controls an explorer (viewed from the top down, Figure 4) which can be moved in four directions (Up/Down, Left/Right). The Space Key is used to fire the player's gun. The player has three lives, which can be lost when the player collides with any of the enemies.

Enemies

There are three enemies that patrol the maze, differing only in movement (Figure 4).

- The **Beatle** moves Up/Down
- The **Scorpion** moves Left/Right
- The **Mummy** randomly moves in four directions



Player Beatle Scorpion Mummy

Figure 4: Player and Enemies (Habgood & Overmars 2006).

Scoring System

Points are allocated in the following way:

Object	Points
Collecting a Diamond	5
Shooting (with Spud Gun) an Enemy	50
Colliding with Answer Block (Incorrect)	-10
Colliding with Answer Block (Correct)	20

Table 1: Pyramid Panic Scoring System.

Level Design

In order to create an element of challenge, twelve different maze layouts will be produced. These layouts are taken from a home computer conversion of the ‘Gauntlet’ arcade game (due to being more practical to source, than the original arcade game layouts) (Figure 5).

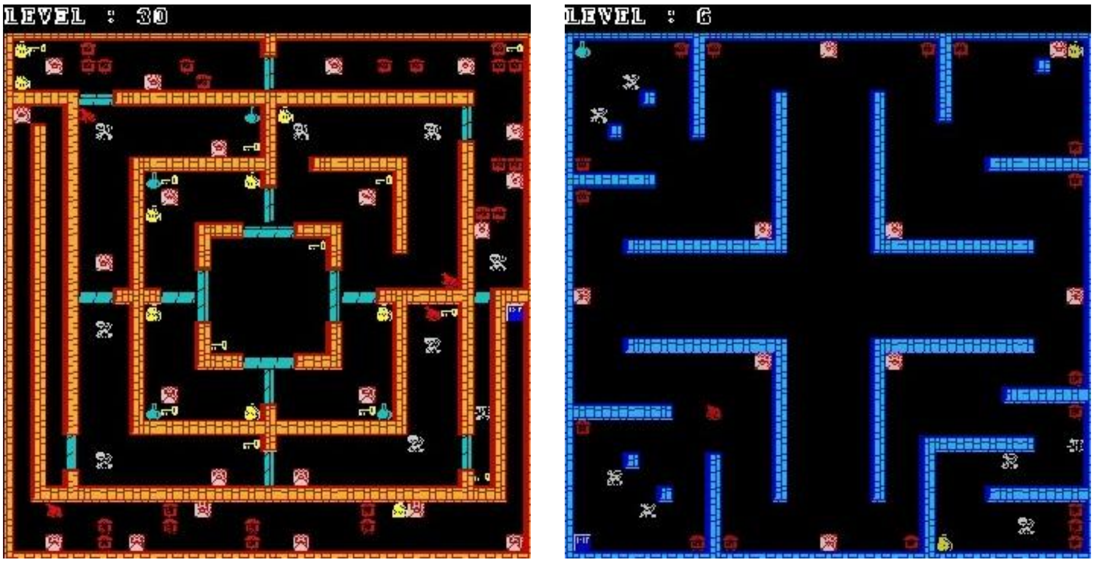


Figure 5: Gauntlet mazes (Pavero Software Ltd. 2009).

Unlike ‘Gauntlet’, the educational version of ‘Pyramid Panic’ will essentially be a single level game. The intention is to randomly alternate the (twelve) maze layouts, so that the player is presented with a different maze upon starting play. It is hoped that this ‘randomness’ will reduce the player’s opportunity to learn the maze layout, and hopefully increase the challenge and fun of exploring the (unknown) maze.

In-game Information will be displayed at the top of the game play area and will consist of the Player’s current score and their remaining number of lives.

User Interface Design

The educational game implementation of ‘Pyramid Panic’ will feature a limited front-end menu system. The intention is to allow quick access to the game itself, but provide additional features (such as a High Score Table, or external Game Help/Information) as menu options for those who may wish to access them.

The overall game design for the education version of ‘Pyramid Panic’ will be based on the generic design, as depicted in Figure 6.

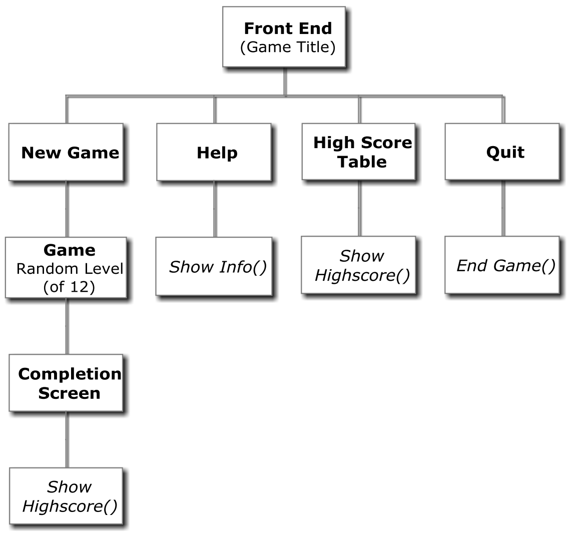


Figure 6: Games Maker ‘Pyramid Panic’ Design.

Appendix D: Prototyping Pilot / Main Study - Game User Guides

As part of the Prototyping Pilot and subsequent Main Study, user guides were produced for each of the pilot/study games.

In order to comply with university regulations on appendix length, only the guides for the author developed games, ‘194X’ and ‘Pyramid Panic’, have been included within this Appendix. Additionally, these guides have been reformatted in order to accommodate the thesis custom margin settings.

194X

Introduction

Britain is under attack!

Captain, it is your job to fend off the attackers!

As you fly across the sea, you see 12 waves of enemy planes coming towards you!

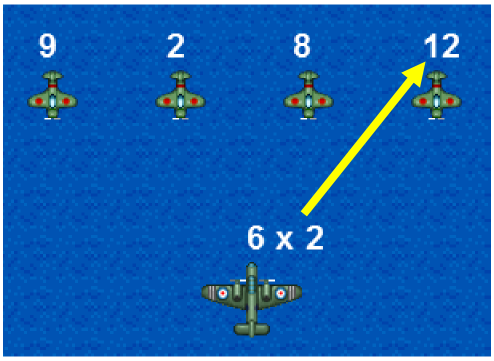
- Your plane displays a **sum**.
- Each wave of enemies, display **answers** to the sum.

You must shoot the enemy plane that displays the correct answer to your sum!

Shoot the 'correct' enemy and you will be awarded **50** points!

Shoot the wrong enemy and you lose (minus) **100** points…

Example:



The current sum (displayed above your plane), is **6 x 2**

So to score maximum points, you would shoot the enemy plane displaying the correct answer of **12** (6 x 2 = 12).

If you make it past the 12th wave of enemy planes, you will have to battle the enemy 'Big Boss' plane!!!

Good Luck Captain, I hope that your mathematical skills are as good as your flying ones!

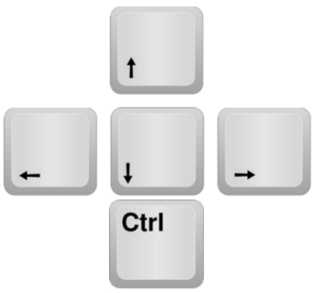
How to Play the Game

When you start 194X, you will see a menu screen with the following options:

	**Play** – This option starts the game! Fly your plane (using the keys listed below) and try to shoot down the enemy plane displaying the correct answer to the current sum! (displayed above your plane) Before you play the game, click on the Times Table button (see below), so that you can select a Times Table – otherwise a times table will be randomly selected for you!
	**Times Tables** – Use this option to select a times table (1x to 12x). During the game all of the sums/answers that are displayed will be taken from your selected table.
	**Score** – Want to know who has the highest game score? Select this option to find out!
	**Help** – Information about this game!
	**Quit** – Allows you to quit/exit the game.

Controls

To control your plane, use the following keys on your computer keyboard.



Arrow (or Cursor) Keys These keys control the your plane's movement (**Up**, **Down**, **Left** & **Right**)
CTRL (Control) Key – use this key to **fire** at the enemy planes

Pyramid Panic

Introduction

While exploring an ancient pyramid, you suddenly find yourself trapped within its maze!

Your job, Doctor, is to escape!

As you walk around the maze, you will discover a total of 10 math sums, each sum with four possible answers…

You must select the correct answer for each sum, in order to escape the pyramid!

To select the correct answer (for the given sum), just walk into the answer and it will disappear.

- Select the 'correct' answer and you will be awarded **20** points!
- Shoot the wrong answer and you lose **(minus) 10** points…

Example:

One of (the 10) sums is **10 x 2**

So to score maximum points, you would walk into the correct answer of **20** (10 x 2 = 20).

Placed around the maze are some **diamonds**, which you can collect for extra points!

Unfortunately, you are not alone… Walking around the maze is a number of ancient Mummies, Beatles and Scorpions. If you come into contact with any of these occupants, you will lose one of your **three** lives!

If you lose all three lives – you will never escape the pyramid!

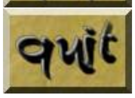
Luckily, you have your old trusty Spud Gun with you, which you can use to defend yourself against the pyramid's occupants.

Can you answer the 10 sums within the pyramid, in order to escape?

Good Luck! Hopefully your mathematical skills are as good as your exploring ones!

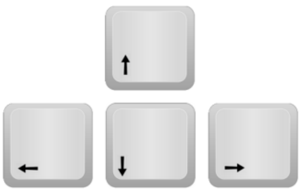
How to Play the Game

When you start Pyramid Panic, you will see a menu screen with the following options.

	**Play** – This option starts the game! Walk around the maze and try to collect as many correct answers (to each of the 10 questions) as you can! Before you play the game, click on the Times Table button (see below), so that you can select a Times Table – otherwise a times table will be randomly selected for you!
	**Times Tables** – Use this option to select a times table (1x to 12x). During the game all of the sums/answers that are displayed will be taken from your selected table.
	**Score** – Want to know who has the highest game score? Select this option to find out!
	**Help** – Information about this game!
	**Quit** – Allows you to quit/exit the game

Controls

To travel around the maze, use the following keys on your computer keyboard

	**Arrow** (or Cursor) Keys These keys control your movement (**Up**, **Down**, **Left** & **Right**) To 'collect' the answer to each sum, just walk into it.
	**Space Bar** (If pressed at the same time as an Arrow Key) – will fire your Spud Gun in the direction that you are moving.

Appendix E: Prototyping Pilot / Main Study - Questionnaires

As part of the Prototyping Pilot and Main Study, the author produced two questionnaires designed to elicit feedback from the sample group, in relation to the pilot/study games.

This Appendix includes two completed (anonymised) copies of each questionnaire:

- Game Format Grading Sheet
- Game Graphics Grading Sheet

Game Format Grading Sheet (1) – Page 1

Game Format Grading Sheet

How would you grade the following games? (on a scale of 1 to 5)

1 = Very Good, **2** = Good, **3** = Don't Know, **4** = Bad, **5** = Very Bad

Name	*Grade (1 to 5)*	*What do you think about the game?*
Moon Maths	1	It's good if you want to learn your times tables.
194x	2	It quite a good game we enjoyed it.
Math Balls	1	It will be good maths game.
Pyramid Panic	2	this is another one that's good for times tables.
Maths Magic	5	we didn't even know how to play it.

Which format of game do you prefer?

1 = Very Good, **2** = Good, **3** = Don't Know, **4** = Bad, **5** = Very Bad

Game Style	*Grade (1 to 5)*	*Comments...*
Point and Click (like Moon Maths/ Math Balls)	1	I like these games.
Flying Games (Like 194x)	1	I like this game.
Maze Game (Pyramid Panic/Maths Magic)	4	I liked Pyramid though.

Game Format Grading Sheet (1) – Page 2

How did you find the math questions in the games?

1 = The Math was Good!, **2** = It was OK, **3** = Don't Know, **4** = I Disliked the Math!, **5** = Would Prefer No Math!

Name	***Grade (1 to 5)***	***Comments...***
Moon Maths	2	It is good and the maths is very good as well
194x	3	it is a very good game and it helps me with my ~~Grandfcrasher~~ Guardanshen
Math Balls	4	I like it is really good I think it is the best game
Pyramid Panic	1	It is very good and helped me with my times tables
Maths Magic	5	It is very bad I dont like it at ~~tll~~ all

If you could, how would you improve the following games?

Name	***I would...***
Moon Maths	I would like to ~~do it~~ improve it by more maths.
194x	put more times tables in it
Math Balls	I would enjoy it with more mathes and more fun I only won to 2 games I think it can do better
Pyramid Panic	with out the zombes
Maths Magic	with more times tables

Game Format Grading Sheet (2) – Page 1

Game Format Grading Sheet

How would you grade the following games? (on a scale of 1 to 5)

1 = Very Good, **2** = Good, **3** = Don't Know, **4** = Bad, **5** = Very Bad

Name	*Grade (1 to 5)*	*What do you think about the game?*
Moon Maths	2	I think it nyds to be a bit harder
194x	3	I think is a little bit hard and a little bit good.
Math Balls	5	I think is a bit hard
Pyramid Panic	1	I think it is exelant
Maths Magic	4	I think it nyds to be a bit eysey

Which format of game do you prefer?

1 = Very Good, **2** = Good, **3** = Don't Know, **4** = Bad, **5** = Very Bad

Game Style	*Grade (1 to 5)*	*Comments...*
Point and Click (like Moon Maths/ Math Balls)	2	I Fiyel good about it
Flying Games (Like 194x)	3	I Fyle lilly good
Maze Game (Pyramid Panic/Maths Magic)	1	I Fiyel Filly lilly good

Game Format Grading Sheet (2) – Page 2

How did you find the math questions in the games?

1 = The Math was Good!, **2** = It was OK, **3** = Don't Know, **4** = I Disliked the Math!, **5** = Would Prefer No Math!

Name	***Grade (1 to 5)***	***Comments...***
Moon Maths	1	I think it needs more maths
194x	4	I think it needs less maths
Math Balls	5	I think it needs no maths
Pyramid Panic	2	I think more maths
Maths Magic	3	I think no more maths

If you could, how would you improve the following games?

Name	***I would...***
Moon Maths	Add more maths
194x	A bit easier
Math Balls	no maths
Pyramid Panic	Add more maths
Maths Magic	A bit less maths

Game Graphics Grading Sheet (1) – Page 1

Game Graphics Grading Sheet

How would you grade the computer graphics for the following games? (on a scale of 1 to 5)

1 = Very Good, **2** = Good, **3** = Don't Know, **4** = Bad, **5** = Very Bad

Name	***Grade (1 to 5)***	***Comments***
194x	2	quit good.
294x	2	beter than the user.
1982	1	It is the Best ~~gam~~ game in the wolld.
Pyramid Panic	1	Best game ever.
Space Maze Panic	3	I carplotly donot no ~~wate~~ whatat to do.
Block Panic	1	very, very, very good.

Game Graphics Grading Sheet (1) – Page 2

How much fun were the following games to play? (on a scale of 1 to 5)

1 = Great Fun, **2** = Fun, **3** = Don't Know, **4** = A little Fun, **5** = Not Fun

Please circle **one** of the numbers for each game

194x	1	2	3	4	5
294x	1	2	3	4	5
1982	1	2	3	4	5

Pyramid Panic	1	2	3	4	5
Space Maze Panic	1	2	3	4	5
Block Panic	1	2	3	4	5

If you could, how would you improve the following games?

Name	*I would...*
194x	nothing
294x	nothing
1982	noting
Pyramid Panic	make it not as confusing
Space Maze Panic	Make their be an Exit
Block Panic	notin g

Game Graphics Grading Sheet (2) – Page 1

Game Graphics Grading Sheet

How would you grade the computer graphics for the following games? (on a scale of 1 to 5)

1 = Very Good, **2** = Good, **3** = Don't Know, **4** = Bad, **5** = Very Bad

Name	*Grade (1 to 5)*	*Comments*
194x	2	Really good and easy and I really enjoyed the 8 times Tables
294x	3	very tricky but I really enjoyed it
1982	5	Not bad but I think There could be more better
Pyramid Panic	1	very Good I love it
Space Maze Panic	4	We enjoyed it.
Block Panic	1	very brilent you can make it harder

Game Graphics Grading Sheet (2) – Page 2

How much fun were the following games to play? (on a scale of 1 to 5)

1 = Great Fun, **2** = Fun, **3** = Don't Know, **4** = A little Fun, **5** = Not Fun

Please circle **one** of the numbers for each game

194x	1	2	3	4	5
294x	1	2	3	4	5
1982	1	2	3	4	5

Pyramid Panic	1	2	3	4	5
Space Maze Panic	1	2	3	4	5
Block Panic	1	2	3	4	5

If you could, how would you improve the following games?

Name	***I would...***
194x	
294x	
1982	
Pyramid Panic	
Space Maze Panic	
Block Panic	you can try and make it harder.

Appendix F: Main Study - Field Notes

This final Appendix includes samples of the field notes, written by the author, during the Prototyping Pilot and the Main Study.

Included within this Appendix:

1. Two samples of field notes taken during the pilot/study
2. An impromptu pupil created questionnaire, referenced in the last paragraph of the second sample of field notes (‘*Field Notes (2)*’)

Field Notes (1)

8th March 2013 - Friday

~~15~~ 10 x msi wind Netbooks (wireless G) } 2 Pupils per comp
5 x Samsung Netbooks (wireless N)

Wireless Access Points in every room

Slow Login to comp + network (games had to been started before hand)

Pupils did diagnostic test (27 Pupils - Mixture of Y3 + Y4)

Pupils then played Math Balls

1. Pupils Jumped Into Playing games
2. Initially struggled with menu of game (due to imprecise buttons / positioning)
3. Pupils Alternated between 'Easy' and 'Hard' settings
4. Some Pupils (Perhaps Y4) found 'Easy' To Easy ~~and~~ and 'Hard' too hard! (This may be due to games not being targeted specifically at KS2 Pupils)
5. Some Pupils Jumped onto MathMagic (which they found difficult)
6. Pupils found menu System less than intuitive (so did author!)
7. Sluggish-ness of Netbook, meant that there was a delay in running games / on restarting them when Pupil ran into Problems
8. Desktop needed to be refreshed to re-reveal desktop icons
9. Games ran across network (Slow delay)
10. how would these ~~desktop~~ netbooks Cope with Proper Comp Sci Curriculum in 2014?
11. mixture of reactions - Some Pupil Like, Some Pupils got bored Quick

Field Notes (2)

22nd March 2013 (Fri - Funky Friday)

Wireless Lan connections improved, making the process of logging in and running games easier

class seemed genuinely more enthusiastic

1944x appeared to be more enthusiastically played - due to being slower (i.e. easier)

Pupils were seen playing 1944x from math point of view (i.e. shooting plane with 'correct' answer)

Space Maze Panic - seen as 'new' game due to having different graphics,

Black Panic was surprising quite popular - in part due to being made easier (i.e. no zombies)

(All games slowed down, zombies removed from Block Panic in response to Pilot 1 Feedback)

Black Panic Like Silly Man

Both Black Panic + 1982 seemed quite ~~to~~ popular - not only did the 'retro' graphics of Block Panic ~~not~~ put pupils off, but in one/two cases pupils liked the simple graphics of 1982 ('Ace', better! best)

A number of pupils managed to ~~complete~~ complete a level of a couple of the games (mainly Black Panic) - due to no zombie zombies

Seem more motivated to fill out questionaires - one pupil produced his own questionaire / ~~comments~~ comments on whole paper

Impromptu Pupil Created Questionnaire

On 1982 each time you hit an enemy I want to grow.

On 294X it gos up to 100 times tables I want it to.

~~#~~ I like Block Ponic

194X	
1982	
Pyramid Ponic 2	