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A Digital Game Maturity Model

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Abstract

Game development is an interdisciplinary concept that embraces artistic, software engineering, management, and business disciplines. The growth of the digital game industry is enormous and gaining importance day by day. This growth imposes severe pressure and a number of issues and challenges on the game development community. In addition to functional and technological requirements, game development includes other factors that are equally important to the success of any game project. Game development is considered as one of the most complex tasks in software engineering. Hence, for successful development of good-quality games, the game developers must consider and explore all related dimensions as well as discussing them with the stakeholders involved.

This research facilitates a better understanding of important dimensions of digital game development methodology. The increased popularity of digital games, the challenges faced by game development organizations in developing quality games, and severe competition in the digital game industry demand a game development process maturity assessment. Consequently, this study presents a Digital Game Maturity Model to evaluate the current development methodology in an organization. The objective is first to identify key factors in the game development process, then to classify these factors into target groups, and eventually to use this grouping as a theoretical basis for proposing a maturity model for digital game development. In doing so, the research focuses on three major stakeholders in game development: developers, consumers, and business management.

The framework of the proposed model consists of assessment questionnaires made up of key identified factors from three empirical studies, a performance scale, and a rating method. The main goal of the questionnaires is to collect information about current processes and practices. This research contributes towards formulating a comprehensive and unified strategy for game development process maturity assessment. The proposed model was evaluated with two case studies from the digital game industry.

Keywords

Digital game, game business performance, game development process, developers, consumers, game players, maturity model, empirical analysis, process assessment, game development methodology.

Dedicated to My Family

I dedicate this thesis to my loving husband for supporting me with his love and affections, and for his dedicated partnership for success in my life.

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List of Abbreviations and Symbols

ACM	Association for Computing Machinery
AI	Artificial Intelligence
AM	Asset Management
AOSE	Agent Oriented Software Engineering
API	Application Programming Interface
CIBM	Customer-Integrated Business Model
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
CRM	Customer Relation Management
DGI	Digital Game Industry
DGMM	Digital Game Maturity Model
DML	Development Maturity Level
DPA	Development Process Activity
DPR	Development Performance Rating
ESI	European Software Institute
EU	Ease of Use
FFA	Fun Factor Analysis
GED	Game Engine and Development
GDD	Game Design Document

GDLC	Game Development Life Cycle
GQM	Goal Question Metrics
GP	Game Prototyping
GN	Game development activity Number
GDPAs	Game Development Process Activities
GML	Game Maturity Level
H	Hypothesis
HCI	Human Computer Interaction
I	Innovation
IEEE	Institute of Electrical and Electronics Engineers
ISO/IEC	International Organization for Standardization/ International Electro-technical Commission
JME	Java Micro Edition
J2ME	Java 2 Micro Edition
KPAs	Key Process Areas
MO	Market Orientation
MDP	Message Driven Pojo
M3G	Mobile 3D Graphics
MIT	Massachusetts Institute of Technology
ML	Maturity Level
MMOG	Massive Multi-Player Online Games

MMORPG	Massive Multiplayer Online Role Playing Game
MS^1	Maintenance Support
MS^2	Monetization Strategy
MVC	Model View Controller
NA	Number of Applicable Statement
NES	Nintendo Entertainment Systems
OGRE	Object-Oriented Graphic Rendering Engine
PC	Personal Computer
PCA	Principal Component Analysis
PLS	Partial Least Square
P2P	Peer-2-Peer
PHEG	Playability Heuristic for Educational Games
PAEG	Playability Assessment of Educational Games
PT	Passing Threshold
QA	Quality Architecture
QEF	Quantitative Evaluation Framework
ROCA	Resource Oriented Client Architecture
RPG	Role Playing Game
RQs	Research Questions
RM^1	Risk Management

RM^2	Relationship Management
RMM	Requirement Management Modelling
RUP	Rational Unified Process
S	Statement
SN	Statement Number
SC	Stakeholder Collaboration
SE	Software Engineering
SEI	Software Engineering Institute
SLR	Systematic Literature Review
SPICE	Software Process Improvement and Capability dEtermination
TCM	Team Configuration Management
TM^1	Test Management
TM^2	Time to Market
UAT	User Acceptance Testing
UML	Unified Modelling Language
WWW	World Wide Web
XP	eXtreme Programming
2D	2 Dimensional
3D	3 Dimensional

Chapter 1

1 Introduction

With the rapid advancement of computer technology, the significance of software engineering is increasing in our daily lives. It affects every aspect of our lives today, including working, living, learning, and education. Digital games are a popular mode of entertainment and an important technology application which have become increasingly accepted by people of all ages. The tremendous growth rate of the digital game market makes it obvious that game technology is easily accessible and has become more convenient (SUPERDATA, 2015; Newzoo, 2015). As a result, more and more people like to play games and have become motivated to design their own games. Furthermore, the game industry is so innovative that any technological advances either in hardware or software are applied to games before being adopted by other scientific fields (McShaffry, 2003; Rhyne *et al*., 2000). This remarkable growth of the digital game industry is capturing everyone's attention and also contributing to economic growth on a national level.

Digital games are software applications that are installed on hardware devices such as video game consoles, computers, and handheld devices. Digital game development involves multidisciplinary activities, which makes it a complex process that is different from traditional software development. The multidisciplinary nature of the processes involved, which combine sound, art, control systems, artificial intelligence, and human factors, distinguish game development from other types of software development. A good quality game is intended to ensure that a developed game adheres to a defined set of quality criteria from developer's perspective or meets the requirements of the players in terms of it playability and usability factors and able to capture the business in *digital game industry* (DGI) market. It has become critically important to improve the game development process to address the issues faced by game development organizations in developing high-quality games to remain competitive and meet their financial objectives.

Digital game development is a complex task that requires real-time and high-quality performance. A number of game development tasks like real-time audio playback, high display frame rate, and fast processor response have an impact on game performance. Game programming is another difficult task that requires expert programmers dealing with thousands of lines of code. The variety of multi-disciplinary tasks, the low level of programming, and the large size of programs demand straightforward documentation, flexible design, and sustainable implementation. These will also help to ensure effective collaboration among the various development groups and to expedite future developments. Consequently, game developers need best practices guidelines and an assessment model to deal with the challenges they face in carrying out current processes. Ultimately, this will help them to improve current practices and will enable them to achieve high quality levels.

No study to date has directly addressed the assessment and improvement of the digital game development process to produce high-quality games, which would be ultimately beneficial for any country's economy. Process maturity models such as CMM (Paulka *et al.*, 1993) and CCMI (Lisandra & Roberto, 2003) proposed by researchers in the past can be used to assess maturity level of software development processes, but they provide guidelines only from a general perspective. However, game development is different from traditional software development and faces many specific challenges, discussed in detail in Chapter 2. Researchers so far have focused mostly on the technical aspects of game development, without considering improvements to the game development process. Other important perspectives on digital games also need to be captured, such as those of business, developers, and consumers. This effort will ultimately help to assess the maturity level of game development processes in an organization and provide guidelines to improve them. It would ultimately be beneficial to digital game performance in the market.

1.1 Game Development Process

The digital game domain covers a great variety of player modes and genres (Gredler, 1995; 2004). The complexity of digital games has posed many challenges and issues in software development because it involves diverse activities in creative arts disciplines

(storyboarding, design, refinement of animations, artificial intelligence, video production, scenarios, sound effects, marketing, and finally sales) besides technological and functional requirements (Keith, 2010). This inherent diversity leads to a greatly fragmented domain from the perspectives of both underlying theory and design methodology. The digital game literature published in recent years has focused mainly on technical issues. Issues of game production, development, and testing reflect only the general state of the art in software engineering. Pressman (2001) stated that a game is a kind of software that entertains its users, but game development faces many challenges and issues if only a traditional software development process is followed (Kanode & Haddad, 2009; Petrillo *et al*., 2009).

Figure 1.1 shows the general phases of the game development process and a related list of key process activities.

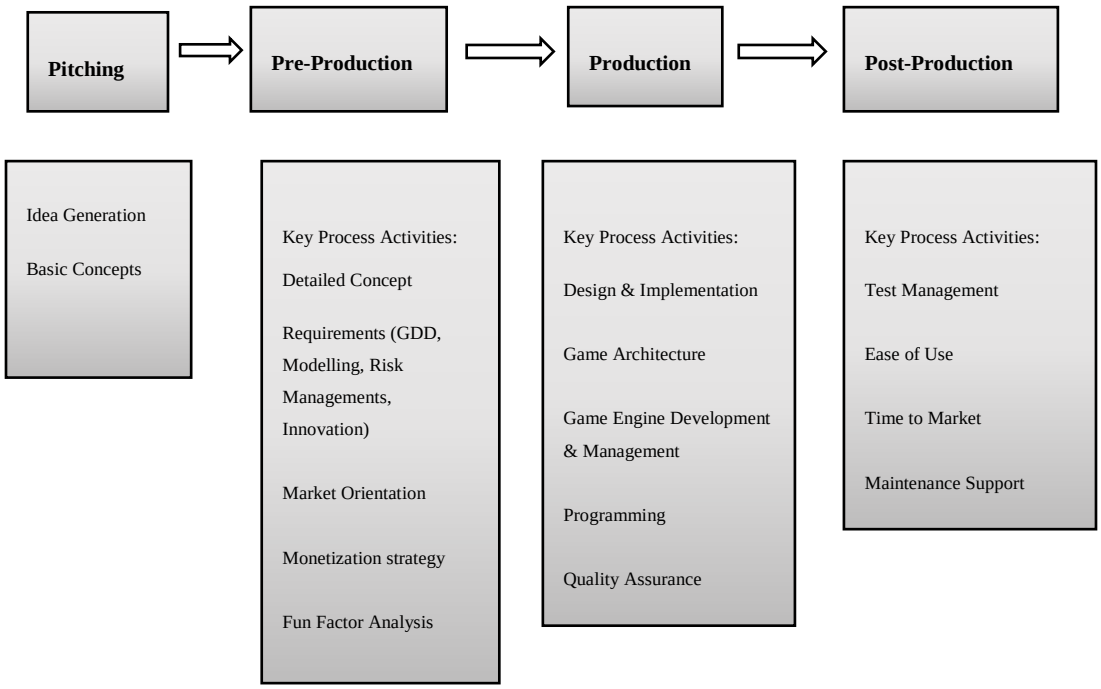

Figure 1.1 Game Development Process

In traditional software engineering, the development phase usually involves activities like application design and implementation, and the production phase is when the software

actually runs and is ready for use. However, in the *Game Development Life Cycle* (GDLC), the production phase includes the development process, which is the pre-production phase of the software engineering process, and the production phase of software engineering is actually the post-production phase of the GDLC (Bethke, 2003). Therefore, the GDLC is different from the traditional software engineering process, and many researchers (Kanode & Haddad, 2009) have studied the challenges faced by this domain. The most prominent observation made in these studies is that to address the challenges faced by the GDLC, more rigorous software engineering strategies must be used. However, the proposed GDLCs by many researchers (Ramadan & Wadyani, 2013; Hendrick, 2009; McGrath, 2011; Bethke, 2003) do not ensure the quality of the development process. Hagan *et al.* (2014) published a systematic literature review of software process models used for game development. They concluded that agile and hybrid approaches are used for game development by most organizations. They also reported that Scrum (Kanode & Haddad, 2009), Kanban (Polk, 2011), Rapid Development Application (RAD) (Birchall & Gatzidis, 2013), XP (Musil *et al*., 2010), and incremental (Kanode & Haddad, 2009) methodologies are used by game development organizations but no proper software process improvement initiatives were adopted. Managing game development has become a much harder process that anyone could have initially imagined, and because of the fragmented nature of the domain, no clear picture of its advancement can be found in the literature.

1.2 Research Objective

The main objective of this research is to investigate digital game process maturity from different stakeholders' perspectives. The study focused on the following points:

1. Identification of factors that may contribute to digital game maturity assessment.
2. For purpose of digital game process assessment, a *Digital Game Maturity Model (DGMM)* is presented by using key factors as a measuring instrument.
3. The maturity and performance of the current game development process is assessed using the digital game maturity model.

Empirical investigation helped to identify key factors that have a positive influence or impact on game business performance and the development process. After key factors had been identified from different stakeholders' perspectives, a research model is developed to establish the relationship between these identified factors and improvements in game performance and the development process. To provide a digital game development assessment methodology, the identified key factors from the empirical investigation are used as a measuring instrument to develop a *Digital Game Maturity Model*. The structure of a *Digital Game Maturity Model* is composed of assessment frameworks based on identified stakeholder's perspectives such as business, developers, and consumers. The developed model is then used to assess the current status or maturity of digital game development process by describing the assessment approach and conducting case studies. The methodology for assessing the game development maturity profile, once the individual perspective assessment results had been obtained, became an integral feature of a *Digital Game Maturity Model*. The proposed model will help management and development team such as developers, designers, artists, and project managers to carry out assessments of their development practices and find ways to improve them.

1.3 Research Motivation

SECOR (2012) reported that the digital game industry, especially video games, will generate world-wide revenues of up to US $86.8 billion by 2016. It is clearly recommended in their report that Ontario game developers must demonstrate business acumen and management practices in their development processes. The main challenge for developers is to achieve a balance between developing high-quality games and remaining within fixed budgets and deadlines. In the global digital game industry, Canada is a major player, both in terms of size and of quality of talent and resources. For these reasons, Canada has already replaced the United Kingdom in the third rank of computer game producers around the world (Software Association of Canada, 2013). To establish a leading DGI in Canada and attract foreign investment as proposed by the Ontario 2012 report (SECOR, 2012), all stakeholders must strive to follow a process model to engineer games of the highest quality.

Lack of research in this area has also provided a motivation to select this domain. Hagan *et al.* (2014) performed a systematic literature review of game development processes. They addressed three research questions:

- "What are the software process models in game development?"
- "What are the *software process improvement* (SPI) initiatives used in game development?"
- "What factors influence the adoption of software process models and SPI in game development?"

A systematic literature review demonstrated that most development companies used mixed, agile, or *ad-hoc* approaches and that no proper SPI initiatives were adopted. They also highlighted the importance of developing best-practice models for game development. Actually, most of the literature related to game development is found in the grey literature such as magazines, developer blogs, game development groups, and web sites of game companies. This observation lends added importance to investigating what is actually happening in game development. Vargas *et al*. (2014) performed a systematic mapping study on the quality of serious games. They investigated the particular quality characteristics of serious games and the methods used to investigate quality. The quality characteristics extracted from their research were effectiveness, efficiency, satisfaction, freedom from risk, and context coverage. They also identified product quality characteristics and revealed that no studies were found for compatibility, resource utilization, maintainability, and maturity assessment of games. They also suggested the urgent need for a quality assurance method that can evaluate game quality from the early stages of development and can be applied to any game.

The proposed digital game maturity model would capture various stakeholders' perspectives and would help game development organizations to improve the quality of their final product, i.e., the digital game. The contribution of this research is the first digital game maturity model that can accelerate the creation of digital games, achieving shorter time to market, lower cost, and high quality, and can also help stakeholders to

make correct decisions. This research is exceedingly beneficial to the digital game industry and also fills the research gap of concise game development process improvement guidelines and process assessment tools.

1.4 Problem Statement

The DGI has shown economic potential in both the entertainment and software industries (PWC Global Media, 2011). Organizations involved in the game development business are facing strong competition and high consumer expectations because more development companies are entering the digital game industry every day. Rapid and continual changes in technology and intense competition not only affect the business, but also have a great impact on development activities. Because the industry has high economic potential and generates million-dollar projects, it sets high standards for game performance and exerts strong pressure on organizations. To deal with this strong competition and high pressure, game development organizations must continuously assess their activities and adopt a proper evaluation methodology. Use of a proper assessment methodology will help the organization identify its strengths and weaknesses and provide guidance for improvement. However, the fragmented nature of the game development process requires a comprehensive evaluation strategy which has not yet been entirely explored.

An assessment framework is therefore proposed here to develop a comprehensive strategy for game development and a performance maturity model. The maturity scales are identified by initial frameworks for each perspective: business, developers, and consumers. The important steps in the digital game performance assessment framework can be described as follows.

***Research problem - I*:** Identification of factors that make a direct or indirect contribution to maturity assessment of digital games.

- *Research problem (i):* Framework to evaluate the developer's perspective factors in digital game development and performance.

- *Research problem (ii):* Framework to evaluate the business perspective factors in digital game development and performance.

- *Research problem (iii):* Framework to evaluate the consumer perspective factors in digital game development and performance.

***Research problem - II*:** Development of a *Digital Game Maturity Model* for the game development process and its performance in an organization.

- *Research problem (i):* Maturity scales for digital game performance.
- *Research problem (ii):* Assessment questionnaire for digital game performance.
- *Research problem (iii):* Rating methodology for digital game performance.

Research problem - III: Application of a *Digital Game Maturity Model* to assess the current state of game development organizations.

- *Research problem (i):* Definition of assessment methodology.
- *Research problem (ii):* Conducting case studies.
- *Research problem (iii):* Results interpretation based on assessment data.

1.5 Research Paradigm and Method

The main objective of this research is to develop a maturity model for digital game performance assessment that could assess the current state of an organization. The three identified research problems were categorized into three research phases based on their dependencies. Table 1.1 depicts the research methodology for all three phases of this research. Figures 1.2, 1.3, and 1.4 further illustrate all the steps under each research phase and the research plan used to develop a digital game maturity model for the game development process and its performance. The main research goals and milestones are defined in the form of stages in each research phase, as shown in Table 1.1.

Table 1.1 Research Methodology

A Digital Game Maturity Model (DGMM)			
	Research phase 1	**Research phase II**	**Research phase III**
Goal	Identification of factors that make a direct or indirect contribution to maturity assessment of digital game performance in an organization	Development of Digital Game Maturity Model	Application of the digital game maturity assessment model to assess the current maturity of game development organizations
Results	Key factors for maturity assessment	Maturity scale, guidelines, and rating methodology	Assessment of maturity level of digital game development organizations
Procedure	1. Systematic literature review 2. Empirical investigation of key business, consumer, and developer factors.	Results from research phase I are used to develop a maturity scale, a set of guidelines, and a rating methodology.	1. Development of assessment methodology 2. Case studies 3. Interpretation of results
Research question that answers this problem	RQ1: What are the impacts of key business, consumer, and developer factors on the overall performance of digital games?	RQ2: Can a maturity model be developed for digital games?	RQ3: How mature are digital game industry organizations in developing quality digital games?
Philosophical perspective/ paradigm	Positivist/quantitative-exploratory and confirmatory study	Positivist/quantitative-confirmatory study	Positivist/quantitative-confirmatory study
Method	Survey Research	Survey Research	Case Study Research
Data collection technique	1. Search electronic databases such as ACM, IEEE, Science Direct, John Wiley, and Google Scholar for relevant studies 2. Assessment questionnaire	Research phase I results & survey	Interviews/questionnaires and available literature
Data analysis approach	Systematic literature review approach and empirical investigation	Validation through case study approach	Validation through case study approach
Empirical source	Available literature and assessment questionnaire for digital game industry organizations.		

The research problems identified in Section 1.4 were addressed by providing appropriate solutions. A comprehensive literature review is also included in this research methodology and helped in defining maturity level scales based on identified key factors in digital game development. A *Digital Game Maturity Model* is used to assign the organization a maturity profile that will help it determine and monitor its strengths and weaknesses in the activities currently performed during the game development lifecycle. It will also help the organization improve the quality and productivity of its development process. Overall, the proposed model will make it possible to assess the effectiveness of development processes in an organization and help it predict the performance of its digital games in the market.

Figure 1.2 illustrates the research plan used to address research problem 1 and its sub-problems as identified in Section 1.4.

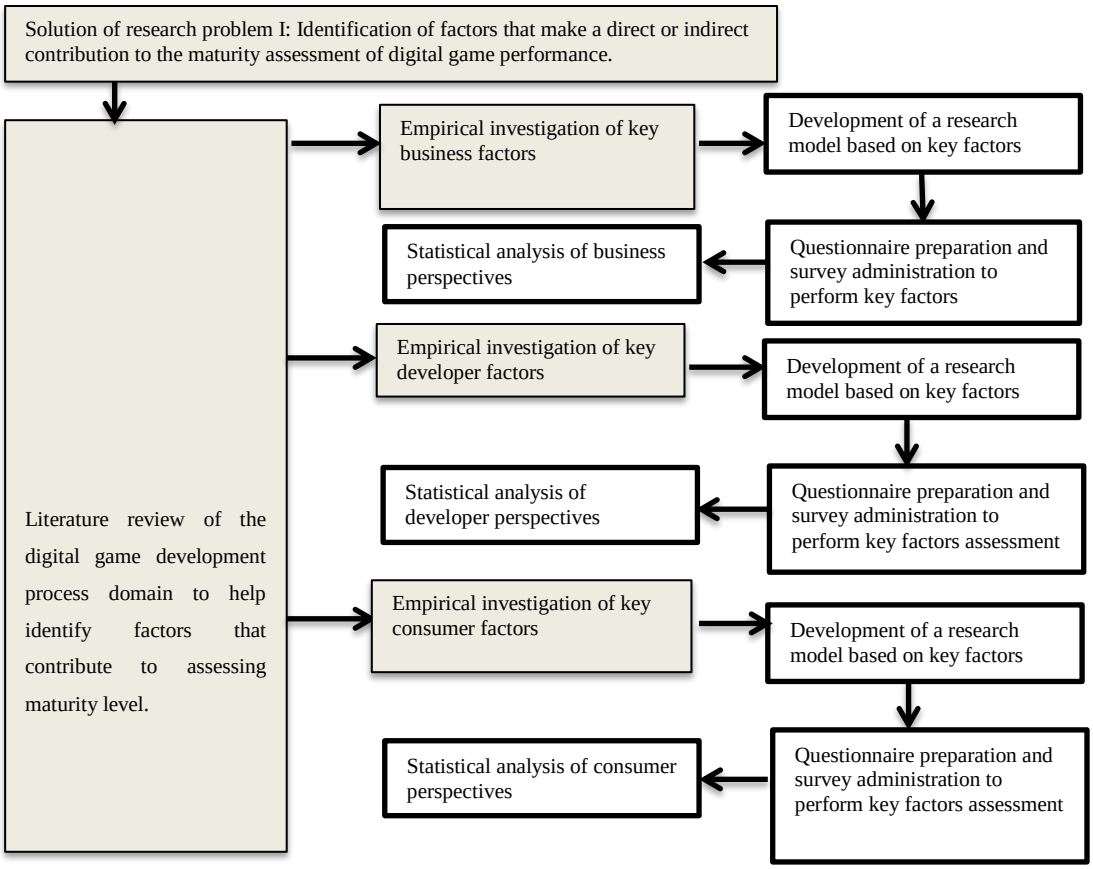

Figure 1.2 Research Phase I: Empirical Investigation of Factors

Figure 1.3 illustrates the stages of phase II of the research plan used to address problem solutions in this phase.

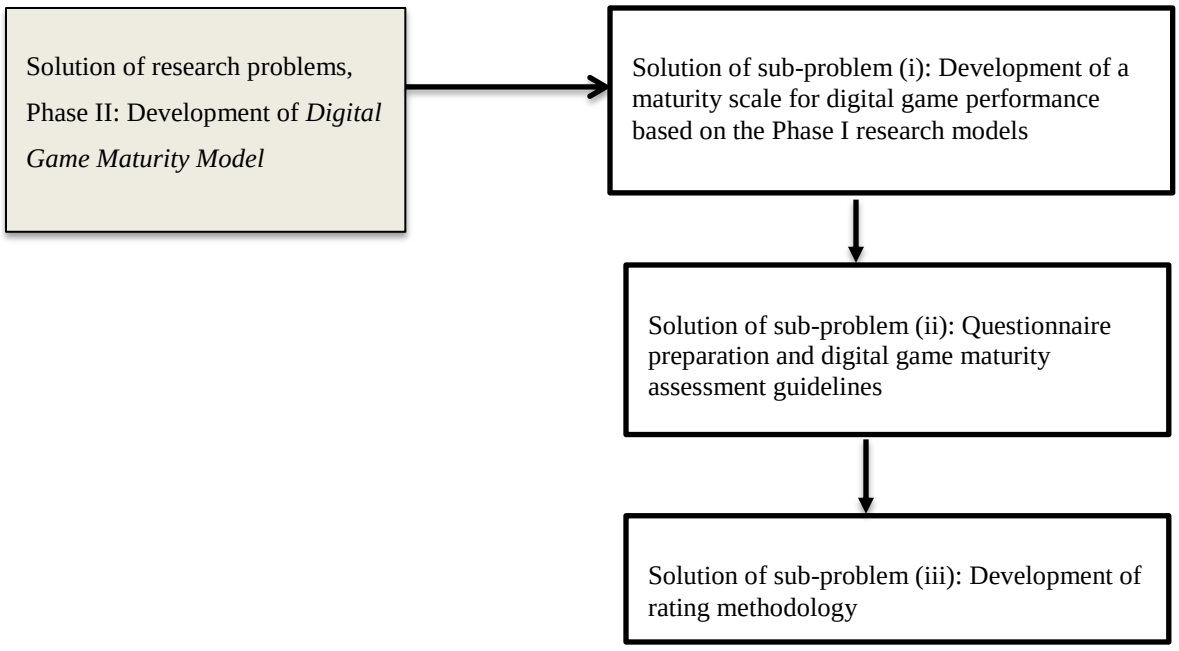

Figure 1.3 Research Phase II: Development of Digital Game Maturity Model

Figure 1.4 illustrates the phase III stages of the research plan used to address problem solutions in this phase.

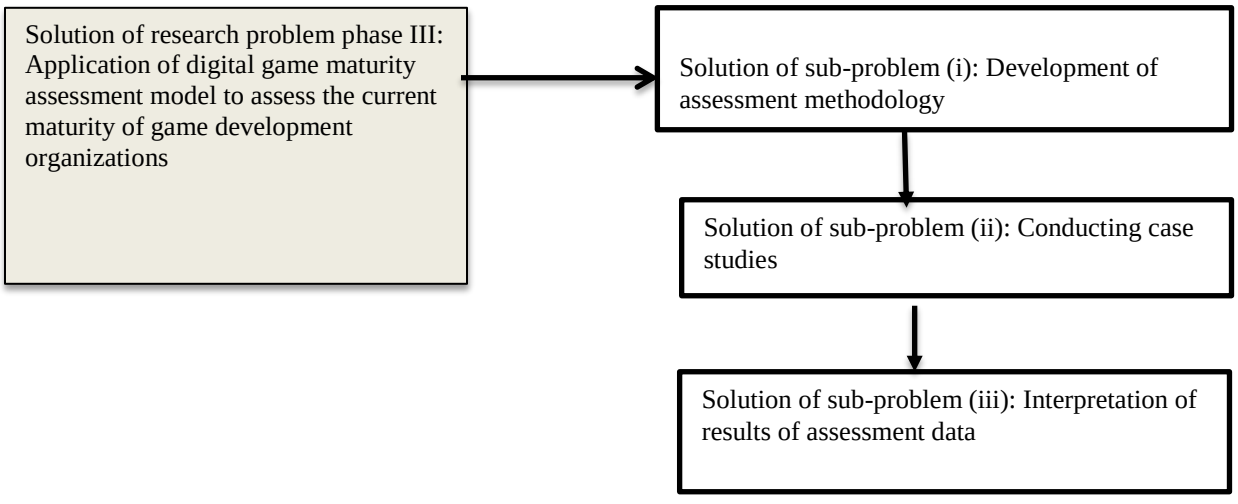

Figure 1.4 Research Phase III: Application of Digital Game Maturity Model

1.6 Research Questions

As discussed before, game development organizations have been facing strong pressure to gain and retain competitive advantage. They need to identify different ways to control budgets, reduce time to market, and improve quality. This research introduces the first *Digital Game Maturity Model* for game development processes. In the digital game development field, no studies have been done that directly address the issue of process improvement and assessment. This provided the motivation to propose the *Digital Game Maturity Model* due to the many challenges faced by organizations in the game development process, including i) lack of research in this area, ii) lack of development processes and good practices, and iii) lack of an assessment model.

Therefore, this research attempts to find answers to a series of *research questions* (RQs) to fill the research gap in game development process assessment. The answers to the research questions provided a comprehensive methodology for assessing the game development process. The answers to the research questions will also help organizations build the capability to identify gaps and bottlenecks in their current processes. The following questions constitute the theme of this research:

RQ-1: Is it possible to differentiate clearly between the software development process and the game development process?

RQ-2: Are there any frameworks for the assessment of game development processes?

RQ-3: What are the areas of game development that particularly need researchers' attention?

RQ-4: What are the key factors that influence the game development process from a developer's perspective?

RQ-5: Can key game development factors for game projects be identified from a business perspective?

RQ-6: From the consumer's perspective, what are the key game development factors that affect the quality of a game project?

RQ-7: How can assessment of game development processes be performed within a game development organization?

RQ-8: Can specific scales be developed to represents the maturity level of game development practices in a game development organization?

RQ-9: What are the future implications of the development of a DGMM?

1.7 Contribution to Knowledge

The main objective of this research is to assess the current maturity level of organizations in the digital game industry by proposing a *Digital Game Maturity Model*. This research has highlighted three major research problems in assessing the maturity level of digital game development processes. This research has focused mainly on providing solutions to these identified research problems. The main goal of this PhD research is to fill an important research gap by providing guidelines and an assessment methodology for the digital game industry through addressing the highlighted issues. The major contributions and milestones of this thesis are as follows:

1. Development of innovative assessment framework for DGI.

2. Identification of factors (from literature review) that directly or indirectly contribute to the maturity assessment and an assessment of *critical success factors* (CSFs) from different stakeholder's perspective (developers, consumer and business). This step provides the experimental validation of the developed model.

3. Development of a Digital Game Maturity Model for digital game industry organizations using maturity assessment scales, assessment questionnaires, and a rating methodology for digital game performance.

4. Use of a Digital Game Maturity Model to assess the current maturity of digital game industry organizations by defining an assessment methodology and conducting two case studies. This step will help to fine tune the model for

evaluation purpose and also creates a roadmap for future game development process assessment efforts.

1.8 Thesis Structure

The organization of this thesis is based on five articles that have been published or are under review in various reputed software engineering journals. Accordingly, these articles are cited in the corresponding chapters. Chapter 2 contains a detailed discussion on research background related to game development, its different components and challenges. A summary of related work is also provided. Chapter 3 then provides a systematic literature review of the *game development life cycle* (GDLC).

Chapter 4 presents an empirical investigation that examines the CSFs for improving game development from a developer's perspective. Exploring diverse developers' preferences for digital game development will provide a significant benefit to improve the development process by generating valuable insights. The study conducted and reported in this chapter can enhance our understanding of the developer's perspective as a factor in digital game success. Consequently, game development organizations can use these CSFs to address issues in game development and eventually enable quality improvement of the resulting game. Therefore, this empirical investigation provides a justification for including the identified CSFs as a measuring instrument for maturity assessment of the game development process.

As highlighted earlier, game development organizations are facing high pressure and competition in the digital game industry. Business has become a crucial dimension, especially for game development organizations. Accordingly, Chapter 5 investigates empirically the influence of key business factors on the business performance of games. This is the first study in the game development domain that demonstrates the interrelationship between key business factors and game performance in the market. The results of the study provide evidence that game development organizations must deal with multiple key business factors to remain competitive and handle the high pressure in the digital game industry. Furthermore, the results of the study support the theoretical assertion that key business factors play an important role in game business performance.

Finally, this study should enable game development teams to improve their understanding of the relationship between key business factors and their impact on game development.

One of the important game development choices is to consider the consumer perspective to produce quality digital games. Accordingly, Chapter 6 attempts to provide a better understanding of the consumer's perspective as a factor in digital game success. It focuses mainly on an empirical investigation of the effect of consumer factors on the digital game development process and finally on the quality of the resulting game. This research study investigates empirically the influence of consumer key factors on digital game development. The results provide evidence that game development organizations must deal with multiple key consumer factors to remain competitive and handle high pressure in the digital game industry.

In Chapter 7, a DGMM is presented. A DGMM facilitates a better understanding of the important dimensions of digital game development methodology. The model framework consists of assessment questionnaires, a performance scale, and a rating method. The assessment questionnaires contain factors selected from a literature review and from three empirical investigations carried out based on three stakeholder's perspectives: developer, consumer, and business. The main goal of the questionnaires is to collect information about current processes and practices. In general, this research contributes towards formulating a comprehensive and unified strategy for game development maturity evaluation. Two case studies are conducted and their assessment results reported. These demonstrate the maturity level of current development practices in two organizations.

Finally, Chapter 8 concludes this thesis and provides a summary of the research contribution of this dissertation in the area of game development. This chapter also discusses future research directions in game development process assessment.

Chapter 2

2 Research Background

This chapter provides relevant particularities of digital games and development processes. This chapter also aims to differentiate between the traditional software engineering process and the game development process. Moreover, this chapter presents challenges of game development process along with a comprehensive overview of available software and digital game maturity assessment models.

2.1 Digital Games Concepts

Now that the DGI has reached the point that it rivals other well-established entertainment industries such as music and cinema. As a result, the digital gaming business has grown enormously, has made billions of dollars in profit, and has started to mature over time (Petrillo & Pimenta, 2010). The game development process has also had an impact on the industry, which now counts on special methodologies and mature processes for its development, ultimately leading to an enhanced game development process.

The origins of computer games for home users lie in the 1980s. At that time, major computers included the Commodore 64, Sinclair ZX Spectrum, and Amstrad 464, which had slow 8-bit processors with limited memory. All available computers at that time came with largely the same hardware resources. This simplified the development requirements greatly, and developers worked directly on the machines. Consequently, programmers verified the speed of developed games directly and determined whether or not it met requirements. Another consequence of limited memory and resources was that developers had to use every clock cycle and every bit of memory to make the best game possible. Therefore, they directly programmed the available hardware, a practice that gave birth to the term, “writing directly to the metal”.

Because there were no good compilers or assemblers at that time, developers had to assemble their programs themselves. The developers would write instructions for the processors in the form of op-codes and then translate these into hexadecimal digits. The translated digits were then entered into memory directly and verified. This was not an

easy procedure, and different series of machines had different hardware. Therefore, platform independence was also an issue. After years and years of game development, new operating systems, hardware, and programming languages were introduced and gave birth to the modern-day game development process.

The DGI is highly innovative and dynamic. As a result, in many situations, new advances in hardware and software are directly applied to games before appearing in any other domain. Consequently, digital games support a wide variety of platforms and cover a variety of game genres (Ampatzoglou & Stamelos, 2010). The following section explores differences between traditional software development and game development process.

2.2 Traditional Software Development vs Game Development

This section focuses on providing an overview of game development process and intends to describe the essential differences and gaps between the traditional software development process and the game development process.

2.2.1 Digital Game Development

The digital game development process is influenced by software development methodologies. However, game development teams' roles are very much unlike traditional software development teams. The game development team is made up of creative and artistic members, each of whom might perform more than one role at the same time (Bates, 2004). The modern game development process is more complex because of team size and requirements and complex coding needs. Despite these characteristics, digital game development requires an iterative process with a short analysis phase and a long creative or design phase (Redavid & Adil, 2011). The following section focuses on describing the various elements involved in the game development process and the phases of game development in general.

2.2.1.1 Game Development Team

Team management and configuration might vary constantly in the game development process due to its dynamic and creative nature. Figure 2.1 shows various roles in the

digital game industry such as publisher, owner or senior management, admin support team include IT, media, PR marketing, finance, legal administration, project director/manager/producer and finally development team. However, to carry out game development, following are the required roles that often participate in the process.

Design team: This is made up of a lead designer, game designers, storywriters/ script writers, and content or level designers (Liming & Vilorio, 2011). Mainly, these are responsible for game launch and the development of game design documents.

Programming team: The team is composed of a multiplayer network programmer, a lead programmer engineer or tools programmer, an artificial intelligence (AI) programmer, a user interface programmer, and a graphics programmer (Liming & Vilorio, 2011). They are responsible for implementation of all technical aspects by selecting an appropriate game architecture, special features, and delivery platforms, considering implementation implications, and realizing the conceptual design (Bates, 2004).

Assets/Visual art creation team: Often composed of an art director, a lead artist, a concept artist, a modeller, a 2D concept artist, a 3D model builder, a 3D character builder or animator, a 3D cut scene artist, an art technician, and a level builder (Liming & Vilorio, 2011). This team is responsible for the creation of all visual art assets, which give a finished look to the developed game.

Audio team: This team can be formed by involving a sound/audio engineer and a composer (Liming & Vilorio, 2011). They create the auditory aesthetic and sound effects for the desired game.

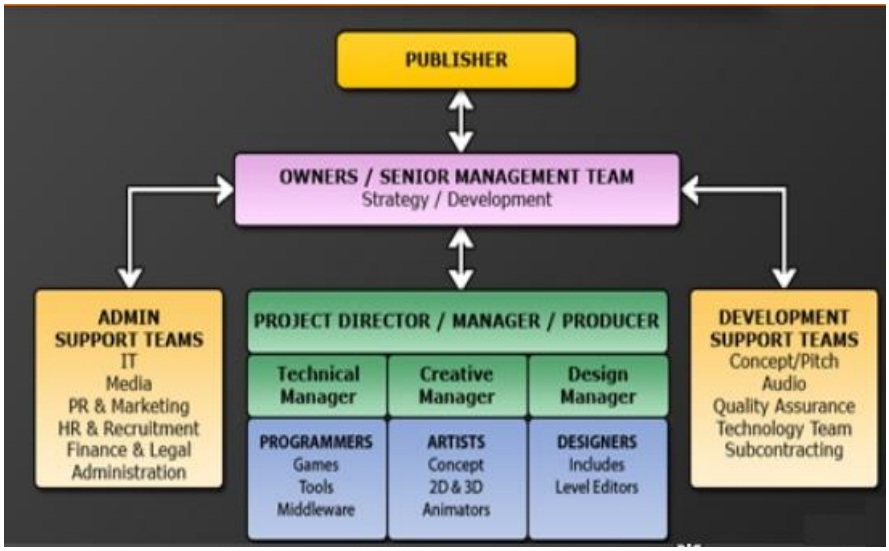

Figure 2.1 Different Roles in DGI

(adapted from: http://www.slideshare.net/iTawy/introduction-to-game-development-55854080).

Testing team: These play an important role in the game development process to ensure game quality. The team is made up of a test lead and testers (internal or external). To carry out testing, they perform different activities involving a test plan, identification of incidents and risks, and feedback to the programmers.

The DGI does not use formal software engineering principles effectively for game development because these are not completely suitable for their projects (Bates, 2004). However, game development is considered to intersect with software engineering (Ampatzoglou & Stamelos, 2010) and to share common challenges and problems (Petrillo *et al*. 2009; Petrillo and Pimienta, 2010). This overlap makes SE principles a potential medium to tackle game development issues as well (Redavid & Adil, 2011).

2.2.1.2 Development phases

The common phases of the game development lifecycle can be described as follows.

Concept Phase: This phase involves idea generation for a new game project, high-level game concept, concept document, or pitch document. In addition, the major gameplay elements, game genre, and appearances are defined during this phase.

Pre-production Phase: The main objective of this phase is to define the production path, perform game design, develop the project plan, and produce the initial prototype. However, this phase is equivalent to the requirements phase of traditional software development, and the game design document is the final artifact of this phase.

Production phase: Game implementation is performed during this phase with the help of the programming and asset creation team. This phase is longer than the pre-production phase.

Post-production phase: This involves testing of the final game. Testing is very important for game development, and most of the time, it requires "black box testing" (Nidhra & Jagruthi, 2012), which makes it different from traditional software testing (Redavid & Adil, 2011; Kasurinen, 2012).

2.2.1.3 Game Development Methodologies

Software engineering (SE) refers to the application of engineering principles to software development by following a systematic approach (ISO/IEC and IEEE Computer Society, 2014). A systematic SE approach to software development is carried out by using various specialized methodologies. These methodologies are used to plan, control, and structure various development processes by following specific life cycles with clear responsibilities, phases, iterations, and outputs (ACM, 2006). A number of software development methodologies are available. Hence, industries and organization need to investigate carefully each available approach or framework to find the one that best fits their development culture and ultimate goals.

Moreover, Kanode and Haddad (2009) stated that an important incorrect assumption has been made that game development follows the waterfall method. More recently, researchers have agreed that it must follow the incremental model because it combines the waterfall method with an iterative process. Petrillo *et al.* (2009) reported a major concern that developers creating software in the game industry commonly use very poor development methodologies. The GDLC is the object of questions on many forms that attempt to determine what types of practices are used. However, this question has no

single answer. Few researchers have explored GDLC practices and then tried to answer questions like, “what are the phases of the GDLC?” Blitz Game Studio (2014) proposed six phases for the GDLC, including pitch (initial design and game concept), pre-production (game design document), main production (implementation of game concepts), alpha (internal testing), beta (third-party testing), and finally the master phase (game launch). Hendrick (2009) proposed a five-phase GDLC consisting of prototype (initial design prototype), pre-production (design document), production (asset creation, source code, integration aspects), beta (user feedback), and finally the live phase (ready to play). McGrath (2011) divided the GDLC into seven phases: design (initial design and game design document), develop/redevelop (game engine development), evaluate (if not passed, then redevelop), test (internal testing), review release (third-party testing), and finally release (game launch). Another GDLC proposed by Chandler (2010) consisted of four phases: pre-production (design document and project planning), production (technical and artistic), testing (bug fixing), and finally post-production (post-release activities). The latest GDLC proposed in 2013 by Ramadan and Widyani (2013) was based on the four GDLCs previously described. They proposed six phases, including initiation (rough concept), pre-production (creation of game design and prototype), production (formal details, refinement, implementation), testing (bug reports, refinement testing, change requests), beta (third-party testing), and finally release (public release).

A GDLC is different from a traditional software development engineering process, and all phases of the proposed GDLC can be combined into three main phases: pre-production, production, and post-production. The pre-production phase includes testing the feasibility of target game scenarios, including requirements engineering marketing strategies; the production phase involves planning, documentation, and game implementation scenarios with sound and graphics. The last phase post-production involves testing, marketing, and game advertising. The major difference in software development and game development is in the design phase because design of game may undergo major change in late development. The other differences are content development and quality criteria. Therefore, they do not strictly follow the SE standards and practices. Nevertheless, the differences between SE and games development are not

exclusive; it seems that traditional SE does not fully support game development activities and provide process assessment procedures (Penzenstadler et al., 2012).

From the above discussion, it can be easily concluded that game development process is different from traditional software engineering development process. Kasurinen *et al.* (2013) argued that current software engineering knowledge is unable to bridge the gap between software engineering and certain aspect of game development. The overall development process to produce a game includes art, audio and gameplay other than software development discussed above. In the game development process, the content and production activities are performed in tandem with the development and engineering activities. Further, it is well agreed that the game development process is a multidisciplinary activity that involves the merging of creative and technical talent to bring a concept to life, where the main activities can be categorized into content and production, and engineering at each phase of the development process.

Moreover, sometime game development organizations reduce their development process due to of high competition and extreme market demand so they can be first to market (Kaitilla, 2014). This reduction of the development process definitely affects game quality. Because of these types of complex project-management tasks, the game development process diverges from traditional software development. Therefore, it has become important now to investigate the challenges or issues faced by game development organizations in developing good quality games.

2.3 Challenges in Game Development Assessment

Digital games are different from movies and other software. Interactivity is the main feature that makes games different from movies, whereas the content of the game as a medium is what makes it different from other software. The final important feature of games is the fun factor. Digital games are developed for several platforms simultaneously with different architectures and are performance-sensitive. Most of the times, reusability and maintainability are not considered important for game development. However, a game engine may be reused, but most of the time, application code is not reused. Therefore, games have a different development structure from other software. Figure 2.2

depicts the main elements of digital games. Typically, any game has the following structure:

- Start-up
- Introductory Movie
- Front End
    - Game option
    - Sound option
    - Video option
- Loading game
- Main game
    - Introduction
    - Game Play
        - Game modes
    - Pause option
- End game movie
- Credits
- Shutdown

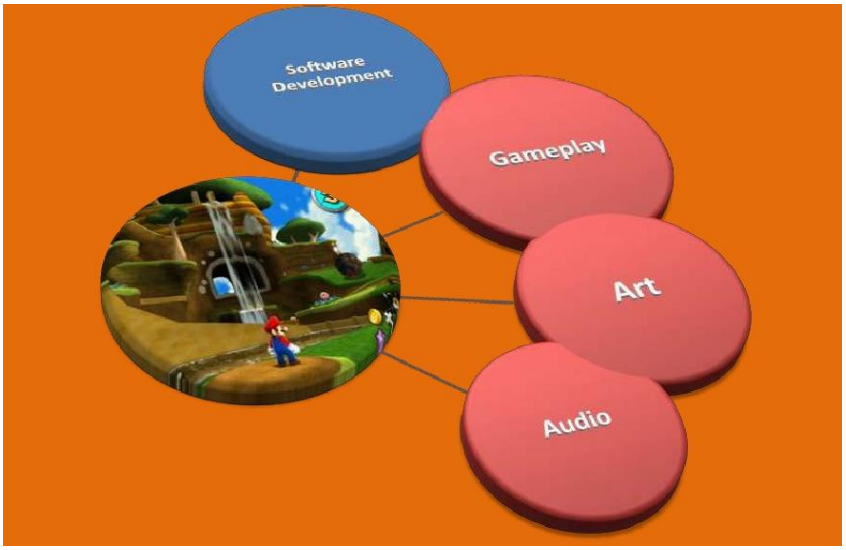

Figure 2.2 Elements other than Software Development involved in Game Development

(adapted from http://www.slideshare.net/AhmedSaker/game-development)

In terms of intangibility, digital games are just like any other software application. However, game development is different from software development because software applications usually provide services. On the other hand, the main objective of games is to provide fun. Digital games are developed to entertain their users. In general, in

software development, user experience is measured to ensure quality, and a project is considered successful if delivered within budget and on schedule. An important question here is how to measure the fun factor in games, which makes assessment of the game development process challenging. Some measures are available in SE, but they are not very applicable to game development because the later is driven by innovation.

A number of development methodologies are available, which can be followed as discussed above. Game development projects are usually a kind of large-scale software project involving large numbers of team members from diverse disciplines. Murphy-Hill *et al*. (2014) mentioned that the game development process is highly agile and creative in nature, which makes development activities and methods more iterative. Therefore, these methods do not strictly meet SE standards and practices.

Many researchers have discussed game development challenges. Petrillo *et al.* (2009) surveyed the problems faced by game development organizations. The problems identified were categorized into four groups: scheduling problems, quality problems, budget problems, management and business-related problems. The overall game development process was considered to combine both an engineering process and the creation of artistic assets. Ramadan and Widyani (2013) compared various game development strategies from a management perspective, and some researchers (Lee et al., 2006; Ayyad & Massod, 2010; Pena, 2011) have proposed frameworks for game development. To manage the development life cycle effectively, guidelines based on best practices are required. Petrillo and Pimenta (2010) highlighted the presence of agile practices in game development processes. Tschang (2003) and Petrillo *et al.* (2009) highlighted the issues in the game development process and its differences from traditional software development practices. Management of development-team members and their interaction is critically important in this aspect. Hullett *et al.* (2011; 2012) have provided data analytics and empirical analysis of the game development process and discussed issues of interdisciplinary team involvement. Best practices in game development must consider certain elements such as staying on budget, timing and producing the desired output. To assess game quality, five usability and quality criteria (functional, internally complete, balanced, fun and accessible) can be used, but a process

maturity model specific to the game development process is still needed to measure these processes for better management and high performance.

Profitable game development is another challenging endeavour. Every year, over 15,000 games are published and compete for player's attention and time (Isbister & Schaffer, 2008). This competitiveness of the global market and the high cost of developing good-quality games are reasons for the digital game industry to improve its development processes.

The following section discusses general software development assessment maturity models and available game development maturity models.

2.3.1 General Software Development Assessment and Maturity Models

Humphrey (1990) described a software process as a set or order of organizational activities that can be controlled by various entrance and exit criteria imposed by machines, humans, and methods. The actual objective of software process assessment is to develop a high-quality software product within budget and on schedule that meets the needs of its stakeholders. Fuggetta (2000) provided a broad description of the software development process, specifying that it should contain software product development, deployment, and maintenance as well as organizational policies and structures, human activities, and the functionalities and technologies used in the process. The software process maturity level of an organization can be assessed by its ability to define, manage, measure, and control the software development process. Assessment of the software process maturity of an organization has emerged as a popular and vital research area in software engineering. Assessment determines the current status of software development processes and has become an essential activity for targeting software process improvement in terms of development and management within the organization. Some well-known international organizations have defined standards for software process assessment, such as the International Standards Organization (ISO), the Software Engineering Institute (SEI), the International Electro-Technical Commission (IEC), and the European Software Institute (ESI).

The *capability maturity model* (CMM) (Paulka *et al*., 1993) was proposed by the SEI and has been adopted by most organizations in the software industry to perform software assessment. The CMM encompasses five maturity levels, ranging from the initial level 1 to the optimized level 5. Excluding level 1, each level is made up of key process areas (KPAs) and serves as an objective to achieve a certain maturity level. Each KPA has a certain set of features, and if these are collectively achieved, then the goal of the KPA has been accomplished. CMM concepts have also been included in CMMI (Lisandra & Roberto, 2003) over time to integrate various disciplines like integrated process and product development, software engineering, system engineering, and supplier sourcing. The BOOTSTRAP (Simila *et al*., 1994) methodology has also been used to perform process assessment of organizations by identifying their weaknesses and strengths and offering improvement guidelines. BOOTSTRAP is also made up of five levels, but divides the process area into technology, organization, and methodology. Software Process Improvement and Capability dEtermination (SPICE) (Emam & Melo, 1997) describes a process assessment reference model for process capability assessment. SPICE is also based on CMM, but has six maturity levels with a set of nine documents.

Furthermore, the family of ISO-9000 standards is helpful for setting up a quality management system within an organization for software maintenance and development, as well as for other purposes. ISO-9000-3 can be used to apply ISO-9001 to software supply, development, and maintenance. It also provides guidelines for documentation, responsibility, corrective actions, and software development audits to fulfil ISO-9000 requirements (Parzinger *et al*., 2001). ISO-12207 (Singh, 1996) provides a framework for improving software engineering and management by grouping broader classes such as primary, support, and organizational activities. ISO/IEC 15504 (Zahran, 1998) provides guidance for software process assessment concepts and addresses the two contexts of process capability determination and process improvement. In addition, some of the approaches (Kerzner, 2005; Crawford, 2002; Murray & Ward, 2006) used for project management maturity models based on CMM have been explored in this context.

All the approaches explored in this section concentrate mainly on engineering process assessment specifically for software development activity. As discussed earlier, the

digital game development process is different from traditional software development. Its three perspectives have been identified: business, developers and consumers. The software process assessment approaches discussed above cannot be directly used to assess digital game development processes and performance. The proposed approaches and maturity models in the literature capture only the software process aspect of product development. CMMI can be used to assess the general software process. Various researchers in different domains, such as software product lines (Ahmed & Capretz, 2010) and usability of open software systems (Raza *et al*., 2012) have proposed other maturity models. The proposed models cover the broader aspects of software products by including additional dimensions/ perspectives in the maturity assessment process. To assess digital game maturity, it is necessary to cover, not only the general perspective, but also other important perspectives that directly or indirectly contribute to the performance or maturity of digital games in the market. However, for the digital game development process and its performance assessment, no comprehensive method has been proposed that helps an organization to identify its strengths and weaknesses in the various activities performed during game development.

2.3.2 Game Development Assessment and Maturity Models

Digital game process assessment is a very new area of research, and not much work has been reported in this area. Currently, there is no prescribed and systematic way of measuring the maturity level of a digital game development process. According to de Boer *et al*. (2003), *gamification* is the application of game design and game mechanics to motivate and engage people to achieve their targets. They proposed a game maturity model that focuses on using gamification or applied gaming within an organization to gain competitive advantage. The proposed model was based on four perspectives: i) value, ii) process, iii) coverage, and iv) type, with each perspective having five levels. They also analyzed case studies to test their proposed maturity model and demonstrated that the model was an excellent management tool. In fact, the proposed game maturity model did not address assessment of digital game development processes, but rather the use of gamification.

Lee *et al*. (2006) examined the ISO 12207 (Pressman, 1999) and RUP (Lisandra & Roberto, 2000) standards and proposed a game software development process that was applicable to small and medium-sized companies. By conducting panel interviews with practical game developers from the game industry, they identified a set of core elements of game development software and performed requirements analyses for different game genres. The proposed game design process model elaborated inputs and outputs for each activity. The empirical study focused only on the processes of game development and did not cover broader aspects.

Gorschek *et al*. (2011) discussed the process maturity model for market-driven products from the management and requirements engineering perspectives only. The proposed model contained 70 practices, and the interdependencies among them were divided into five process areas. The dependencies among the various practices were defined in the form of AND, OR, REQUIRES, and value-based operators, but they remain to be explored in further detail. Digital games are also a market-driven product, and the proposed model will be helpful in the pre-production phase to address the need to determine and improve process maturity. However, the model is limited to the requirements engineering phase, and its validation remains to be explored.

In short, it can be observed that general software assessment models are not suitable for direct application to game development process assessment. Moreover, in the digital game development field, no studies have been published that directly address the issue of process improvement and assessment. Therefore, this research aims to propose a *DGMM* to respond to the many challenges faced by organizations in the game development process and also to bridge the research gap in this area by providing an assessment model for development processes and practices.

Chapter 3

3 Literature Review[1]

Game development process differs from the traditional software development process because it involves interdisciplinary activities. Software engineering techniques are still important for game development because they can help developers to achieve maintainability, flexibility, lower effort and cost, and better design. This chapter presents state-of-the-art research on the game development software engineering process and highlights areas that need further consideration by researchers. In this study, a systematic literature review methodology based on well-known digital libraries is used. The largest number of studies has been reported for the production phase of the GDLC, followed by the pre-production phase. In contrast, the post-production phase has received much less research activity than the pre-production and production phases. The results of this study suggest that the GDLC has many aspects that need further attention from researchers; this especially includes the post-production phase.

3.1 A Systematic Review of the GDLC

Creation of any game involves cross-functional teams including designers, software developers, musicians, script writers, and many others. Entertainment Software Association (2014; 2015) reports have highlighted the latest trends in the digital game industry. Game development careers have currently become highly challenging, dynamic, creative, and profitable (Liming & Vilorio, 2011). The ability to handle complex development tasks and achieve profitability does not happen by chance, but rather a common set of good practices must be adopted to achieve these goals.

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[1]Parts of this chapter were submitted to the Journal of Software Engineering Research and Development:

S. Aleem, L. F. Capretz, and F. Ahmed, (2016a). Game development life cycle: A systematic review. Journal of Software Engineering Research and Development, Springer, Submitted, 28 pages.

The game industry can follow the good and proven practices of traditional software engineering, but only a clear understanding of these practices can enhance the complex game development engineering process. This systematic literature review is the first step towards identifying research gaps in the GDLC field.

3.1.1 Related Work

A systematic literature review provides a state-of-the-art examination of an area and raises open research questions in a field, thus saving a great deal of time for those starting research in the field. However, to the best of our knowledge, no systematic literature review has been reported for the GDLC. Many researchers have adopted the systematic literature review approach to explore different aspects of digital games. Boyle *et al*. (2012) conducted a systematic literature review to explore the engagement factor in entertainment games from a player's perspective. In this study, 55 papers were selected to perform the systematic literature review. The study highlighted the different aspects of engagement factors with entertainment games; these include subjective feelings of enjoyment, physiological responses, motives, game usage, player loyalty, and the impact of playing games on a player's life. Connolly *et al*. (2012) explored 129 papers to report the impacts and outcomes of computer and serious games with respect to engagement and learning by using the systematic literature review approach.

Another study also reported the importance of engagement in digital games by using a systematic literature review approach. Osborne-O'Hagan *et al*. (2014) performed a systematic literature review on software development processes for games. A total of 404 studies from industry and academia were analyzed, and various software development adoption models used for game development were discussed. The findings of the study were that qualitative studies reported more agile practices than the hybrid approach. The quantitative studies used an almost hybrid approach. It was also noted that lightweight agile practices such as Scrum, XP, and Kanban are suitable where innovation and time to market are important. A risk-driven spiral approach is appropriate for large projects. Only one systematic study was performed related to research on software engineering practices in the computer game domain rather than the GDLC (Ampatzoglou & Stamelos, 2010).

This chapter reviews the existing evidence in the literature concerning the GDLC process and suggests areas for further investigation by identifying possible gaps in current research. Furthermore, the aim of this chapter is to cover the state of the art for the GDLC, and to accomplish this, an evidence-based research paradigm has been used. In the software engineering field, Dyba *et al*. (2005) and Kitchenham (2004) have proposed the possible use of an evidence-based paradigm. The *systematic literature review* (SLR) research paradigm constitutes the first step in an evidence-based paradigm research process, and its guidelines for performing systematic research are thoroughly described by Brereton *et al*. (2007) and Kitchenham (2004).

This chapter provide the answer to the third research question: what are the areas of the GDLC that need researchers' attention? The purpose of this chapter is to find out the research gaps in the GDLC processes. The answer to the research question posed above can be obtained by performing a systematic literature review of the GDLC topics that need researchers' attention in this field.

3.2 Review Methodology

In this work, the conceptual description of the SLR process presented by Kitchenham (2004) was used to investigate the research intensity for each phase of the GDLC. Conceptually, SLR provides an opportunity for researchers to collect empirical evidence from the existing literature about a formulated research question. Although most authors followed the general SLR guidelines provided by Kitchenham (2004), there were slight variations in the description and presentation of the conceptual process layout. The generic SLR guidelines stated by Kitchenham (2004) are further elaborated here, and the overall process is described as a set of activities. This study started by selecting a topic, at which point the study objectives were also clearly defined and the boundaries of the domain delineated.

3.2.1 Selection of Topic and Research Questions

Selecting a topic for SLR is of crucial importance because many factors such as individual or community interest, research gaps, and research impact contribute to shaping research questions on the topic. Our understanding of the GDLC is continuously

evolving, and many areas in this field lack generalized evidence. It is critically important for the game industry to identify a quality-driven GDLC process. Several studies have investigated different phases of the GDLC, but they do not offer systematic, comprehensive, and thorough methodological research specific to this topic.

In this review, studies from 2000 to 2015 are explored to answer the following research questions:

RQ1: What is the intensity of research activity on the GDLC topics?

RQ2: What topics are being researched in the pre-production, production, and post-production phases?

RQ3: What research approaches are being used by researchers in the digital game domain?

RQ4: What empirical research methods are being used in the digital game domain?

The number of publications has been identified by us to address RQ1. A graphical representation has been used to represent the increase or decrease in the number of publications per year as a measure of research activity. To address RQ2, RQ3, and RQ4, each study selected has been affiliated to a research topic, to a certain approach, and to a specific methodology used for the research. Details of this classification into corresponding categories are discussed in sections 3.2.5.1 and 3.2.5.2.

3.2.2 Review Team Formation

A multidisciplinary team is needed to perform a high-quality scientific SLR. To enhance the thoroughness and minimize the potential bias of a study, a SLR is normally undertaken by more than one reviewer. The SLR team for this review was made up of three people. Two people were designated as principal reviewers. One person was also selected as the project leader to handle additional administrative tasks such as team communication, points of contact, meeting arrangements and documentation, task assignment and follow-up, and quality assurance. Table 3.1 details the tasks required for the SLR process.

3.2.3 Establishment of Review Procedure

In the SLR, the review procedure is based on an online search. The search strategy for an SLR is a plan to construct search terms by identifying populations, interventions, and outcomes. In this case, alternative spellings and synonyms as well as Boolean operators were used to generate possible combinations. Some of the search cases are represented below.

Results for (a): Software games, development, life cycle, process,

Result for (b): Software game: (“Software game” OR “online game” OR “computer game” OR “video game” OR “serious games” OR “Digital games”). Development: (“advancement” OR “steps” OR “evolve”). Life cycle: (“design” OR “implementation” OR “testing” OR “evaluation” OR “requirements”). Process: (“progression” OR “method”).

Results for (C): Software game: (“Software game” OR “online game” OR “computer game” OR “video game” OR “serious games”) AND Development: (“advancement” OR “steps” OR “evolve”) AND Life cycle: (“design” OR “implementation” OR “testing” OR “evaluation” OR “requirements”) AND Process: (“progression” OR “method”).

To ensure that all relevant research concerning this area of study was reviewed, journals and conferences from 2000 to 2015 were covered, by using sources such as IEEE Explorer, ACM Digital Library, Science Direct Elsevier, Taylor & Francis, Google Scholar, and Wiley Publications. If the information required, as indicated on the form shown in Table 3.2, was not explicitly present in the potential study, then that paper was peer-reviewed by all team members and, after discussion, validated for correctness. Otherwise, each paper was reviewed by one reviewer. Each study involved some general information and some specific information, as indicated on the form.

Table 3.1 Reviewer's Involvement in SLR Tasks

General information about a research article	
Article Title	
Author(s) Name	
Name of Journal/Conference was published in	
Retrieval Database of Research article	
Publication Date	

Table 3.2 Publication-Specific Data

Specific Information about a Research Article	
A) Research Methodology used in SLR	
Empirical	
Descriptive	
Exploratory	
B) Empirical research methods	
Experiment	
Survey	
Case study	
C)Type of publication	
Journal	
Conference	
Workshop	
D) Research activity by country	
Country name	Number of publications
E) Year of Publication	
2000–2005	
2006–2010	
2010–2015	

3.2.4 Quality Criteria

In this research, quality guidelines were defined based on a quality instrument that was used to assign a quality score to each article as a basis for data analysis and synthesis. The quality instrument consisted of four sections: a main section containing a generic checklist applicable to all studies, and three other sections specific to the type of study.

The checklist was based upon SLR guidelines (Kitchenham, 2004) and was derived from Kitchenham (2004). The detailed checklist is shown in Table 3.3. Some of the checklist items could be answered by "yes" or "no" and also included a "partial" option. A value of 1 was assigned to "yes," 0 to "no," and 0.5 to "partial"; then the sum of the checklist values was used to assign a quality score to the study to assess document quality.

3.2.5 Defining Coverage Criteria

The research study selection was based on the following coverage criteria.

Inclusion Criteria for Study: For SLR, articles and research papers from 2000 to 2015 were included, and to evaluate their suitability, the following criteria were analyzed:

- The study should be thoroughly reviewed by at least one of the reviewers.
- Only the following types of studies were considered: case studies, theoretical papers, and empirical analysis surveys.
- The full text of the article should be available.
- If any article identifies any challenges and problems in digital games, that article is included as a review.
- Studies that describe motivation for game application.

Table 3.3 Quality Checklist Data (Kitchenham, 2004)

Quality Checklist	
Generic	
Are the aims clearly stated?	Yes/No
Was the study design appropriate with respect to its research aim?	Yes/No/Partial
Are statistical methods justified by the authors?	Yes/No
Are negative findings presented?	Yes/No/Partial
Are all research questions answered?	Yes/No
Are the data collection methods adequately described?	Yes/No
Empirical Analysis	
Was population size reported?	Yes/No
Did the authors justify the sample size?	Yes/No
Is the sample representative of the population to which the results will be generalized?	Yes/No
Theoretical Analysis	
Does the author report personal observations?	Yes/No
Is there a link between data, interpretation, and conclusions?	Yes/No
Does the study cover all literature up to that point in time?	Yes/No
Is the focus of study reported?	Yes/No
Case Study	
Is the case study context defined?	Yes/No
Is the case study based on theory and linked to existing literature?	Yes/No
Is clear evidence established from observations to conclusions?	Yes/No/Partial

Study Exclusion Criteria: The following criteria were used to determine articles to be excluded:

- Articles published on company web sites.
- Articles not relevant to the research questions.
- Articles not describing any phase of the game development life cycle.

Study Selection Procedure: This procedure involved two phases. In the first phase, an initial selection was made on the basis of the inclusion criteria and after reading the title, abstract, and conclusion of each article. In the second phase, if a particular article met the criteria, then the whole article was studied. One hundred forty-eight papers were identified after final selection, as shown in Figure 3.1. Table 3.4 shows the results found in each data source, and Appendix I contains a full list of selected publications.

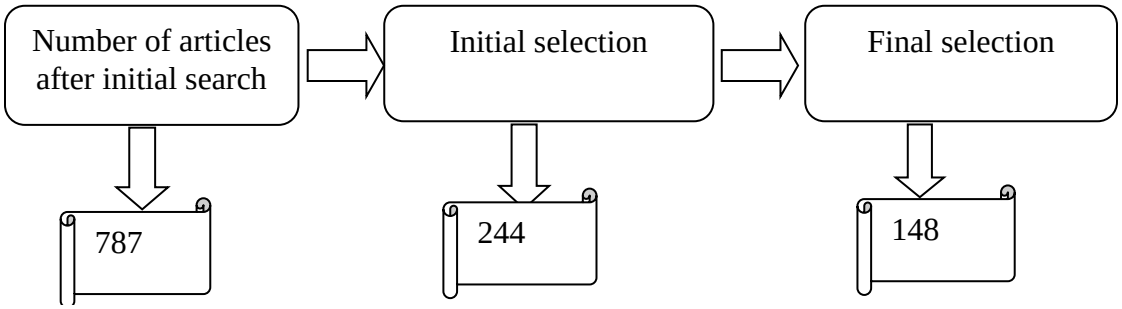

Figure 3.1 Study Selection Process

Table 3.4 Results Found in Each Data Source

Resource	**Total results found**	**Initial selection**	**Final selection**
IEEE Explorer	349	145	94
ACM	120	30	17
Elsevier	200	38	15
Taylor & Francis	10	6	4
Springer	20	15	5
John Wiley	73	5	2
Google Scholar	15	12	11
Total	**787**	**244**	**148**

3.2.5.1 Classification of Topics in the GDLC

This section includes a classification of the topics covered by each study with respect to the pre-production, production, and post-production phase issues involved. The 2012 ACM classification system was used for classification, which is the same method used by

Cai and Card (2008). The proposed classification system has been adopted by many journals and conferences specifically for software engineering topics. The same classification was used here to classify the papers under study, and these were further fabricated based on studies found in the GDLC domain. Table 3.6 presents the selected classification schema.

3.2.5.2 Research Approaches and Methods Classification

Research articles can be characterized based on their method and approach, as described by Glass *et al*. (2002). The main categories for scientific approach are descriptive (a system, tool, or method; a literature review can also be considered as descriptive studies), exploratory (performed where a problem was not clearly defined), and empirical (findings based on observation of its subjects). To evaluate new methods or techniques, three major empirical research methods are used: surveys, case studies, and experiments (Wohlin *et al*., 2000). Table 3.5 describes the three major empirical research types; Dyba and Dingsoyr (2008) also used the same type of empirical classification.

The data collected were statistically analyzed as follows:

- To address RQ1, the number of studies published per year, whether journal articles or conference publications, and the number of publications on the GDLC hosted by each digital library.
- To address RQ2, the major topics of the GDLC that are investigated in the software game domain.
- To address RQ3 and RQ4, the research approach or method used by number of studies.

From Section 3.2.5, data were tabulated and presented in Appendix II.

Table 3.5 Empirical Methods

Empirical method	**Description**
Survey	One or more questionnaires are filled out by a set of subjects either directly or by Internet, and results are derived from the answers.
Experiment	A specified task is performed in a highly controlled environment by a set of subjects. The results are the observations made by the subjects; in addition, task outcome inspection gives answers to research questions.
Case study	According to a methodology, an activity, project, or assignment is examined, and project measurements provide results.

Table 3.6 GDLC Classification of Topics (Cai and Card, 2000)

GDLC topics
Pre-production phase
Game process development management
Requirements specification
Game system description language
Reusability
Game design document
Game prototype
Design tools
Risk management
Production Phase
Assets creation
Storyboard production
Development platforms
Formal language definition
Programming
Game engine
Implementation
Post-production Phase
Quality assurance
Beta testing
Usability testing
Empirical testing
Tools for testing
Marketing

Table 3.7 Type of Citation and Per Year Research Activity

	Years													
Citation type	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Book	0	0	0	0	0	0	0	0	0	0	0	0	3	2
Journal	1	2	2	2	3	4	1	4	2	5	2	2	4	0
Conference	1	1	4	1	1	5	7	14	15	15	17	10	4	10
Workshop	0	0	0	0	0	0	0	1	1	0	0	1	0	1
Total	2	3	6	3	4	9	8	19	18	20	19	13	11	13

3.3 Results

This section presents the results of statistical analysis of the data set. The characteristics of the data set are tabulated for better understanding. To trace the categories of each mapped study, the interested reader is referred to Appendix II. Table 3.7 presents GDLC topics research activity per year based on the type of article or publication (journal/conference/workshop), excluding 2016 because it is not yet completed.

Moreover, Figure 3.2 shows the list of countries most active in GDLC topics research. Table 3.8 shows the number of publications in the GDLC domain by publisher among the digital libraries. The data from Tables 3.7 and 3.8 and Figure 3.2 will be the basis of analysis for RQ1. Table 3.9 represents the results of GDLC topic classification based on the ACM software engineering categories. The data from this table provide a basis of analysis for RQ2. Tables 3.10 and 3.11 provide a basis of analysis for RQ3 and RQ4.

Table 3.8 Number of Publications by Publisher

Publisher name	Number of publications
ACM	17
IEEE	94
Springer	5
Elsevier	15
Taylor & Francis	4
John Wiley	2
Google Scholar	11

Table 3.9 GDLC Topics

GDLC topics	Frequency	Percentage
Pre-production phase	58	39.18
Management	18	12.16
Requirements specification	9	6.08
Game system description languages	6	4.05
Reusability	3	2.02
Game design documents	11	6.75
Game prototyping	7	4.72
Design tools	3	2.02
Risk management	1	0.67
Production phase	66	45.27
Asset creation	7	4.72
Storyboard production	3	2.02
Development platforms	13	8.78
Formal language definition	2	1.35
Programming	17	11.48
Game engine	11	8.10
Implementation	13	8.78
Post-production phase	24	16.21
Quality assurance	2	1.35
Beta testing	5	3.37
Heuristic testing	6	4.05
Empirical testing	2	1.35
Test tools	1	0.67
Marketing	8	5.40

Table 3.10 Empirical Research Methods

Empirical method	Frequency
Case study	10/30
Experiment	6/30
Survey	14/30

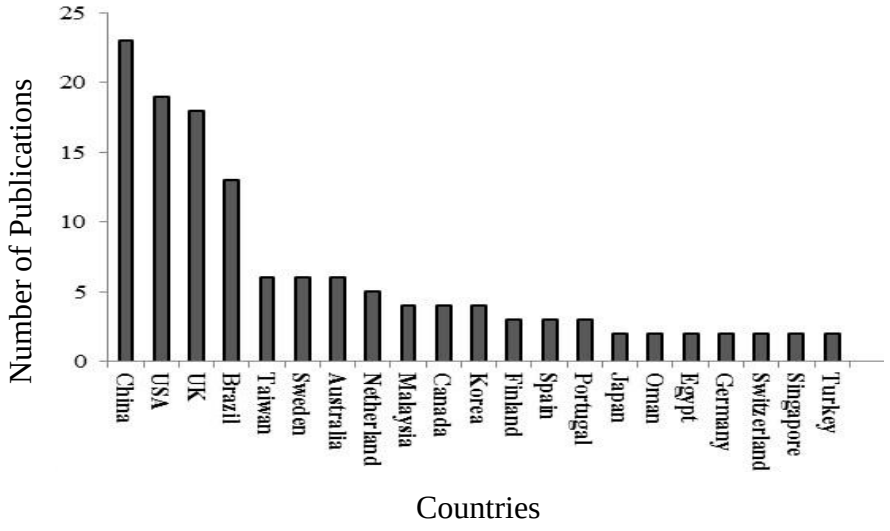

Figure 3.2 Research Activity by Country

Table 3.11 GDLC Research Approach

Research approach	Frequency
Descriptive	61
Empirical	30
Exploratory	57

3.4 Discussion

This section provides an analysis of the results and discusses the findings concerning the RQs formulated in Section 3.3. To identify GDLC domain-specific characteristics, the

findings of this review will be compared to results from similar studies done by Cai and Card (2008), Glass *et al.* (2002), and Dyba and Dingsoyr (2008).

3.4.1 GDLC Research Intensity

Table 3.7 clearly shows that GDLC research intensity has increased during the last few years. Figure 3.3 shows an increase in GDLC research over time. The *y*-axis represents the number of publications in the form of a fraction and is calculated by taking year (*i*)'s number of publications as the numerator and year (0)'s number of publications as the denominator. From Table 3.7, 2007 was taken as year (0), and the first data point of the graph was calculated for year (1) i.e., 2008. Figure 3.3 shows the results up to 2015. Years are given on the *x*-axis.

Figure 3.3 illustrates that during the last few years, research activity in the GDLC domain has continuously increased, and the number of publications in the GDLC domain has increased at a polynomial rate since 2005. During 2013, 2014, and 2015, a drop in research activity can be noted. It seems obvious that most of the work related to GDLC research activity was not published on the selected sources for this study. During 2014, most research activities were reported on game development associations/groups Web sites, like the DIGRA (*Digital Game Research Association*) association and Gamasutra, or on game developers' personal blogs.

Looking at research activity by country, China now dominates GDLC research, but its research into the game domain started only in 2010. In four years, China has come to dominate this area of research. Before 2010, the United States and the United Kingdom were dominant.

Authors from North and South America have played a dominant role since 2004 and are still contributing in this area. Contributors in Europe also started research into the GDLC domain in 2007, but the Asian continent has dominated the GDLC domain since 2010. This situation can be visualized in Figure 3.4. The most popular venue for GDLC research publication is IEEE; it seems that IEEE accounts for the main bulk of publications (approximately 63%), followed by Elsevier, Springer, and ACM.

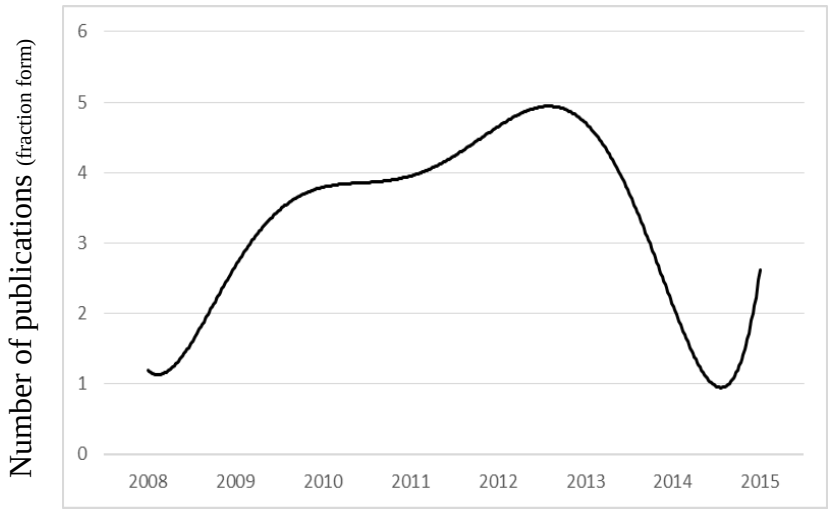

Figure 3.3 Increase in GDLC Research Activity

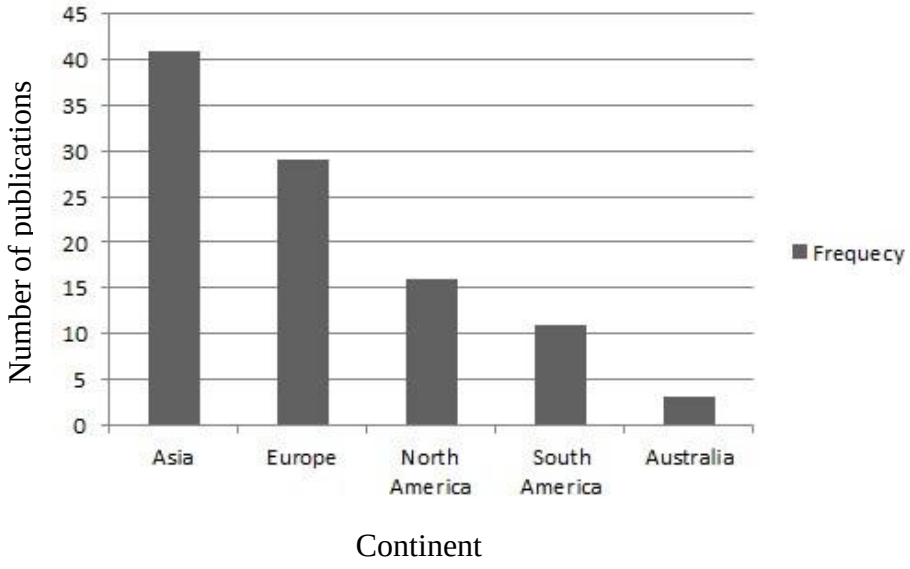

Figure 3.4 Research Activity by Continent

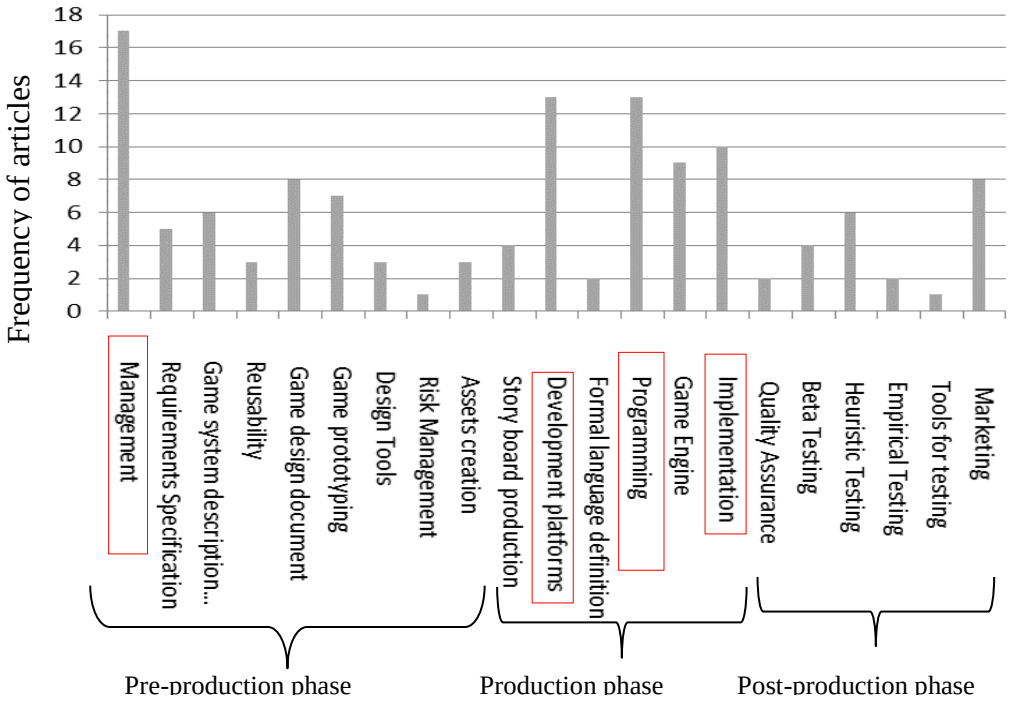

Figure 3.5 GDLC Research Topics.

3.4.2 GDLC Research Topics

This section addresses the identification of main research topics in the GDLC domain. Table 3.9 clearly suggests that most research has been conducted in the production phase, followed by the pre-production phase. On the other hand, the post-production phase has not attracted much research interest. These GDLC topics are somewhat different than in software engineering because of two factors: first, the GDLC domain has special needs and priorities, and second, it is a young domain which requires more fundamental research in the area of requirements, development, and coding tools. When the GDLC domain becomes mature, then other areas in the field, like testing and verification, will attract the interest of researchers.

As mentioned earlier in Section 3.1, games have specific characteristics, which the conventional software development process cannot completely address. In the past years, research on GDLC topics has become more active because, unlike other software products, games provide entertainment and user enjoyment, and developers need to give

more importance to these aspects. As a result, research about the pre-production phase has increased. The implementation phase is shorter than in the traditional software implementation process because of the short time to market. This production-phase research intensity has attracted the interest of many researchers, and maximum research activity has been reported because the GDLC domain requires efficient development and coding techniques. McShaffrey (2003) also highlighted the importance of the production phase to counteract poor internal quality. There is much less research activity in the post-production phase than in the pre-production and production phases.

Figure 3.5 presents the growth of each GDLC research topic since 2000. It is apparent that in the pre-production phase, the most researched topic is management of the game development process, followed in this order by production-phase development platforms, programming, and implementation topics. In the post-production phase, the marketing area attracted the largest amount of research interest. The state-of-the-art research is descriptions of actual primary studies and, therefore these are mapped according to the research topics they addressed (Budgen *et al.*, 2008). Next, a short description of each GDLC topic is presented along with a full reference list. A full reference list of all the studies included is presented in Appendix I.

3.4.2.1 Pre-Production Phase

3.4.2.1.1 Management

In the pre-production phase, most of the studies categorized under this topic address management issues during the GDLC. The overall management of the game development process combines both an engineering process and creation of artistic assets. Ramadan and Widyani [S1] compared various game development strategies from a management perspective, and most studies like [S3], [S6], [S7], and [S8] have proposed frameworks for game development. Game development guidelines can be followed to manage the GDLC. The presence of agile practices in the game development processes is also highlighted by some studies. Tschang [S4] and Petrillo et al. [S17] highlighted the issues in the game development process and their differences from traditional software

development practices. Management of development-team members and their interaction is critically important in this aspect.

Some studies [S10] and [S11] have provided data analytics and empirical analysis of the game development process and issues of interdisciplinary team involvement. Best management practices in the game development process must consider certain elements such as staying on time and on budget and producing the desired output. To assess game quality, five usability and quality criteria (functional, internally complete, balanced, fun, and accessible) can be used, but a process maturity model specific to the game development process is still needed to measure these processes for better management and high performance.

3.4.2.1.2 Requirements Specification

One of the main differences between the traditional software development process and the GDLC is the requirements phase. The game development process requires consideration of many factors such as emotion, game play, aesthetics, and immersive factors. In four studies, the authors have discussed the requirements engineering perspective to highlight its importance to the whole game-software development process. They discussed emotional factors, language ontology, elicitation, feedback, and emergence [S19], [S20], [S21] and [S22]. In particular, game developers must understand these basic non-functional requirements along with the game play requirements and incorporate them while developing games. The main challenges in requirements identification are a) communication among stakeholders with diverse backgrounds, b) incorporation of non-functional requirements with game play requirements, such as media and technology integration, and c) validation of non-functional requirements such as fun, which is very complex because it is totally dependent on the target audience. Callele *et al*. [S20] fabricated a further set of requirements based on emotional criteria, game-playing criteria (cognitive factors and mechanics), and sensory requirements (visual, auditory, and haptic). The requirements specification phase must address both the functional and non-functional requirements of game development.

3.4.2.1.3 Game System Description Language

Many description languages are currently used by developers, such as the UML model, agent-based methodologies, and soft-system methodologies. Quanyin *et al*. [S32] proposed the UML model for mobile games. They performed experiments and reported that it would be a good model for further development of games on the Android operating system. Shaker *et al*. [S33] extracted features of the Super Mario Brothers game from different levels, frequency sequences of level elements, and statistical design levels. Then, they analyzed the relationship between a player's experience and the level design parameters of platform games using feature analysis modelling. Taylor *et al*. [S28] proposed a soft system methodology for initial identification of game concepts in the development process. The proposed approach can be used instead of a popular description language because it provides an overview of the game. Chan and Yuen [S30] and Rodriguez *et al*. [S31] proposed an ontology knowledge framework for digital game development and serious games modelling using the AOSE methodology. A system description language for games must be both intelligible to human beings and formal enough to support comparison and analysis of players and system behaviours. In addition, it must be production-independent, adequately describe the overall game process, and provide clear guidelines for developers.

3.4.2.1.4 Reusability

Reusability of software (Capretz & Lee, 1992) and development platforms in game development has been reported by some researchers, but to obtain its full advantages, commonality and variability analysis must be done in the pre-production phase. This category addresses reuse techniques for game development software (Ahmed & Capretz, 2011). Neto *et al*. [S34] performed a survey that analyzed game development software reuse techniques and their similarity to software product lines. Reuse techniques in game development could reduce cost and time and improve quality and productivity. For reuse techniques, commonality and variability analysis is very important, similarly to a software product line. Szegletes and Forstner [S36] proposed a reusable framework for adaptive game development. The architecture of the proposed framework consisted of loosely coupled components for better flexibility. They tested their framework by

developing educational games. The requirements of the new game must be well aligned with the reusable components of the previously developed game.

3.4.2.1.5 Game Design Document

The *game design document* (GDD) is an important deliverable in the pre-production phase. It consists of a coherent description of the basic components, their interrelationships, directions, and a shared vocabulary for efficient development. Westera *et al*. [S37] addressed the issue of design complexity in serious games by proposing a design framework. Furthermore, Salazar *et al*. [S38] highlighted the importance of a game design document for game development and provided an analysis of many available game design documents from the literature. They also compared their findings with traditional software requirement specifications and concluded that a poor game design document can lead to poor-quality product, rework, and financial losses in the production and post-production phases. Hsu *et al*. [S40] pointed out the issues of level determination in games and trade-off decisions about levels. They proposed an approach to solve the trade-off decision problem, which is based on a neural network technique and uses a genetic algorithm to perform design optimization. Khanal *et al*. [S41] presented design research for serious games for mobile platforms, and Cheng *et al*. [S42] conducted design research for integrating GIS spatial query information into serious games. Finally, Ibrahim and Jaafar [S43] and Tang and Hanneghan [S44] worked on a game content model for game design documents. Currently, GDD suffers from formalism and incomplete representation; to address this issue, the formal development of GDD is very important. A comprehensive GDD (focused on the game's basic design and premises) results in good game quality.

3.4.2.1.6 Game Prototyping

Game prototyping in the pre-production phase helps the developer to clarify the fundamental mechanics of the final game. Game prototyping in the pre-production phases is considered important because it is used to convey game and play mechanics and also helps in evaluating a game player's experience. Reyno and Cubel [S49] proposed automatic prototyping for game development based on a model-driven approach. An

automatic transformation generates the software prototype code in C++. De Silva *et al.* [S48] proposed community-driven game prototyping. The developer can approach a well-established community and focus on the technical stuff rather than starting from scratch. They used this approach for massive, multi-player online game development. Guo *et al.* [S50], Kanev and Sugiyama [S51], and Piexoto *et al.* [S52] proposed analysis of rapid prototyping for Pranndo's history-dependent games, 3D interactive computer games, and game development frameworks respectively. Prototypes also help to identify missing functionality, after which developers can easily incorporate quick design changes. Model-driven or rapid-prototyping approaches can be used to develop game prototypes.

3.4.2.1.7 Design Tools

Game design tools are used to help game developers create descriptions of effects and game events in detail without high-level programming skills. Cho and Lee [S56] and Segundo *et al*. [S57] proposed an event design tool for rapid game development and claimed that it does not require any kind of programming skill. These tools also enable reuse of existing components and reduce the total time of the game-creation process.

3.4.2.1.8 Risk Management

In the game development domain, risk management factors do not attract much discussion by researchers. Risk management is very important from a project management point of view. Identifying risk factors in the game development process is also important. In game development, the project manager is the game producer and must bring together management, technical, and aesthetic aspects to create a successful game. The study by Schmalz *et al*. [S58] is the only study highlighting the issue of risk management in video development projects. They identified two risk factors during the development process: failure of the development strategy and absence of the fun factor. In game development, important risk factors can be the development strategy, the fun factor or extent of originality, scheduling, budgeting, and others, but very low priority has been given by game developers to formal analysis of risk factors.

3.4.2.2 Production Phase

3.4.2.2.1 Asset Creation

Asset creation in the production phase is the foundation stage where game developers create the various assets and then use them in the game implementation phase. In the production phase, the first step is to create assets for the game. One of these assets is audio content. Migneco *et al*. [S63] developed an audio-processing library for game development in Flash. It includes common audio-processing routines and sound-interaction Web games. Minovic *et al.* [S65] proposed an approach based on the model drive method for user interface development, and Pour *et al.* [S64] presented a brain-computer interface technology that can control a game on a mobile device using EEG Mu rhythms. For audio processing, open-source libraries are available, especially for games. Audio and interface designs are examples of game assets.

3.4.2.2.2 Storyboard Production

Storyboard production is the most important phase of game production; it involves development of game scenarios for level solutions and incorporation of artificial intelligence planning techniques for representing the various features of games through a traditional whiteboard or flowchart. Pizzi *et al*. [S59] proposed a rational approach that elaborated game-level scenario solutions using knowledge representation and also incorporated AI techniques to explore alternative solutions by direct interaction with generated storyboards. Finally, Anderson [S61] presented a classification of scripting systems for serious and entertainment games, and Cai and Chen [S62] explored scene editor software for game scenes. Their approach was based on the OGRE .Net framework and C++ technology. Various scripting editors based on different technologies are available for game developers to produce storyboards. Some of this software helps to develop and edit scenes at different game levels, and other software helps by generating game levels automatically based on a description.

3.4.2.2.3 Development Platforms

The studies classified under this category proposed various types of platforms for game development. Development platforms provide a ready-made architecture for server-client

connectivity and help developers create games quickly. Open-source development platforms are available, but developers must customize them according to the required functionality. Peres *et al*. [S69] used a scrum methodology for game development, especially for multiple platforms, and implemented interfaces with social networking Web sites such as Twitter and Facebook. Jieyi *et al.* [S70] proposed a platform for quick development of mobile 3D games. First, the platform implemented the game template in two environments such as the Nokia series 60 platform (Nokia, 2009)and the Symbian OS. The second part of the process involved analysis of the entire game structure and extraction of game parameters for later customization. Finally, the tool could be used for game customization. Lin *et al*. [S73] developed intelligent multimedia mobile games for embedded platforms. The proposed communication protocol was able to control the embedded platform to make the game usable and entertaining. Mao *et al*. [S78] presented a logical animation platform for game design and development, and Alers and Barakova [S81] developed a multi-agent platform for an educational children's game. Suomela *et al*. [S77] highlighted the important aspects of multi-user application platforms for rapid game development. Some researchers have proposed a development platform similar to that described above that provides connectivity along with client customization and necessary updating of game servers.

3.4.2.2.4 Formal Language Description

Game semantics can be classified under formal language descriptions for programming languages; only two studies were reported under this classification. The formal language description of game semantics provided a way to gain insight into the design of programming languages for game development. Mellies [S99] proposed a denotational prepositional linear logic for asynchronous games, and Calderon and McCusker [S100] presented their analysis of game semantics using coherence spaces. Very little work has been reported in this area, and very few game semantic descriptions of languages have been published.

3.4.2.2.5 Programming

Code complexity is increasing, especially in game development, because of the incorporation of complex modules, AI techniques, and a variety of behaviours. The most common programming languages used in game development are object-oriented structured languages such as Java, C, and C++. Studies classified under this category explored the programming aspect of game development. Rhalibi *et al*. [S82] proposed a development environment based on Java Web Start and JXTA P2P technologies called Homura and NetHomura. This environment extends the JME game engine by facilitating content libraries, providing a new interface, and providing a software suite that supports advanced graphical functionalities within IDE. The other two studies, done by Meng *et al*. [S84] and Chen and Xu [S85], also explored programming languages such as C++, DirectX, and Web GL and Web Socket technologies for game development. Three studies by Yang *et al.* [S87], Yang and Zhang [S89], and Wang and Lu [S88] explored collision detection algorithms from a game logic aspect for software games, proposed A* search, and AI optimization-based algorithms.

Wang *et al.* [S83] proposed a game development framework based on J2ME technology. Zhang *et al*. [S92] also explored the effects of object-oriented technology on performance, executable file size, and optimization techniques for mobile games and suggested that object-oriented technology should be used with great care because structured programming in game development is highly competitive. Bartish and Thevathayan [S86] and Fahy and Krewer [S90] analyzed the use of agents, finite state machines, and open-source libraries for the overwhelmingly complex process of multi-platform game development. Optimization techniques can be used with object-oriented programming to avoid unnecessarily redundant classes and inheritance and to handle performance bottlenecks. These languages can be used across different development environments such as Android, iOS, Windows, and Linux. Researchers have proposed various approaches and tools for efficient game development. The integration of various development artefacts into games can also be done by generative programming, which also helps to achieve efficient development.

3.4.2.2.6 Game Engine

A game engine is a kind of special software framework used in the production phase for creating and developing games. Game engines consist mainly of a combination of core functionalities such as sound, a physics engine or collision detection, AI, scripting, animation, networking, memory management, and scene graphs. Hudlicka [S108] identified a set of requirements for a game engine, including identification of the player's emotions and the social interactions among game characters. This is the only study that has highlighted the important functionalities that an effective game engine must support. Another study by Wu *et al*. [S101] focused on game script engine development based on J2ME. It divided script engines into two types. The first type was a high-level script engine that included packaging and refining of the script engine. The second type, the low-level script engine, included feature packages associated only with API. Four studies, [S102], [S105], [S106], and [S107], explored the development of game engines on mobile platforms. Finally, Anderson *et al*. [S109] proposed a game engine selection tool. Recently, developers have been using previously developed or open-source game engines to economize on the game development process. Various researchers have proposed script-based, design pattern-based, and customizable game engines. In the GDLC process life cycle, game engines automate the game creation process and help a developer produce a game in less time.

3.4.2.2.7 Implementation

The foundations of game theory are used in game development because it is a branch of decision theory that describes interdependent decisions. Most studies in this category described different aspects of game implementation technologies on various types of platforms. They considered improving programming skills, 2D/3D animations and graphics, sound engineering, project management, logic design, story-writing interface design, and AI techniques. Various kinds of game implementation technologies can be found in the literature. Vanhutupa [S117] presented a survey of implementation technologies, especially for browser games. The technologies explored in these studies are mainly server applications (application runtime, server-side scripting, and user interface and communication), client applications, databases, and architecture. The same

study also described the accessories that can be used for implementation: application platforms, game engines, and various types of plug-ins. Karam and Abd El-Sattar [S112] proposed an interactive computer-based game framework for implementation. The framework includes steps from design through implementation that are based on game theory foundations and focus mainly on game models, Nash equilibrium, and strategies of play. The proposed framework includes architectural design and specifications, a proposed game overview, a game start-up interface and difficulty scaling, game modelling, the game environment and player control, and a free-style combat system.

Four studies, [S113], [S114], [S119] and [S120], focused mainly on a development framework for mobile devices. Su *et al*. [S113] proposed a framework describing implementation of various main modules such as pressure and movement, a thread pool based on the I/O completion port, and a message module. They also claimed that their proposed framework addressed the problems of traditional frameworks such as the single-server exhaustion problem, synchronization, and thread-pooling issues. Jhingut *et al*. [S114] discussed 3D mobile game implementation technologies from both single-player and multi-player perspectives. They also evaluated two game APIs: MDP 2.0 and M3G API. Finally, Kao *et al*. [S120] proposed a client framework for mobile devices that used a message-based communication protocol and reserved platform-specific data as much as possible. A few researchers have proposed agent-based frameworks as explored above for effective communication and synchronization between system components.

3.4.2.3 Post-Production Phase

3.4.2.3.1 Quality Assurance

Process validation plays an important role in assessing game quality. Collection and evaluation of process data from the pre-production phase through to the post-production phase either provide evidence that the overall development process produces a good-quality game as a final product or reveal that it cannot. Only two studies were reported under this classification. Stacey *et al*. [S125] used a story-telling strategy to assess the game development process. They carried out a two-year case study on a four-person development team. Astrachan *et al*. [S126] tried to validate the game creation process by

analyzing the development process and design decisions made during development. The scope of studies done under this category was limited. The case studies were done for small teams and were limited to only one phase. In the game development process, quality assurance and process validation are critical components, and standard methodologies are lacking. More exploration is needed to provide deeper insights. QA for games needs more research attention because very little work has been reported.

3.4.2.3.2 Beta Testing

Beta testing in games is used to evaluate overall game functionality using external testers. Beta testing is a kind of first public release for testing purposes by users. Game publishers often find it effective because bugs are identified by users that were missed by developers. If any desired functionality is missing, it must be addressed at this stage. This testing is performed before final game release. Under this classification, only four studies, [S127], [S128], [S129], and [S130], were reported. Hable and Platzer [S129] evaluated their proposed development framework for mobile game platforms. Omar *et al.* [S128] evaluated educational computer games and identified two evaluation techniques: *playability heuristic for educational games* (PHEG) for expert evaluators, and *playability assessment of educational games* (PAEG) for real-world users. The proposed AHP (Analytic Hierarchy Process)-based Holistic Online Evaluation System (AHP_HeGES), for educational computer games online evaluation tool can be used in the evaluation process. Very little work was reported in this category.

3.4.2.3.3 Heuristic-Based Testing

Heuristics are a kind of design guideline and can be used as an evaluation tool by game design developers or users. Basically, heuristics can be used in software engineering to test the interface. In games, evaluation must extend beyond the interface because other playability experiences such as the game story, play value, and mechanics also need evaluation. Six studies, [S132], [S133], [S134], [S146], [S147], and [S148], fell under this classification. Al-Azawi *et al.* [S132] proposed a heuristic testing-based framework for game development. The proposed framework divides testing by two types of user: experts and real-world users. Experts evaluate playability, game usability, and game

quality factors. Users evaluate the game as a positive or negative experience. Omar and Jaafar [S133] and Al-Azawi *et al*. [S134] proposed a framework for the evaluation phase in the game development process. Heuristic testing can be done during the development process and repeated from the early design phase. It is perfect for game testing because after the game is implemented, if anything goes wrong, it will be too expensive to fix and will affect the project schedule. This topic also needs attention by researchers.

3.4.2.3.4 Empirical Testing

Empirical testing approaches for the game-testing phase have been explored by only a few researchers. The approaches described by these researchers have focused only on final-product quality and usability. Only two studies were reported under this classification, [S135] and [S136]. Escudeiro and Escudeiro [S135] used a *quantitative evaluation framework* (QEF) to evaluate serious mobile games and reported that QEF frameworks are very important in validating educational games and final-product quality. Choi [S136] analyzed the effectiveness of usability-expert evaluation and testing for game development. Experimental results showed the importance of the validation process in game development. The scope of the studies done under this category was very limited, and other aspects of final-product testing have not been explored by researchers.

3.4.2.3.5 Testing Tools

Development of testing tools has not been addressed by many researchers. Only one study [S137] was reported under this classification. Cho *et al*. [S137] proposed testing tools for black-box and scenario-based testing. They used their tool on several online games to verify its effectiveness. Tools for game testing facilitate the testing process. The proposed scope of the study was also limited, and available testing tools have focused only on evaluation of online games.

3.4.2.3.6 Marketing

After a game has been developed, the final step is marketing. Marketing of games includes a marketing strategy and a marketing plan. The marketing strategy is directly related to the choice of users and the types of games that are in demand. The marketing

plan is something that a publisher can give to a distributor to execute on the publisher's behalf. Some studies have been done from the perspective of game-user satisfaction that provide a baseline for the factors that game developers must take into account for new game development. Yee *et al*. [S142] described a game motivation scale based on a three-factor model that can be used to assess game trends. Three studies, [S139], [S143], and [S144], empirically investigated the perspective of game-user satisfaction and loyalty. No study in the literature has directly captured a marketing strategy and a marketing plan for games.

3.4.3 GDLC Research Approach

Table 3.11 shows that most GDLC studies have used an exploratory and descriptive research approach. Figure 3.6 shows a comparison between the three research approaches used in the GDLC domain. Figure 3.7 shows a comparison among the empirical research methods used in the GDLC domain. The results suggest that surveys are most frequently used in GDLC domain research.

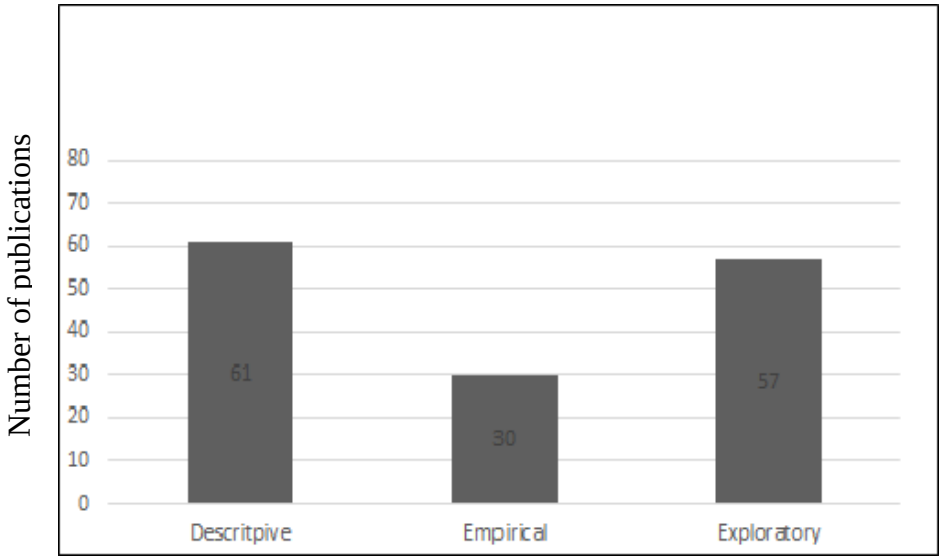

Figure 3.6 GDLC Research Approaches

These results were to be expected because the GDLC domain has been growing only since 2005; before 2010, most studies followed the descriptive approach because the field was young. After 2010, more studies have followed the exploratory approach because the domain has been maturing. More specifically, exploratory and descriptive approaches seem now to be equally used in the GDLC domain.

3.4.4 GDLC Empirical Research Methods

The experimental empirical method is less used in the GDLC domain, as mentioned by Wholin *et al*. (2000), because carrying out formal experiments requires significant experience. The case study method has also been used infrequently by researchers. The reason for this could be that case studies require project data obtained through various types of observations or measurements, and no research database or repository is available for the GDLC domain. Finally, the survey method was more common than the other two methods. This is reasonable because the GDLC domain is still immature and researchers are trying to produce knowledge by questioning game users, experts, and others.

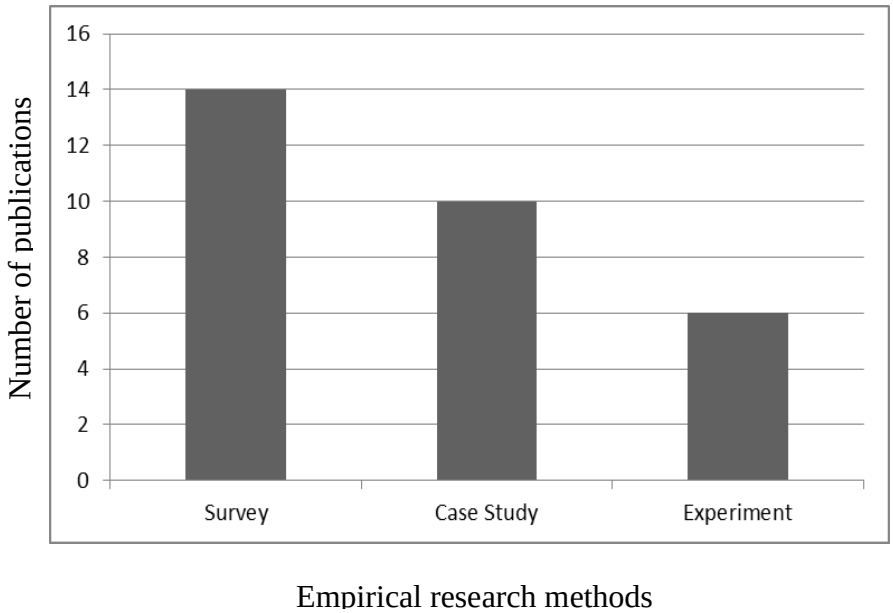

Figure 3.7 Empirical Research Approaches.

3.5 Threats to external validity

This section of the chapter mentions some possible threats and limitations to the validity of this study. In the literature, there is a chance that the word *game* was not part of the title of some studies, but that nevertheless they discussed game development. These studies may, therefore, have been excluded from the primary dataset by the search procedure. Other threats are also linked to a systematic literature review such as generalization and subjective evaluation (Shadish *et al*., 2002).

Moreover, there are limitations to the results obtained, although significant amounts of time and effort were spent to select the papers that were studied. More specifically, the search was limited to academic databases. It is obvious from the results of RQ1 that developers now prefer to submit their work on blogs or forums. However, posts on different game forums and blogs cannot be included in a systematic literature review because they do not fulfil the quality criteria used for paper selection. In addition, the exclusion of less-known journals and conferences from the Web of Science and the Scopus index might have led to a different dataset. Finally, the classification scheme might have altered the results if they were classified by a scheme, such as the waterfall model, instead of the ACM classification scheme. Despite these limitations, the results of our systematic literature review will be useful to game development organizations and developers of digital games to identify important topics.

3.6 Conclusion

The main objective of this chapter was to provide an insight into the GDLC domain because, in the past, researchers have pointed out that it is different from the traditional software development process. To achieve this objective, a systematic literature review was performed, which confirmed the first step of the evidence-based paradigm. The results also confirmed that the GDLC domain is different from the traditional software engineering development process and that research activity is growing day by day, attracting the interest of more researchers. This study describes the various topics in the GDLC domain and highlights the main research activities related to the GDLC. The

research topics identified under GDLC were a combination of different disciplines, and together they completed the game development process.

The most heavily researched topics were from the production phase, followed by the pre-production phase. On the other hand, in the post-production phase, less research activity was reported. In the pre-production phase, the management topic accounted for the most publications, whereas in the production phase, the development platform, programming, and the implementation phase attracted the most research. The production phase has attracted more research because game developers focus more on implementation and programming because of the limited game-development time period. The post-production phase included process validation, testing, and marketing topics. Very little research activity was observed in this area because the quality aspect of game development is not yet a mature field. In addition to research topics, more researchers used exploratory and descriptive research methods; as for empirical research methods, more surveys were carried out by researchers than case studies or experiments.

In summary, this chapter presents a systematic literature review of the GDLC topics. Overall, the findings of this study are important for the development of good-quality digital games because they highlight the areas that needs research attention. The results of this study have shown that the fragmented nature of the GDLC process requires a comprehensive evaluation strategy, which has not yet been entirely explored. Finally, this kind of research work provides a baseline for other studies in the GDLC domain and highlights research topics that need more attention in this area. The findings of this study will also help researchers to identify research gaps in the GDLC and highlight areas for further research contributions.

Chapter 4

4 Developer Perspective for Game Development: An Empirical Investigation[2]

The growth of the digital game development industry is enormous and is gaining importance day by day. This growth imposes severe pressure and a number of issues and challenges on the game development community. In addition to functional and technological requirements, game development includes other factors that are equally important to the success of any game project. One important game development choice is to consider the developer perspective to produce good-quality digital games by improving the game development process. Game development is a complex process, and for successful development of good-quality games, game developer must consider and explore all related dimensions as well as discussing them with the stakeholders involved. This chapter provides a better understanding of developer's perspective as a factor in digital game success. This study focuses mainly on an empirical investigation of the effect of key developer factors on the game development process and eventually on the quality of the resulting game. A quantitative survey was developed and conducted to identify key developer factors for an enhanced game development process. For this study, the developed survey was used to test the research model and hypotheses. The results provide evidence that game development organizations must deal with multiple key factors to remain competitive and to handle high pressure in the DGI. The main contribution of this study is to investigate empirically the influence of key developer factors on the game development process. To improve the current game development process and develop good-quality games, it is important for developers to consider the identified key factors.

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[2]Parts of this chapter were submitted in Journal of Computer Science and Technology:

S. Aleem, L.F. Capretz and F. Ahmed, (2016b). Critical success factors to improve the game development process from a developer's perspective, Journal of Computer Science and Technology, Springer, Submitted, 35 pages.

4.1 Research Motivation for Inclusion of the Developer's Perspective

A few talented individuals from diverse backgrounds like mathematics, and physics with no educational background in engineering or computer science developed the first digital games. At that time, developers were mainly focused on how to develop interesting games rather than on architecture or software engineering principles. The current success of the game industry, continuous enhancements in game technology, and the need to meet the ever-higher expectations of the players resulted in a complex game development process.

The main research motivations behind the inclusion of the developer's perspective in assessing the game development process are the rapid and continual changes in technology and the severity of competition among game development organizations. Nowadays, games are developed by large teams because game projects have grown in size and complexity (Blow, 2004). Various stakeholders are involved in the development process and have different expectations and world-views. For example, the game designer does not know the level of complexity involved in implementing artificial intelligence to represent the behaviour of a non-player character. A software engineer may think that some features in the game design document are infeasible to implement due to time deadlines or technical constraints. Another important requirement that must be part of the game is the fun, flow, and enjoyment factors. Game development processes have different phases and are influenced by many factors. Identifying the key success factors in a game development process is extremely important for sustaining the economic growth of the digital game industry.

However, very little research has been reported in the academic literature about key success factors for game development from a developer's perspective. Many topics in digital games need attention from researchers, as has been highlighted by some studies (Ampatzoglou & Stamelos, 2010; O'Hagan *et al*., 2014; Viana *et al*., 2014). Moreover, researchers and game developers have different points of view. Mostly, game developers

prioritize game development by rapid creation and implementation of content. On the other hand, scientists and researchers prioritize investigation and research into the individual components of a system. Researchers do not have resources to develop a standard game, whereas developers rarely publish the results of their experience. This indicates that there is a need for collaboration between researchers and developers that will be ultimately beneficial to game industry standards. This study also attempts to fill this communication gap between researchers and developers. The observations discussed above motivated us to carry out an empirical investigation of key success factors that can help developers to improve their development practices and will contribute towards the development of a maturity assessment model for digital games.

The rest of this chapter discusses the literature review of identified factors, describes the research methodology used for this study, and finally presents the results of the empirical investigation. A discussion and a set of conclusions from the study are also presented.

4.2 Literature Review of the Factors

In recent times, the DGI has seen unprecedented growth. To succeed in a highly competitive environment, game developers must bring innovative, good-quality games to the table. Identifying key success factors to improve the game development process will help developers to maintain the pace. Key factors in the game development process are the least addressed area in digital game research. Various factors have been identified from a literature review of published articles on digital games as a basis for discussion of the game development process. Table 4.1 briefly presents the identified factors, with references for each. The identified factors and the related literature are described in the following sub-sections.

4.2.1 Team Configuration and Management

The development of digital games involves multi-disciplinary team configuration and management. More specifically, team configuration and management are considered critical to the success of any game development project. Game development requires intensive team management (Claypool & Claypool, 2005). Team management can be defined as the process of administration and coordination between groups of individuals

who are performing specific tasks (Eric *et al*., 1990). It involves forming various groups, establishing collaboration among them, setting objectives for a common set of interpersonal dynamics among team members, and performance appraisals. The game development process also involves configuration and management of multidisciplinary teams or teamwork projects and management of collaboration among them. The term "teamwork" refers to a group of individuals who are completing a specific task (Muchinsky, 2003). The term *collaboration* can be defined as the level of shared understanding and coordination among teams and the maintenance of this level (Rossen *et al*., 2008).

Table 4.1 Identified Factors from Developer's Perspective

Factor	**References**
Team Configuration & Management	Claypool and Claypool (2005); Eric *et al*. (1990); Musil *et al*. (2010); Tran and Biddle (2008); Stacey *et al*. (2007); Barros *et al*. (2009).
Game Design Document Management	Kasurinen *et al.* (2014); Bosser (2004); Callele *et al.* (2005); Callele *et al.* (2010); Reyno and Cubel (2009); Almeida and da Silva (2013); Ahmed and Jaafar (2011); Bringula *et al.* (2014);
Game Engine Development	Robins (2009); Sherrod (2007); Cowan and Kapralos (2014); Hudlicka (2009); Yan-Hui *et al.* (2011); Rodkaew (2013); Vanhutupa (2011); Sousa and Garlan (2002); Aitenbichler *et al*. (2007); Pimenta *et al*. (2014); Neto *et al*. (2009); Peker and Can (2011).
Game Asset Management	Llopis (2004); Hendrikx *et al*. (2011); De Carli *et al*. (2011); Phelps (2005); Pranatio and Kosala (2010); Lasseter (1987); Xu and CuiPing (2009); Chehimi et al. (2006); Manocha *et al.* (2009); Pichlmair (2007); Migneco *et al.* (2009).
Quality of Game Architecture	Wang and Nordmark (2015); Amendola *et al*. (2015); Lukashev *et al*. (2006); Rhalibi *et al*. (2009); Jhingut *et al*. (2010); Kosmopoulos *et al*. (2007); Al-Azawi *et al.* (2014); Segundo *et al*. (2010).
Game Test Management	Redavid and Farid (2011); Helppi (2015); Charles *et al*. (2005); Wilson (2009); Marri & Sundaresaubramanian (2015); Kasurinen and Smolander (2014); Al-Azawi *et al*. (2013); Omar and Jaafar (2011); Straat and Warpefelt (2015).
Programming Practices	Robins (2009); Sarinho and Apolinario (2009); Czarnecki and Kim (2005); Chen *et al*. (2014); Anderson (2011); Zhang *et al*. (2007); Xu and Rajlich (2006); Wang and Norum (2006); Meng *et al.* (2004).

Very few research studies have investigated the importance of multidisciplinary team configuration and management in digital game development. Musil *et al.* (2010) highlighted the importance of heterogeneous team collaboration in the video game development process. They proposed a method based on the Scrum methodology to improve workflow integration and collaboration between heterogeneous game development team members. The proposed process separates the pre-production, production, and post-production phases. Management through collaboration and integration of heterogeneous disciplines in game development is achieved by executing daily heterogeneous discipline-specific workflows in a sprint iteration adjusted by daily scrums. They claimed that this approach will enable each discipline to use the workflows in which they are most proficient in accordance with the demands and pace of other involved disciplines.

Tran and Biddle (2008) discussed the collaboration factor for team management in serious game development. They explained that the collaborative process is based on ethnography and a qualitative approach. The proposed model includes many factors such as physical resources, social relationships, organizational goals, and team knowledge. They conducted a case study that determined that collaboration between multidisciplinary team requires teams to communicate frequently, to respect each other's contributions, and to share the same model and goals for game development. Stacey *et al*. (2007) and Barros *et al*. (2009) also investigated the collaboration factor in multidisciplinary game development teams and the development of computer games.

To determine whether proper team configuration and its management has any impact on the game development process, "team configuration and management" was selected as an independent variable, as shown in Figure 4.1. Hence, Hypothesis 1 can be stated as follows:

Hypothesis 1: Team configuration and management have a positive influence on the enhanced game development process.

4.2.2 Game Design Document Management

The GDD has also been identified as an important factor in improving the game development process. The GDD is the outcome of the pre-production phase of game development. It is developed and edited by the game design team to organize their efforts and their development process. The form of the GDD varies widely across studios and genres. Basically, the GDD includes the goals of the game, the genre of the game, the overall flow, the story behind the game, the characters and their dialogue, special effects, the number of elements and feature fits within the game, and feature creeping information if required. Typically, this document is developed to express the concept of the game and to provide a basis for requirements engineering in the game development process. Game designers can trace back all their efforts to the requirements analysis in the GDD.

In the game development process literature, researchers have explored the importance of the game design document and its management in various ways. Some of them have highlighted the importance of the GDD by discussing the importance of requirements engineering in game development. For example, Kasurinen *et al*. (2014) highlighted the importance of requirements engineering in the game development process. They interviewed 27 software professionals from game development organizations to obtain insight into their development process. The findings showed that the professionals follow approaches or methods that are somewhat comparable to requirements management and engineering, but not to particular requirements engineering practices. Bosser (2004) suggested that massively multi-player game design needs a prototyping tool and proposed a framework model to facilitate its design. They also suggested that game prototyping is important and helpful for better game design. Callele *et al*. (2005) also investigated the importance of requirements engineering in the video game development process. They suggested that the reasons for the failure of any game may be rooted in problems of transforming the pre-production phase document, i.e., the GDD, with any implied information and application of domain knowledge from the pre-production phase into the production phase.

An understanding of upcoming media and technology developments, game play, and non-functional requirements is also considered important for the GDD. Callele *et al.*

(2010) described how the GDD is helpful in obtaining a better understanding of the game design process and explained the definition of gameplay process in cognitive game development. Reyno and Cubel (2009) proposed a model-driven game development method that ultimately accelerates game design. Almeida and da Silva (2013) performed a systematic review of game design methods and of various available tools. They emphasized the use of standardized tools to develop the GDD. Other researchers have emphasized inclusion of the user perspective and have provided game design guidelines. Ahmed and Jaafar (2011) emphasized the importance of user-centered game design and proposed that it should be considered at the concept phase of game development. Bringula *et al*. (2014) gathered user perceptions to determine how a serious game should be developed. Based on their study, they suggested some design guidelines for four-dimensional game design, including storyline, aesthetics, reward systems, and the game objective.

To develop a good-quality game, the GDD must be properly managed so that production team members can easily move it into game production. GDD management has also been selected as an independent variable in this study, and therefore the following hypothesis is proposed:

Hypothesis 2: Formal documentation and management of the game design document has a positive and significant effect on the overall game development process.

4.2.3 Game Engine Development

Game engines are considered to be a powerful tool by game developers and have been in use for more than two decades. A game engine is a software layer that helps in the development process by enabling developers to focus solely on game logic and experimentation (Robin, 2009). Many commercial game engines are available to help game developers with advanced rendering technologies and code reuse, resulting in shorter development time and reduced cost. Sherrod (2007) defined the game engine as a "framework comprised of a collection of different tools, utilities, and interfaces that hide the low-level details of the various tasks that make up a video game". Overall, the game

engine represents the basic structure of the game as it appears in the middle layer, between the application layer and the various underlying platforms.

In the literature, most researchers often use the terms “game engine” and “game development framework” interchangeably. This study uses the term “game engine” to refer to the development tool that includes most of the functionality and features that become part of any digital game. The list of primary features that can be part of any modern game engine includes scripting, rendering, animation, artificial intelligence, physics, audio, and networking. Cowan and Kapralos (2014) performed a survey on different available frameworks and game engines used for serious game development only. They compared all the commercially available game engines and their various features. The results of their study suggested that most of the game engines that have been developed to create entertainment games could also be used for serious game development. Hudlicka (2009) suggested a set of requirements that are necessary for game engine development, specifically for affective games. Research has been also done on development of game engines specific to different platforms, such as for the Android platform (Yan-Hui *et al*., 2011), a 3D role-playing game for cross-platform development (Rodkaew, 2013), and browser games (Vanhutupa, 2011).

A few researchers have explored the means of addressing the challenges faced by developers in supporting and building development tools (Sousa & Garlan, 2002; Aitenbichler *et al*., 2007). However, they were not successful in achieving the required feature and design flexibility. Researchers proposed different solutions for game engines to address the challenges they faced. Pimenta *et al*. (2014) proposed that game engines enable fast learning for game developers and include the ubiquitous characteristics of the game design and development process. Neto *et al*. (2009) discussed the issue of game engine standardization in digital game development. Game developers are interested in producing the same game for different platforms and rely mostly on the same game engine. They suggested that commonality and variability assessment must be done to enable game engine reuse. Peker and Can (2011) proposed a methodology for developing game engines for mobile platforms based on design goals and design patterns. They emphasized the need to design goals and strategies for implementation in the game

engine. For mobile platforms, the basic design goals suggested by them were usability, efficiency, portability, and adaptability. To determine whether standard game engine development has a positive impact on the overall game development process, game engine development was considered as an independent variable in this study. Hence, the following hypothesis is proposed:

Hypothesis 3: Game engine development has a significant impact on the game development process.

4.2.4 Game Asset Management

Anything can be considered as a game asset that contributes to the visual appearance of a game, whether artwork (including 3D elements or textures), music, sound effects, dialogue, text, or anything else. Llopis (2004) stated that "game assets include everything that is not code: models, texture, materials, sound, animations, cinematics, scripts, etc." Actually, game assets include any piece of data that can be used by a game engine aside from code, scripts, and documentation. The elementary unit of game assets can be referred to as a game bit (Hendrikx *et al*., 2011) and typically has no value when considered independently. There are two categories of bits: characters, which can be an asset that interacts in a simulated environment, and abstract bits, which are kinds of sound and texture that can be used together to produce a concrete bit. The main nine kinds of game bit are texture, sound, vegetation, buildings, fire, water, stone, clouds (concrete), and behaviour. Game space definition is another game asset, which is part of content generation for any game. It provides a kind of game environment where game bits can be placed.

In the literature covering game asset creation and management, researchers have explored game assets in term of animation, audio processing libraries for different genres, and content generation for games. De Carli *et al*. (2011) and Hendrikx *et al*. (2011) carried out a survey of procedural content generation techniques for game development. Animation in games is considered an important asset because it has a great impact on game performance (Phelps, 2005). Studies have been done to explore animation models for different game genres. Pranatio and Kosala (2010) performed a comparative study of

keyframes (Lasseter, 1987) and skeletal animations (Maestri, 2006) for multiplayer games. Their results indicated that skeletal or bone-based frames are better than keyframe models in term of memory load and frames per second. Xu and CuiPing (2009) reviewed currently used 3D accelerators for graphics animation. A wide variety of graphics cards are available to programmers. Hence, they discussed the current benefits and limitations of APIs such as OpenGL and DirectX. Chehimi *et al*. (2006) described the evolution of 3D graphics for mobile platforms. They concluded that the current market presents challenges regarding graphics quality and battery life of mobile devices. These need to be addressed by standardizing successful game development for mobile platforms.

Sound within a game is one of the game assets that enable developers to build responsive, interactive, and attractive games. Currently, game development relies on pre-recorded sound clips that can be triggered during any game event (Manocha *et al*., 2009). These can be managed through dynamic audio processing libraries. Researchers have also studied the use of audio processing libraries in digital game development. Pichlmair (2007) studied music games and determined that they can be classified into two categories, rhythm and instrument games. Their analysis showed that music in video games has seven qualities: rhythm, active score, quantization, synesthesia, play as performance, sound agents, and free-form play. Migneco *et al*. (2009) proposed an audio processing library to enable use of sound in Web-based games using a Flash development tool. They claimed that this approach provided flexibility and great functionality for developing games using Flash technology.

For the reasons discussed above, creation and management of the number of assets required for game development has become challenging. Mechanisms are needed to control the different versions of assets that are developed for games. Commercially, a number of tools are available, such as 3D Studio Max, Maya, and Adobe Photoshop, which can also create various assets like textures, 3D models, animations, sound effects, music, voice recordings, levels, and scenes. Modern game engines also include modules for asset management. Based on a literature review of game asset management, this study has considered game asset management as another independent variable that is

considered important for the game development process. Hence, the following hypothesis is proposed:

Hypothesis 4: Game asset management is important for enhancing the game development process.

4.2.5 Quality of Game Architecture

The primary function of game architecture is to support game play. It helps to define challenges by using constraints, concealment, exploration, and obstacles or skill testing. Game architecture is a kind of blueprint for the underlying complex software modules. It is used to delineate design, perform trade-off analysis, and investigate system properties before implementation and potential reuse. Basically, it draws together gameplay factors and technical requirements. Perfect game architecture would have modularity, reusability, robustness, and tractability features.

The importance of software architecture in game development has rarely been researched. Wang and Nordmark (2006) have explored this topic. Their finding was that software architecture plays an important role in game development, with the focus mainly on achieving high performance and modifiability. They also stated that most developers use game-specific engines, middleware, and tools for game development. A number of studies have explored these various development frameworks. The proposed game development frameworks can help game developers to define their game architecture. Amendola *et al.* (2015) proposed a framework for experimental game development called GLIESE. They proposed that a game architecture should have at least three sub-systems: a game logic processing system (view and model), a graphic processing system (graphic interface and view interface), and an input processing system (event manager, controller, and event publisher). These sub-systems must be clearly separated so that they can work independently. The authors suggested a *model-view-controller* (MVC) (Gamma *et al.*, 1995) pattern for the architecture. Basically, this pattern divides the application into three components: model, view, and controller. The defined relations and collaboration among these components helps in game deployment because ultimately the code associated with each sub-system’s logic will operate in the desired manner.

Lukashev *et al.* (2006) proposed a mobile platform development framework specifically for 3D application. They claimed that their suggested approach would help developers improve the development process. The first stage of the proposed framework is the design phase for creation of the initial model (2D or 3D) and selection of the right modelling tool and graphic format. The second stage, the integration stage, enables developers to put together already-created models into scenes and create animation. The authors suggested that a structural optimization technique could be used to create scenes. The next stage is the utilization stage, in which the created models are converted to mobile format. Implementation is the final step of the framework, where developers put together source code, auto-generated source code, and created resources. Several other studies have also been performed to propose development frameworks for various platforms based on different technologies for defining the system architecture. For example, Rhalibi *et al.* (2009) proposed a 3D Java framework for Web-based games, Jhingut *et al.* (2010) and Kosmopoulos *et al.* (2007) proposed a framework for mobile platforms, Al-Azawi *et al.* (2014) proposed an agent-based agile methodology for game development, and Segundo *et al.* (2010) proposed a game development framework specific to the Ginga middleware.

From the preceding discussion, it is clear that the quality of the game architecture is important for the game development process, and therefore it was considered as another independent variable in this study. The following hypothesis is therefore presented:

Hypothesis 5: Quality of game architecture has a positive impact on the enhanced game development process.

4.2.6 Game Test Management

Game testing is a very important phase of game development. A game can be tested at different levels of development because game testing is different from software testing (Redavid & Farid, 2011). There are many steps involved in game testing other than test-case definition because most game testing is based on black-box testing. Hence, management of overall game test methods becomes crucial. In the pre-production phase, a test plan document should be established to set standards for the game software. Game

quality can be evaluated according to the graphics, sounds, and code that are compiled into the game code. Proper documentation of testing helps developers fix problems more quickly and cheaply. Delays in testing can result in project failure.

Helppi (2015) discussed many game test methods that can be used during the development phase, such as smoke testing that is used to test the user interface logic. Regression testing is performed to check that game quality is still good after any change such as addition of features or add-on components. Connectivity testing is used for networking games and mobile games to test client-server interaction. Performance testing can ensure the real performance of the game. Abuse testing is performed by giving multiple inherent inputs through the controller and determining game performance. Compliance testing makes sure that any compliance standards enforced by any stakeholder are met. Finally, functional testing verifies overall game play and reveals issues related to stability, game flow, game mechanics, integration of graphic assets, and the user interface. Redavid and Farid (2011) also discussed game testing methods used to detect interaction failures and listed them under the term *combinatorial testing* (Helppi, 2015). The second approach involves test flow diagrams, which are used to develop models of game behaviour from a player's perspective. Third is cleanroom testing, which helps to determine game reliability. The test tree is another testing method discussed by the authors, which can be used to organize test cases.

Wilson (2009) also argued that we cannot compare testing methods and rate them as better or not. He suggested that good testing is a combination of 30% *ad-hoc* testing, 40% test cases, and 30% alternating between the two until the strengths of both are determined. Marri and Sundaresaubramanian (2015) discussed game test methods and suggested that the game tester should test game quality by verifying game play, logical consistency, observability, progressive thinking, and reasoning ability, as well as exhaustively testing features, game strategy, and functionality. Kasurinen and Smolander (2014) interviewed seven game development teams from different organizations and studied how they test their games based on grounded theory. They concluded that all participating organizations had the resources to perform technical testing, but that they relied mostly on exploratory and usability testing rather than using a pre-planned

approach. Al-Azawi *et al.* (2013) proposed a set of evaluation heuristics that could be used in game development methodologies for most game genres. Omar and Jaafar (2011) proposed a tool to evaluate the usability of educational games, and Straat and Warpefelt (2015) suggested use of the two-factor theory to evaluate game usability.

Management of game testing during the game development process has clearly come to be of crucial importance for game developers. Hence, test management was selected as another independent variable in this study, and the following hypothesis was proposed:

Hypothesis 6: Game test management has a positive impact on the enhanced game development process.

4.2.7 Programming Practices

Good programming practices are a very important factor in successful game development. A programming team with the necessary skills is definitely considered as the backbone of the game development process. The programmer must select the right coding architecture for each game project. Basically, the lead programmer must select between two types of coding style: either game-specific code (the programmer has to develop everything by him/herself) or game-engine code (where the game engine is the foundation for a game-specific code). The game code can then be organized in various ways (Robin, 2009), such as an *ad-hoc* architecture where the programmer must deal with tightly coupled code. Another choice is a modular architecture-based coding style, where the programmer identifies and separates the code into different modules or libraries. In this type of programming, reuse and maintainability are improved over *ad-hoc*-based coding. However, dependencies between different modules cannot be controlled, which may lead to tight coupling. The directed acyclic graph (DAG) is another way of organizing code. This is also a modular architecture-based coding scheme in which dependencies between modules are tightly controlled. Layered-style coding is also based on a DAG architecture, but modules are arranged in rigid layers, and each can interact only with the modules in the layer directly below.

Game programming involves a wide range of issues and considerations. Most researchers have tried to address these individually. The first is the issue of coupling between different modules. Sarinho and Apolinario (2009) tried to address this problem using a proposed generative programming approach. Generative programming aims to automate the software development process using a number of static and dynamic technologies including reflection, meta-programming, and program and model analysis (Czarnecki & Kim, 2005). The proposed method was based on a game feature model that could represent both common and variable implementation aspects of digital games. Meta-programming resources were used to generate and represent compatible source code for available game frameworks and game engines. The authors concluded that the proposed approach would result in loss of the coupling development strategy between game implementation and its domain software artifacts. Code cloning in open-source games is another issue discussed by Chen *et al.* (2014). They provided a detailed study of the issues of code clones in more than twenty open-source game projects based on C, Python, and Java for various game genres. Selection of a scripting language is another issue in game programming. Anderson (2011) discussed the classification of scripting systems used for digital games. Xu and Rajlich (2006) described a study that explored pair programming practices and concluded that paired programmers completed their task faster with higher quality. They suggested that pair programming is a good approach for game development.

Selection of a programming language is another challenge for today's game developers. Many studies have been done to explore different programming languages for different platforms. Zhang *et al*. (2007) performed experiments on five industrial RPG mobile games developed using the object-oriented programming paradigm. Optimization strategies with structural programming were applied to the same code. The results of the study showed that object-oriented programming must be used with great care and that structural programming is also a good option for mobile game development. Another study (Wang & Nordmark, 2015) highlighted the issues for game development posed by wireless peer-to peer games in a J2ME environment using an available Bluetooth API. The issues discussed included slow device discovery, Bluetooth transfer speed, extra resource consumption, and Bluetooth topology. Meng *et al.* (2004) developed a peer-to-

peer online multiplayer game using DirectX and C# to achieve playability in a .Net environment. Moreover, uniform programming style with good commenting and standard naming and coding conventions must be used to avoid errors in the code.

According to the above discussion, programming practices were selected as an independent variable in this study, and the following hypothesis was proposed:

Hypothesis 7: Good programming practices are important for the enhanced game development process.

4.3 Research Model

The main objective of the proposed research model is to analyze the interrelationship between key factors and game development and also to understand the influence of these factors on overall game quality in the DGI market. The model's theoretical foundation is based on existing concepts found in the game development literature. It is noted that most studies in the literature discuss one or two of the factors mentioned above for digital games and their impact on the overall game development process. To the best of our knowledge, this is the first study in the game development literature that highlights key factors in game development. This study proposes to investigate empirically the influence and association of key game development factors. Figure 4.1 presents a theoretical research model used in this study, which is empirically investigated. The theoretical model evaluates the relationships of various independent variables emerging from software engineering and management concepts such as project management, theory, and behaviour with the dependent variable, enhanced game development, in the context of the game development process. This study mainly investigates and addresses the following research question:

Research Question: How can game developers improve the game development process?

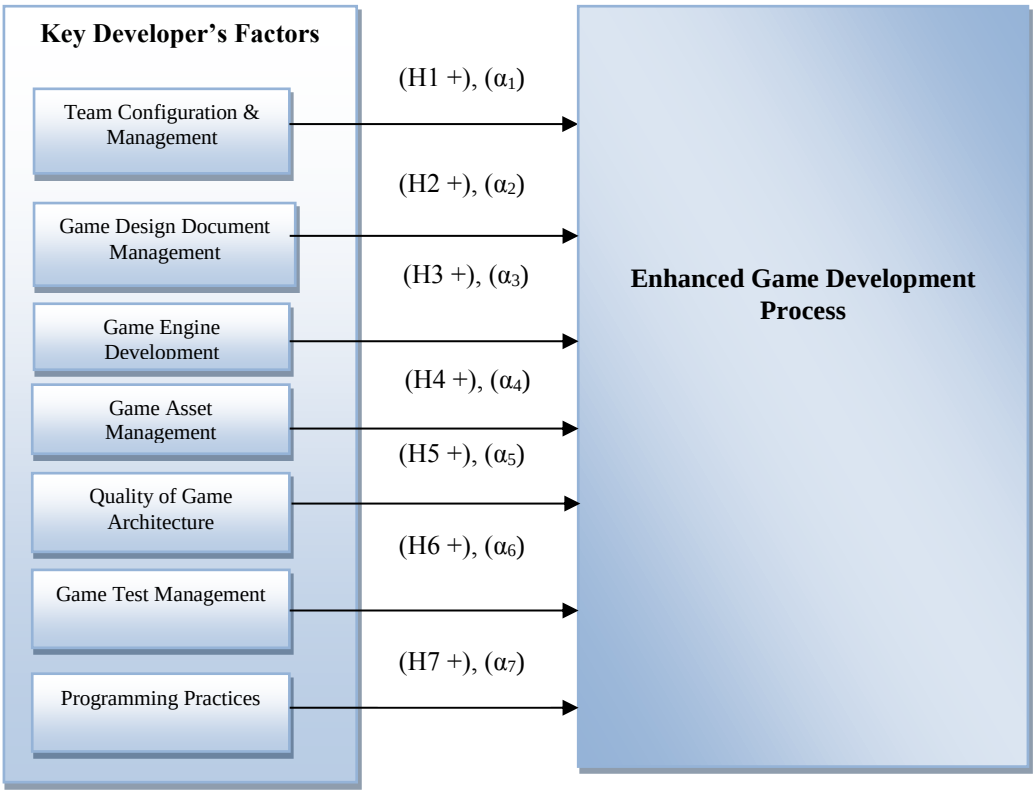

Figure 4.1 Research Model

The research model includes seven independent variables: team configuration and management, game design document management, game engine development, game asset management, quality of game architecture, game test management, and programming practices, and one dependent variable: the enhanced game development process. The multiple linear regression equation of the model is given as Equation 4.1:

Enhanced game development process = $\alpha_0 + \alpha_1 f_1 + \alpha_2 f_2 + \alpha_3 f_3 + \alpha_4 f_4 + \alpha_5 f_5 + \alpha_6 f_6 + \alpha_7 f_7$, where α_0, α_1, α_2, α_3, α_4, α_5, α_6, α_7 are coefficients and f_1–f_7 are the seven independent variables.

4.4 Research Methodology

Developing a digital game involves phases such as pre-production, production and post-production, in which each phase contains a number of activities. Some of these activities

are dependent on others, whereas some are independent. Employees of game development organizations or studios were selected as the targeted respondents of this study. In this study, the term “developer” is used to refer to any game development team member. For purposes of data collection, we initially joined various game development community forums. We also started blogs on game development groups and sent posts on social media about an empirical study request (the list of online sources and screen shots of data collection strategies are attached as Appendix III). Personalized emails were also sent by us to various game developers based on personal contacts or referrals by friends. The respondents participating in the study were part of multinational organizations in Asia, Europe, and North America; statistics describing them are presented in Figure 4.2

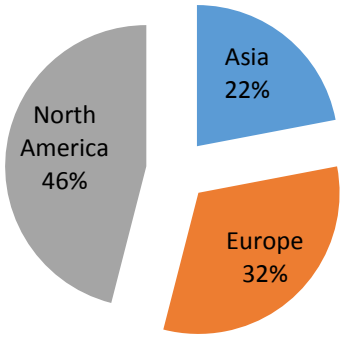

Figure 4.2 Distribution of Respondents by Continent

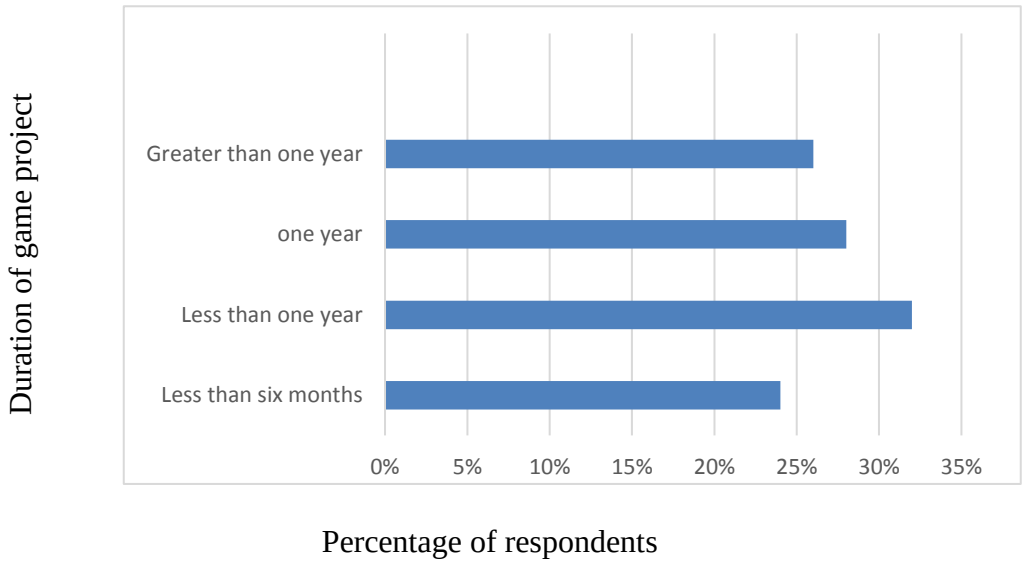

Figure 4.3 Total Software Game Development Duration of Particular Game Projects Considered by Respondents.

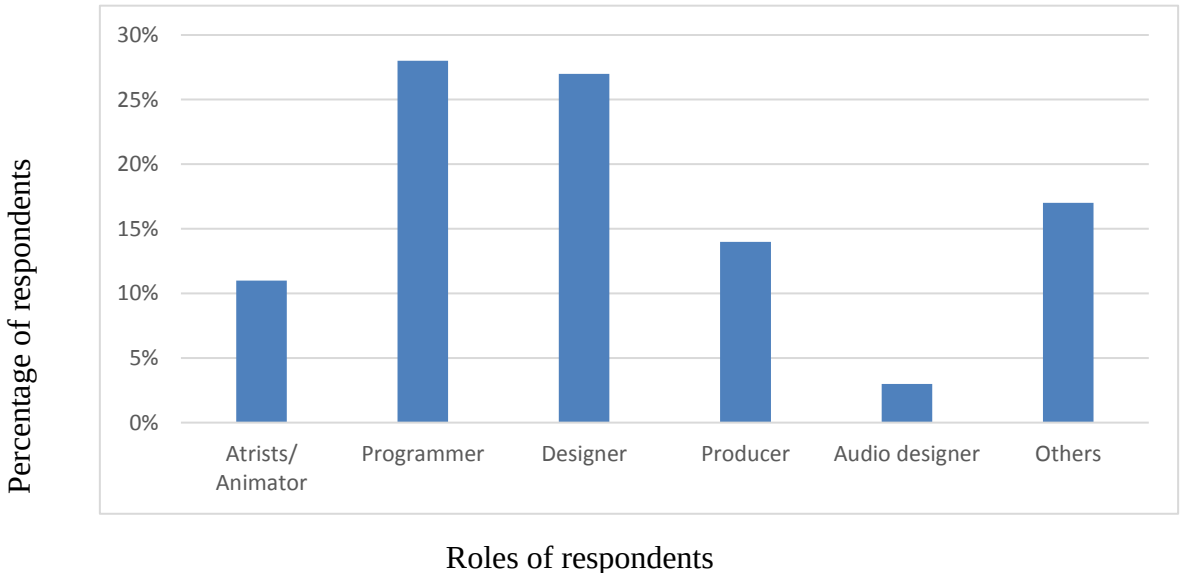

Figure 4.4 Number of Respondents Based on Their Role in the Development Process.

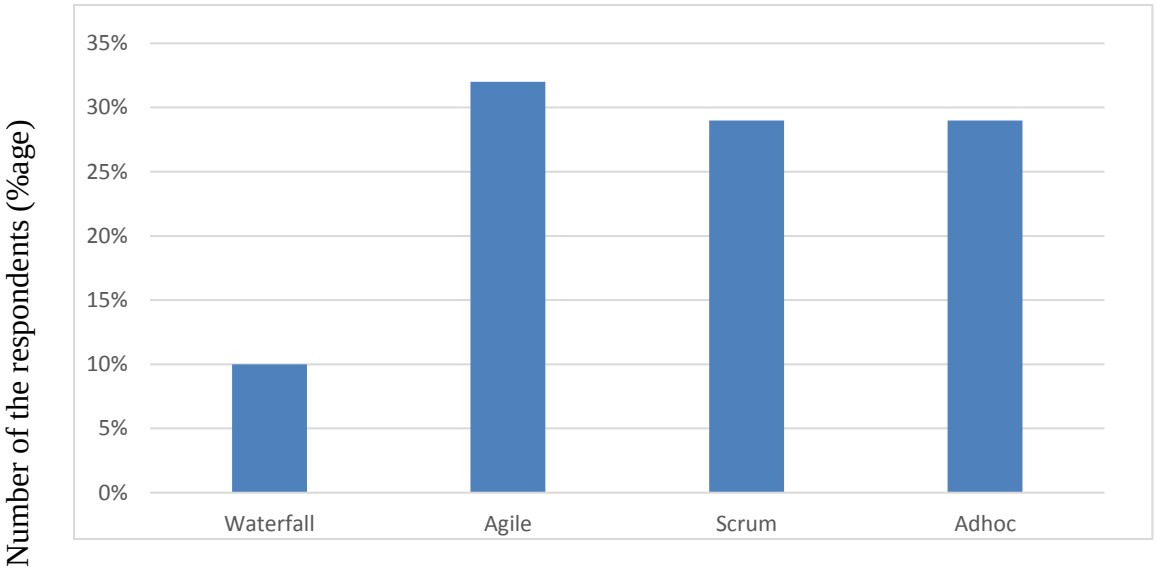

Figure 4.5 Percentage of Development Methodologies used by Respondents

The organizational participants agreed to take part in the study based on a mutual agreement that their identities would be kept confidential. The size of the game project development teams varied from 10 to 50. Figure 4.3 shows the total time period of the game development projects considered by respondents while answering the measuring instrument. Figure 4.4 represents the number of respondents based on their development role in the game project. Figure 4.5 shows the percentage of development methodologies used by respondents for any particular game project.

The participants in the study were mainly part of game projects that were developed for different platforms such as kiosks and standalone devices, the Web, social networks, consoles, PC/Macs, and mobile phones. The game genres implemented in most of their projects included action or adventure, racing, puzzles, strategy/role playing, sports, music-based, and other categories. The qualifications for this study were that the respondent must be a part of a development team that had at least three full-time developers; that the respondent worked on the project for at least one-third of its total duration; and that the project was either completed or cancelled within the last three years.

Finally, respondents must have worked in the development team in some sort of development role, such as a designer, artist, animator, programmer, producer, or sound designer. The survey respondents worked in various capacities such as game designer, artist, programmer, audio designer, and producer. The total number of survey respondents was 118, including a minimum of one and a maximum of four responses from each organization.

4.4.1 Measuring Instrument

This study gathered data on the key developer's factors and the perceived level of enhanced game development process identified in the research model depicted in Figure 4.1. To learn about these two topics, the questionnaire presented in Appendix IV was used as a data collection instrument. First, organizations involved in the game development process were asked to what extent they practiced the identified key developer factors for the game development project in question. Second, they were asked what they thought of the enhanced game development process for different games in the digital game industry. The five-point Likert scale was used in the questionnaire, and with each statement, the respondents were required to specify their level of agreement or disagreement. Thirty-four items were used to measure the independent variables (the key factors), and for the dependent variable (enhanced game development process), nine items were used. The literature related to key developer's factors was reviewed in detail to ensure a comprehensive list of measurement items for each factor from the literature. A multi-item, five-point Likert scale was used to measure the extent to which each key developer factor was practiced for the game development project. The Likert scale ranged from (1) meaning "strongly disagree" to (5) meaning "strongly agree" and was associated with each item. The items for each identified factor were numbered from 1 to 34 in Appendix IV and also labelled sequentially. They were measured for each project that was completed within the last three years based on a multi-item five-point Likert scale. To the best of our knowledge, this is the first empirical study of key digital game developer's factors for the enhanced game development process in the DGI.

4.4.2 Reliability and Validity Analysis

To perform reliable and valid research, quantitative analysis was carried out. Two integral measure of precision, reliability and validity analysis, were used to conduct empirical studies. The consistency or reproducibility of a measurement is referred to as *reliability*. On the other hand, valid inference or agreement between the measured and true values is referred to as *validity*. The measuring instrument designed for this study was also tested by reliability and validity analysis. The test was based on common practices usually used for empirical analysis. Reliability analysis was performed to determine the internal consistency of the multi-scale measurement items designed for the seven identified factors. To evaluate internal consistency, Cronbach's alpha (1951) coefficient was used. Criteria for Cronbach's alpha ranging from 0.55 to 0.70 were considered satisfactory. Researchers have reported different ranges of satisfactory criteria for Cronbach's alpha based on their findings. Osterhof (2001) suggested that a value of 0.60 or higher was satisfactory for reliability coefficients based on his findings. Nunnally and Brenste (1994) reported that a value of 0.70 or higher for a reliability coefficient can be considered satisfactory for any measuring instrument. Van de Ven and Ferry (1980) recommended that a value of 0.55 or higher of the reliability coefficient could be considered satisfactory. A first calculation was performed on the sample dataset to determine the reliability of the dataset using Cronbach's alpha coefficient.

Some of the assessment items for each factor were excluded if they affected the desired value of Cronbach's alpha coefficient. In the sample dataset, other than item no. 1 of team and configuration management, item no. 10 of game design document management, item no. 18 of game engine development, item no. 22 of game asset management, and item no. 30 of programming practices, all assessment items were found reliable. Hence, item nos. 1, 10, 18, 22, and 30 were removed from the instrument. After this, the whole dataset was evaluated using Cronbach's alpha coefficient. The results of these calculations showed that reliability coefficients for the seven factors ranged from 0.61 to 0.76. These coefficients are reported in Table 4.2. Hence, all variables developed for this study could be considered reliable.

Table 4.2 Cronbach's Alpha Coefficient and PCA of Seven Variables

Developers' factor	**Item no.**	**Coefficient α**	**PC eigenvalue**
Team Configuration & Management	1–6 (excluded 1)	0.63	1.48
Game Design Document Management	7–11 (excluded 10)	0.60	1.51
Game Engine Development	12–18 (excluded 18)	0.68	1.49
Game Asset Management	19–22 (excluded 22)	0.81	1.57
Quality of Game Architecture	23–25	0.84	1.01
Game Test Management	26–29	0.64	1.79
Programming Practices	30–34 (excluded 30)	0.86	1.25

Validity analysis was performed for the dataset using principal component analysis (PCA) (Huh *et al*., 2007). PCA is usually used for convergent validity analysis and was calculated here for seven factors. Campbell and Fiske (1959) suggested that convergent validity has occurred in a given case only if the scale items in a measurement instrument are highly correlated and if they move in the same direction in a given assembly. The construct validity of PCA-based analysis was determined using the eigenvalue criterion (Kaiser, 1960). Here, a criterion value greater than one was used to retain any component based on the Kaiser criterion (Kaiser, 1960). Eigenvalue analysis showed that out of the seven variables, five together formed a single factor, whereas game design document management and programming practices loaded on a second factor, and both eigenvalues were greater than one. The reported convergent validity of this study was considered adequate.

4.4.3 Data Analysis Techniques

To perform the empirical investigation for this study, various statistical approaches were used. Initially, the research activity was divided into three phases to evaluate the significance of the proposed hypotheses H1–H7. In phase I, parametric statistical and normal distribution tests were performed. A non-parametric statistical approach was used

in phase II, and for the analysis, a *partial least squares* (PLS) analysis was carried out in Phase III.

To address external threats to validity, both parametric and non-parametric approaches were used. The measuring instrument contains multiple items for each independent and dependent variable, and respondent ratings were aggregated to obtain a composite value. Using a parametric statistical approach in phase I, the Pearson correlation coefficient was calculated for the tests, with a one-tailed *t*-test for each hypothesis H1–H7. For phase II, the Spearman correlation coefficient was used to test hypotheses H1–H7 using a non-parametric statistical approach. Phase III of the empirical investigation was carried out to address issues of non-normal distribution and complexity or small sample size of the dataset. Fornell and Bookstein (1982) and Joreskog and Wold (1982) reported that if non-normal distribution, complexity, small sample size, and low theoretical information are issues, then partial least squares (PLS) analysis will be helpful. The PLS technique was used in Phase III to increase the reliability of the results and deal with the limitation of small sample size. For statistical calculations, Minitab 17 software was used.

4.5 Data Analysis and Results

4.5.1 Phase I of Hypothesis Testing

To test hypotheses H1–H7, parametric statistics were used in this phase. The Pearson correlation coefficient was determined between the independent variables (developer's factors) and the dependent variable (the enhanced game development process) of the research model, as illustrated in Figure 4.1. The level of significance to accept or reject the hypotheses was then selected. Each hypothesis was accepted if its *p*-value was less than 0.05 and rejected if its *p*-value (Westfall &Young, 1993) was greater than 0.05. In Table 4.3, calculated results for the Pearson correlation coefficient are listed.

Table 4.3 Hypothesis Testing using Parametric and Non-Parametric Correlation Coefficients

Hypothesis	Key factor	Pearson correlation coefficient	Spearman correlation coefficient
H1	Team configuration and management	0.29*	0.29*
H2	Game design document management	0.79*	0.74*
H3	Game engine development	0.59*	0.64*
H4	Game asset management	0.45*	0.47*
H5	Quality of game architecture	0.13**	0.19**
H6	Game test management	0.42*	0.37*
H7	Programming practices	0.52*	0.48*

*Significant at $p<0.05$ **Insignificant at $p>0.05$

Hypothesis H1 was accepted because the Pearson correlation coefficient between team configuration and management and the enhanced game development process was positive (0.29) at $p<0.05$. For hypothesis H2 concerning game design document management and the enhanced game development process, the Pearson correlation coefficient was also positive (0.79) at $p<0.05$, and therefore hypothesis H2 was also accepted. Hypothesis H3 concerning game engine development and the enhanced game development process was accepted due to a positive (0.59) correlation coefficient at $p<0.05$. Hypothesis H4 concerning game asset management and the enhanced game development process was accepted based on its positive Pearson correlation coefficient (0.45) at $p<0.05$. Hypothesis H5 concerning quality of game architecture and the enhanced game development process was rejected based on its positive correlation coefficient (0.13), but higher $p>0.05$. Hypothesis H6 regarding game test management and the enhanced game development process was accepted due to its positive Pearson correlation coefficient (0.42) at $p<0.05$. The last hypothesis (H7) relating programming practices to the enhanced game development process was also found to be significant (0.52) at $p<0.05$ and was therefore accepted. Hence, in summary, hypotheses H1, H2, H3, H4, H6, and H7 were accepted and found to be statistically significant. Hypothesis H5 was not supported statistically and was therefore rejected.

4.5.2 Phase II of Hypothesis Testing

Hypotheses H1–H7 were tested based on the non-parametric Spearman correlation coefficient in phase II. Table 4.3 reports the results for the Spearman correlation coefficient. Hypothesis H1 regarding team configuration and management was accepted because of its positive Spearman correlation coefficient (0.29) at $p<0.05$. The Spearman correlation coefficient for game design document management and the enhanced game development process (hypothesis H2) was also positive (0.74) at $p<0.05$ and was also found to be significant. The relationship between game engine development and the enhanced game development process game (hypothesis H3) was found to be statistically significant due to its Spearman correlation coefficient (0.64) at $p<0.05$ and was accepted. For hypothesis H4 regarding game asset management, the Spearman correlation coefficient was positive at $p<0.05$, and therefore H4 was accepted.

Table 4.4 PLS Regression Results for Hypothesis Testing

Hypothesis	**Key Developer's Factor**	**Path coefficient**	R^2	***F*-Ratio**
H1	Team configuration and management	0.29	0.08	11.35*
H2	Game design document management	0.74	0.56	148.9*
H3	Game engine development	0.59	0.34	62.09*
H4	Game asset management	0.07	0.006	0.72*
H5	Quality of game architecture	0.13	0.02	2.3**
H6	Game test management	0.42	0.18	26.20*
H7	Programming practices	0.52	0.27	44.45*

*Significant at $p<0.05$ **Insignificant at $p>0.05$

Hypothesis H5 concerning quality of game architecture and the enhanced game development process was rejected due to its value of $p>0.05$. Hypothesis H6 concerning game test management and the enhanced game development process was accepted due to its positive Spearman correlation coefficient (0.37) at $p<0.05$. The last hypothesis (H7) relating programming practices to the enhanced game development process was also found to be significant (0.48) at $p<0.05$. In summary, hypotheses H1, H2, H3, H4, H6,

and H7 were accepted and found to be statistically significant. Hypothesis H5 was not supported statistically and was therefore rejected.

4.5.3 Phase III of hypothesis testing

Hypothesis testing in phase III was performed using the partial least squares (PLS) technique. The main reason for using the PLS method in this phase was to cross-validate the results obtained from the parametric and non-parametric statistical approaches used in Phases I and II and to overcome their associated limitations.

Tests were also performed on hypotheses H1–H7 to check their direction and significance. The dependent variable, i.e., the enhanced game development process, was designated as the response variable and other individual factors (independent variables) as the predicate variables for PLS examination. The observed results of the structural hypothesis tests are presented in Table 4.4. The table also includes the values of the path coefficient, R^2, and the *F*-ratio.

Table 4.5 Linear Regression Analysis of the Research Model

Model coefficient name	**Model coefficient**	**Coefficient value**	**t-value**
Team configuration and management	α_1	0.06	1.14*
Game design document management	α_2	0.50	7.44*
Game engine development	α_3	0.31	5.19*
Game asset management	α_4	0.21	0.38*
Quality of game architecture	α_5	0.03	6.57**
Game test management	α_6	0.13	2.24*
Programming practices	α_7	0.10	1.58*
Constant	α_0	0.01	1.13*
$\boldsymbol{R^2}$	0.83	**Adjusted $\boldsymbol{R^2}$**	0.68
***F*-ratio**	36.97*		

*Significant at $p<0.05$ **Insignificant at $p>0.05$

The path coefficient for team configuration and management (H1) was observed to be 0.29, with an R^2 of 0.08 and an *F*-ratio of 11.35, and H1 was therefore found to be significant at $p<0.05$. Game design document management (H2) had a positive path

coefficient of 0.74, R^2 = 0.56, and *F*-ratio = 148.9 and was also found to be statistically significant at $p<0.05$. Game engine development (H3) had a path coefficient of 0.59, a low R^2 of 0.34, and an *F*-ratio of 62.09 and was found to be significant at $p<0.05$. Game asset management (H4) had a positive path coefficient of 0.07, a very low R^2 of 0.06, and an *F*-ratio of 0.72 and was judged to be significant because the *p*-value was less than 0.05. Quality of game architecture (H5) (path coefficient: 0.13, R^2: 0.02, and *F*-ratio: 2.3) was found to be statistically insignificant at $p<0.05$. Game test management (H6) (path coefficient: 0.42, R^2: 0.18, and *F*-ratio: 26.20) and programming practices (path coefficient: 0.52, R^2: 0.27, and *F*-ratio: 44.45) were found to be significant at $p<0.05$.

4.6 Research Model Testing

The linear regression equation for the research model is given by Eq. 4.1. The research model was tested to provide empirical evidence that factors important to game developers play a considerable role in improving the overall game development process in the DGI. The test procedure examined the regression analysis, the model coefficient values, and the direction of the associations. The dependent variable (the enhanced game development process) was designated as the response variable and the other independent variables (all the key developer factors) as predicate variables. The results of regression analysis of model are reported in Table 4.5. The path coefficients of six of the seven variables (team configuration and management, game design document management, development of a game engine, game asset management, game test management, and programming practices) were positive and were found to be statistically significant at $p<0.05$. The path coefficient for quality of game architecture was positive, but was found not to be statistically significant at $p<0.05$. The overall R^2 value of the research model was 0.83, and the adjusted R^2 value was 0.68 with an *F*-ratio of 36.97, which was significant at $p<0.05$.

4.7 Discussion

Digital game development is a multidisciplinary activity that has its roots in the management and software engineering disciplines. The digital game industry has become a mass phenomenon, supplemented by a number of possible strategies and exciting

questions for game development companies. More and more companies are entering the market, and hence the intensity of competition is increasing. Established and new entrants both must pay attention to the key factors that help to improve their game development processes and keep them competitive in the market. Now it is time to understand the perspective of game developers and to learn what they think is important to improve digital game quality and how the developed game can become successful in the market. This research is a first step towards this understanding because it will help developers and game development organizations to understand the relationships and interdependences between key factors from a developer's perspective and to understand the enhanced game development process. This research provides an opportunity to explore associations between them empirically. The observed results support the theoretical assertions made here and provide the very first evidence that consideration of key developers' factors while developing games is important for digital game success. This could well result in institutionalizing the digital game development approach, which in turn has a high potential to maximize profits.

Especially in the game development process, multidisciplinary team configuration and management is a huge challenge. Ultimately, development of high-quality games relies on a high level of planning, communication, and organization of multi-disciplinary teams to avoid costly delays and failures. Many factors have been identified by researchers as important to implementing a successful collaboration between any kinds of multidisciplinary team. These factors include interpersonal factors such as trust among team members and ability to communicate (Rossen *et al*., 2008), willingness to collaborate, and mutual respect (Martin-Rodriguez *et al*., 2005). Others are organizational factors, including establishing appropriate protocols and supporting collaboration (Pietroburgo & Bush, 2008). These factors can be implemented by using various software applications that are specifically designed for collaborating on commercial software development projects. The main concern when using these software applications is that they must fit in with the existing computing and workflow environment (Huh *et al*., 2007). Management of the members of various multidisciplinary teams can be evaluated and maintained mainly by examining values and practices, for example, what each individual team member brings to the table, how they use material or assets produced by

other team members, how they reconcile conflicting priorities, and finally how their personal relations influence the collaboration. The multidisciplinary team can use management or collaboration software for task tracking, version control, file sharing, and continuous integration. Successful collaboration between team members enables them to manage easily all phases of game development from start-up, creating a concept, creating a proof of concept, the production phase, and so forth until the game is published.

This study has explored the importance of team configuration and management factors from a developer's perspective. It has found positive associations between team configuration and management and the enhanced game development process. Hence, proper configuration and management of multidisciplinary teams is a crucial part of the game development process. However, it must be balanced with other development issues in the game development process.

Game design document management has been found to be positively associated with the enhanced game development process. The GDD is mainly a pre-production artifact, which is defined by the pre-production phase team to capture a creative vision of the game. Game developers generally feel that imposing too much structure at the start of a game may be highly detrimental (Callele *et al*., 2005), resulting in reduced creativity, constraining expression, and risking the intangibles that create an enjoyable feeling or experience. At the same time, many researchers have highlighted the importance of structure, as discussed in the literature review section. Management of the game design document and its transition into a requirements and specifications document is challenging.

One way to handle this during the pre-production phase is to produce two documents. The first one is the GDD, and the second one is a requirements and specifications document based on the GDD. Managing and transforming the GDD into a production document is complex because the two require different documentation styles. Supportive documentation is also required to help the development team in its transition from pre-production to the production phase. The author of the GDD may not have the requisite writing skills to produce a document that is understandable by the production team

(technical people). Mainly, there is a long list of required skills for a GDD developer, such as knowledge of game design, technical communication, and requirements engineering. Hence, a formal process is needed to support the transition and would likely increase the reliability of the game development process. The results of this study have shown that development and transformation of the GDD is very important and also requires strong management skills to reduce documentation effort. Hence, the results presented here have shown that a good GDD is the greatest contributor to the success or failure of a game development project.

Game asset management was also found to have a positive association with the enhanced game development process. Game assets, defined as any piece of data that is in a format that can be used by the game engine, will be presented to the user. To create and manage game assets, a realistic content generator must be developed that can fill in the missing bits. Trade-offs between realism and performance and between realism and control must also be investigated for any asset created. For graphical animation, a number of 3D model formats can be used by game developers. These can generally be divided into two categories: frame-based animation and skeletal-based animation. Determination of the perfect animation model for a game has become crucial because diverse format types for graphics are available. Eventually, a poor choice could limit the performance of the game itself. For sound effects in games, developers can face certain problems because of unexpected or complex scene configurations. A number of asset management tools exist, but selecting the appropriate one is a challenge because each has its own limitations and benefits.

Improvements in the game development process have been greatly aided by the emergence of game development tools, specifically game engines. A game engine facilitates the game development process by providing various sets of features that help decrease development time and cost. These are available for most game genres (e.g., role-playing games or serious games for training) and vary in cost and complexity. Not all game engines support the entire feature set of all the game genres. Hence, integrating all the technological aspects into one framework is a prohibitively difficult task. It is understandable, therefore, that confusion exists among game developers with regard to

selecting the appropriate game engine. Game development tools should be selected only after determining the game concept and the GDD (Iuppa & Borst, 2010). Most researchers in the area of game development tools have proposed their own architectures for specific genres and platforms. Anderson *et al*. (2008) raised some important open questions for the academic community that are specific to the game engine development research field. The first is the main issue of the lack of a development language. The second question is how to define the boundaries between the game loop and the game engine. For example, what technical aspects should a game engine cover in a game? The third problem is that there is no standardization for game engines because most of them are specific to a particular game genre and game project. The fourth issue involves design dependencies, and the last the need for best practices when creating game engines. It was generally agreed that a game engine should handle diverse inputs and outputs, a restricted set of customizations based on each genre, and an asset and resource management system. The results of this study have also showed that development of a game engine has a positive impact on the enhanced game development process. In other words, game engine development is an important factor that needs more consideration from a developer perspective.

It is a common perception that a good quality or even perfect game architecture is a very important part of the game development process because reworking architecture afterwards is always hard. A game architecture identifies the main structural components of the underlying software and their relationships. In the game development literature, many researchers have proposed different frameworks for different platforms and based on different technologies. As a developer, it is difficult to select among these because all provide a kind of reference architecture and their validity is still in question. The findings of the study do not support a statistically positive relation between quality of game architecture and the enhanced game development process. The direction of association was found to be positive, but the required level of confidence was not supported. Hence, the hypothesis that quality of game architecture has a positive impact on the enhanced game development process was statistically rejected.

Testing in game development is done mainly at a very late stage or the end of development to ensure the quality and functionality of the finished product. Typically, in a particular game project, the leader dedicates a specific amount of time for quality assurance or a beta tester to test the game. Various development methodologies are used to develop games, such as the agile methodology and the waterfall model, but testing must form part of all processes. Every aspect of a game should be tested during the development and production phases. In addition, certain foundational elements should also be tested during the pre-production phase, such as frameworks and platform set-up. The most important aspect of testing for game developers is to integrate testing as part of the production phase to improve efficiency. To ensure continuous quality and delivery of good games to the market, developers must consider majority-testing options during the production phase. Helppi (2015) also researched the possibility that mobile game robustness can be improved by continuous integration, delivery, and testing, and concluded that this approach can improve the outcome of games and result as a more robust end product. Therefore, testing plays an important role in each step of the development phase, and its management throughout the game development process is important. The results of this study have also supported the hypothesis that game testing management is important for the enhanced game development process. At the same time, testing techniques have matured over time, but still need improvement.

Game programming strategy has a direct effect on game performance. There are many concerns associated with today's game programming practices. Game developers must look for solutions to common problems in game programming such as coupling of modules, availability of different scripting and programming languages, platform compatibility issues, memory management, and code optimization strategy, specifically to improve game performance and quality. Hence, game developers must consider various aspects of the game such as speed, flexibility, portability, and maintainability while still coding. Ultimately, the skilled programming team will be able to develop and implement the full functional game. Matching of required skills to the abilities of developers is very important to improve the overall game development process, a conclusion also supported by this study.

The findings of this study will help game development organizations to look for contributing key success factors from a developer's perspective. The findings of this study also provide a justification to include these factors in the process assessment methodology.

4.7.1 Limitations of the study

For software engineering processes or product investigations, various empirical approaches are used, such as case studies, metrics, surveys, and experiments. However, certain limitations are associated with empirical studies and with this study as well. Easterbrooks *et al*. (2007) suggested four criteria for validating empirical studies: internal validity, construct validity, external validity, and reliability. Wohlin *et al*. (2000) stated that generalizing experimental results to industrial practice by researchers is mostly limited by threats to external validity. In this study, measures were taken to address external threats to validity. The random sampling method was used to select respondents from all around the world. Open-ended questions were also included in the questionnaire.

The choice and selection of independent variables was one of the limitations of this study. To analyze the association and impact of factors affecting software game success, seven independent variables were included. However, other key factors may exist which have a positive association with and impact on the game development process, but due to the presence of the selected seven variables in the literature, they were excluded from the study. In addition, other key factors may exist, such as regionally or environmentally based choices, which may have a positive impact on the game development process, but were not considered in this study. Furthermore, the focus of this study was only on developers' factors affecting the enhanced game development process.

In software engineering, the increased popularity of empirical methodologies has raised concerns about ethics. This study has adhered to all applicable ethical principles to ensure that it would not violate any experimental ethics guidelines. Regardless of its limitations, this study has contributed to the digital game development process and has helped game development organizations understand the developer's perspective.

4.8 Conclusion

This study provides a better understanding of the factors important to developers in the digital game development process and explores the impact of key factors on the success of digital games from a developer's perspective. This study has mainly tried to answer the research question that was posed earlier in this study and to analyze the impact of developers' key factors for game development process improvement. The results of this empirical investigation have demonstrated that developers' key factors are very important and play a key role in improving the digital game development process. The results showed that team configuration and management, game design document management, game engine development, game test management, and programming practices are positively associated with the enhanced game development process. The empirical investigation found no strong association or impact between quality of game architecture and the enhanced game development process. In the game development field, this research is the first of its kind and will help game developers and game development organizations achieve a better understanding of key factors for improving the game development process. To improve the current game development process and develop good-quality games, it is important for developers to consider the identified key factors as well as others. This study has provided the empirical evidence and justification to include factors from the developers' perspective in evaluating the game development process maturity.

Chapter 5

5 Business Perspective on Game Development: An Empirical Investigation[3]

Digital game development organizations are looking at new ways to improve existing user experiences, to engage a broad range of consumers, to update their business models, and to include emerging technologies in their development processes. The digital game sector has been identified as a significant contributor to economic growth by many countries around the world, and these countries have embraced aggressive action plans for its growth (Haukka, 2011; Forfas, 2011). This research facilitates a better understanding of the business perspective of digital games. The main objective of this study is to investigate empirically the effect of business factors on the performance of digital games in the market and to answer the research questions asked in this thesis. Game development organizations are facing high pressure and competition in the digital game industry. Business has become a crucial dimension, especially for game development organizations. This is the first study in the game development domain that demonstrates the interrelationship between key business factors and game performance in the market. The results of this study provide evidence that game development organizations must deal with multiple key business factors to remain competitive and handle the high pressure in the digital game industry. Furthermore, the results of the study support the theoretical assertion that key business factors play an important role in game business performance.

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[3]Parts of this chapter were published in following article:

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5.1 Research Motivation

The main development activities in the digital game sector, especially from a business perspective, include elements of the game development value chain, such as technical and creative development, manufacturing of hardware/ console platforms, and game publishing. Distribution can be carried out in a number of ways, including mobile, traditional retail, online, cloud, and download, and after distribution, it also involves customer engagement and community management activities. Game development organizations have also outsourced some of their support services activities such as data hosting, information security, marketing and advertising, billing services, and piracy protection. The number of dimensions involved, such as types of end-user devices or platforms, game genres, channels for publication, and emerging revenue models in the digital game sector, make this sector highly fragmented. It is important for any type of business domain to identify its key important factors that help them to excel in that particular field. The key business factors vary from domain to domain depending upon each business operation. A digital game is a kind of software product that is intangible in nature. According to Levitt (1981), intangible products are highly people-intensive in their delivery methods and production, and business management become more critical for them than for tangible products. Moreover, digital game industry growth is tremendous, and it became crucial to identify key important business factors that help organizations in the digital game industry to reach their maximum potential. Game development organizations must target all these dimensions to retain and maximize their consumer base. The digital game industry has shown economic potential in both the entertainment and software industries (PWC, 2011).

The main research motivation behind this study is that the game industry has high economic potential and generates million-dollar projects; it sets high limits and standards for game performance as well as putting high pressure on organizations. To deal with this severe competition and high pressure, game development organizations must make important decisions quickly regarding different business activities because this has become important for financial growth and business performance. Organizations in the digital game industry must respond quickly to changes in the business and technology

environment, and if they fail to respond appropriately, they will not survive long. There are many examples of commercial failure in the digital game industry, and the best-known one being the video game crash of 1983 (Burnham, 2003). According to Burnham (2003), inexpensive low-quality games with poor business strategies were flooding North America, resulting in complete destruction of the U.S. digital game market. In addition, Sellers (2001) stated that the extra-terrestrial (E.T.) video game and Pac-Man for the Atari 2600 were two examples that contributed to the failure. Most of the failures in the digital game market, such as the Commodore 64 Games System, Nintendo 64 DD, Philips CD-i, Shenmue, Sonic Boom: Rise of Lyric, etc. (Robin, 2009), were due to poor business strategies including market orientation, consumer satisfaction, monetization strategy, and time to market.

Especially in game development organizations, business becomes the most important factor due to severe competition, the fragmented nature of the business, and the poor software engineering practices used by most companies (Kerr, 2000). Identification of key factors to handle high pressure and achieve targeted business and game performance has become highly important. However, no studies that address the important factors in digital game business performance have been published in the literature. The main contribution of this empirical study is to investigate comprehensively the interrelationship among key business factors and game performance in the market. This study also provides an understanding of the influence of the key factors identified by showing empirically how they impact the business organization and digital game performance.

The rest of this chapter presents the research methodology and describes the results and analysis. Finally, it discusses the results and concludes the study.

5.2 Literature Review

Key business factors for digital game organizations are the least addressed area in game development research. The business model for each segment of the game industry is different, and each segment has a different percentage of the revenue share (Neogames, 2011). From a review of the literature, various factors have been identified that contribute

to game business performance. The identified factors and the related literature review are described in the following sub-sections.

5.2.1 Customer Satisfaction and Loyalty

The DGI is facing dramatic changes because it views customer satisfaction as winning over players for their games. The classical definition of customer satisfaction given by Oliver (1997) is "pleasurable fulfilment response toward a good, service, benefit, or reward". Customer satisfaction must be an integral part of the organization and is a financial metric that can be used to measure business performance. However, the relationship between business performance and customer satisfaction is not always clear. Zeithaml (2000) highlighted three problems in measuring this relationship: a) the time lag between measuring improvement in profit and customer satisfaction; b) variables that influence an organization's profits, such as marketing, price, and competition; and c) other variables such as organizational behavioural issues that should be included when measuring the relationship. A positive relationship between customer satisfaction and organizational performance has been reported by many researchers in different industries (Koska, 1990; Nelson *et al*., 1992; Aaker & Jacobson, 1994; Anderson *et al*., 1994; Ittner & Larckner, 1996), but few have explored this relationship in the DGI. Some researchers (Fornell, 1992; Hallowell, 1996; Zhang & Pan, 2009) have also highlighted that higher customer satisfaction in any organization is strongly correlated with greater market growth, proving the strong relationship between customer loyalty and customer retention. The DGI has given a lower priority to customer service for its product (the game) and tends to treat it as a commodity. Often, when players do not obtain a response to their problems, they become disappointed. Johnson (2001) explored the customer service aspect of the DGI. He used the critical incidents technique to examine customer services incidents in the game industry and identified negative and positive customer service experiences. The results of this study provided directions for management that helped them with resource allocation, especially in those areas that provided maximum customer satisfaction and dissatisfaction. Based on this analysis, management could take proper measures to ensure maximum customer satisfaction. In commercial games, the concept of customer satisfaction has a very important place. Lu and Wang (2008) explored the

factors of online game addiction and the role of addiction in online gamer loyalty and customer satisfaction. The results indicated that addiction plays an important role in customer loyalty and satisfaction. Van der Wiele *et al*. (2001) investigated the relationship of customer satisfaction and business performance data within an organization. The results showed empirical evidence that there is a positive relationship between customer satisfaction and business performance. In the literature, only a few researchers have explored the customer satisfaction aspect of the DGI.

To determine whether customer satisfaction has any impact on the business performance of a digital game, "customer satisfaction" was selected as an independent variable, as shown in Figure 5.1. Hence, Hypothesis 8 can be stated as follows:

Hypothesis 8: Customer satisfaction has a positive influence on the business performance of a digital game.

5.2.2 Market Orientation

Market orientation plays a significantly important role in the extensively market-driven DGI. Market orientation involves the study of customers and competitors in the market and deals with the interpretation, acquisition, or use of information about them. The concept of market orientation is based on marketing theory. Zeithaml and Zeithaml's (1984) marketing theory also applies here because it provides continuous guidance for game development organizations on how they should react to opportunities and how, by taking appropriate market actions, the organization can create opportunities by changing the environment. Hunt (2004) describes marketing as a management responsibility that helps in sensing the market and articulating new and valuable propositions. Berry (1983) also highlighted the use of *customer relationship management* (CRM) to develop an appropriate marketing strategy to retain, attract, and enhance customer relationships. Gronroos (1990) defined marketing in the context of CRM, and Fornell and Wernerfelt (1987) described a marketing strategy aimed at attracting new and retaining existing customers and generating increased revenue and profitability. Owomoyela *et al*. (2013) described how organizations can develop their marketing strategies in a way that enables them to build, maintain, and defend their competitive advantage. Managerial judgment

will be helpful in identifying strategic marketing uncertainties and environmental ambiguities.

In the literature, very few studies have described market orientation for the DGI. Lee *et al.* (2006) suggested that game developers must develop market reports in the requirements engineering phase and during game distribution. The marketing team plays an important role in this. The main activities performed by marketing teams along with the CRM team are packaging, advertising, management of marketing agents, and production of a complete marketing plan. Katsaliaki and Mustafee (2012) explored sustainable development strategies for a serious game audience. Analyzing the characteristics and requirements of the target audience helps developers generate a sustainable game development process. Xin (2008) highlighted the barriers in serious mobile game markets and the current market segmentation for serious games. Before developing serious games, developers must analyze the market segment and their own competitive advantage. This study highlights the issue of market analysis before starting a game project to determine what types of games are in demand.

“Market Orientation” has also been selected as an independent variable in this study, and therefore the following hypothesis is proposed:

Hypothesis 9: Market Orientation has a positive influence on the business performance of a digital games.

5.2.3 Innovation

Especially in the DGI, innovation has a special place as a key driver of economic growth and competitiveness. Innovation has many forms and has become known as a critical dimension of achieving better economic performance, especially in knowledge-driven economies. Innovation can be defined as the successful exploitation of new social or commercial ideas and the ability, once new ideas have been brought to market, to reduce cost, improve services, and improve existing arrangements by offering new and effective alternatives. Afuah (2009) defined strategic innovation for organizations as follows: “a strategic innovation is a game-changing innovation in products/services, business models,

business processes, and/or positioning of competitors to improve performance". Johannessen (2013) described a systematic perspective on innovation theory. He considered 14 propositions from the literature and investigated the connection between economic crises and innovation. Basically, innovations in organizations are associated with managing an organization in new ways as well as with new business models. A business model innovation framework has been proposed by Comviva Technologies (2009) that contains an industry model (adoption of new industries by redefining existing ones), a revenue model (reconfiguration of offerings and a pricing model), and an expertise model (value-chain role playing). Lindgardth *et al*. (2009) also proposed an innovative business model including two elements: a value proposition and an operating model. The value proposition is about who the target audience is, what kind of product/service the organization will offer, and what the organizational revenue model will be. The operating model addresses the issue of service/product delivery that generates profitability and includes three critical areas: the value chain, a cost model to generate revenue, and an organization that develops and deploys assets to enhance and sustain competitive advantage.

To determine whether "Innovation" has any impact on the business performance of a digital game, it was selected as an independent variable, as shown in Figure 5.1. Hence, Hypothesis 10 can be stated as follows:

Hypothesis 10: Innovation has a positive influence on the business performance of a digital game.

5.2.4 Relationship Management

Effective CRM is a highly critical element in the success of any business. Wilson (1995) observed that relationship management basically involves developing and maintaining long-term, close, satisfying and mutually beneficial relationships between customers and organizations based on collaboration and trust. In relationship management, customer profiling, promotional strategies, customer service and support, customer information, organizational behaviour, and channel management are all contributing factors. Recently, organizations have been integrating their customers into the design, production, or

delivery of goods and services. These organizations are mainly targeting revenue increases or cost reductions by relying on their customers as co-producers of goods or services that they offer to the market. This trend towards integrating users or customers shows that new organizational choices are being made by companies to generate high margins. This is a fundamental change in business strategy that pushes organizations to think about new ways to mobilize their users to increase revenue. Plé *et al*. (2008) explained the role of customers in this business model. They proposed a theoretical framework called the *customer-integrated business model* (CIBM) by combining customer participation with the business model literature. The framework based on ROCA (*resource-oriented client architecture*) and proposed by Lecocq *et al*. (2006) considered the customer as a resource; the model was illustrated by two case studies. They concluded that more field research is required to explore the relationship between the customer-as-a-resource approach and business profits. Most studies in the literature consider customer participation in service marketing and management, but only a few consider customer integration as a resource. Stanely *et al*. (2008) looked at user integration from a different perspective. They described the cumulative context of a digital game and accumulated all contextual information on a player's activity using mobile sensors to change the game state. Experimental results indicated that the player found the game engaging and fun. Ermi and Mayra (2005) pointed out that user involvement is a multi-dimensional and complex phenomenon that is not totally dependent on the nature of the specific genre or game, but also upon each player's choices or preferences. To determine whether relationship management has any impact on the business performance of a digital game, it was selected as an independent variable. Hence, Hypothesis 11 can be stated as follows:

Hypothesis 11: Relationship management has a positive influence on the business performance of a digital game.

5.2.5 Time to Market

The time-to-market phenomenon has long been recognized as a crucial enabler for business success. From this perspective, organizations can be categorized into pioneers, early followers, and late movers (Ansoff & Stewart, 1967; Robinson *et al*., 1992). The

pioneers emerge as solution providers in the market and gain a sustainable competitive advantage over followers. This enables them to amass a major part of the market, making it more difficult for successors to gain market share. Hence, the timing of entry into the market becomes more crucial for organizations to gain profit and competitive advantage. Products that enter the market at the right time or have short time to market have a high potential for success. A digital game organization's ability to reach the market before its competitors and gain adoption is an important factor in the long-term success of its games. The time-to-market process in the DGI can be defined as integration of new technology into digital game production. Today, digital game organizations can gain competitive advantage by introducing the next generation of technologies into the game market through new game development strategies that enable them to be first in the game industry market. Very few studies in the literature have highlighted the importance of the time-to-market factor specifically in the digital game industry (Lee *et al*., 2006; Ramadan & Widyani, 2013), and none of them has discussed it from a business performance perspective.

To determine whether "Time to Market" has any impact on the business performance of a digital game, it was selected as an independent variable. Hence, Hypothesis 12 can be stated as follows:

Hypothesis 12: Time to Market has a positive influence on the business performance of a digital game.

5.2.6 Monetization Strategy

The DGI sector is learning the game of monetization. Around the world, millions of consumers play games on either online media portals or social networking sites every day. Monetization strategy is very important because it is a risky business. It provides an insight into the organization of a business that either is worthwhile or is not. Monetization strategy in games is similar to the setting of financial objectives for any organization. Financial objectives are defined as organizations set their financial targets over a certain period of time. Financial objectives are different from other types of organizational objectives such as business or customer retention objectives because they

cannot be easily measured monetarily if achieved. Game development involves high costs, and only the top 5% of games in the market are profitable. A game that fails in the market can lead to severe losses or even bankruptcy in the case of small developers. The organization needs therefore to have proper financial management and appropriate financial planning to ensure that enough funding is available when needed. Second, financial controls determine whether the organization is meeting its financial objectives. Finally, financial decision-making is itself very important (Business Builders, 2004).

In social games, players are able to create their own virtual characters and communities and interact with their friends. Companies involved in the game business have developed business models for paid content such as subscription, advertising, and micro-transactions for virtual goods. In general, users are not interested in paying for virtual goods, but the few who pay for them make this business model work. Eventually, micro-transactions, especially in the social game lifecycle, have become a driver for incremental revenue. In the *massive multiplayer online game* (MMOG) sector, the bulk of game revenue is still generated by subscriptions, but use of micro-transactions is growing for virtual goods. The importance of a monetization strategy for the DGI has been explored by only two studies, but not in detail, and neither of them discussed its impact on business performance (Zulkiffli & Perera, 2011).

To determine whether "Monetization strategy" has any impact on the business performance of a digital game, it was selected as an independent variable. Hence, Hypothesis 13 can be stated as follows:

Hypothesis 13: Monetization has a positive influence on the business performance of a digital game.

5.2.7 Brand Name Strategy

A brand name is regarded as a crucial enabler for business success in any organization. The brand is considered as both a point of comparison with other products and a promise of quality to the customer. Bennett (1988) described a brand as a term, name, symbol, sign, design, or combination of any of these concepts that helps to identify the products

or services of a particular seller. Generally, the brand name has high impact on the organization's business. Between the organization and its customers, branded products serve as an interface, and brand loyalty enables marketing by word of mouth. The organization's brand name strategy has a strong impact on the customer decision-making process. Bergstrom (2004) perceived that in the case of products and competitors that are easily replicable or duplicated, brands help customers in the decision process of buying a particular product.

Hence, the DGI has successfully adopted a brand name strategy in the game development process. In games, there are many successful platform brands, including Nintendo, Sony, and Microsoft for consoles, Apple (IOS), Samsung (Android), and others for mobile platforms, and Windows, Apple, and others for PCs. However, no study has described the brand name strategy in the game development process and its impact on business performance.

To determine whether brand name strategy has any impact on the business performance of a digital game, it was selected as an independent variable. Hence, Hypothesis 14 can be stated as follows:

Hypothesis 14: Brand name strategy has a positive influence on the business performance of a digital game.

5.3 Research Model and Hypotheses

The main objective of the proposed research model is to analyze the interrelationship between key factors and game business performance and also to understand the influence of these factors on a game development organization's business performance in the DGI market. Davenport (1993) and Aguilar-Sav'en (2004) described the combination of structured business process activities in an organization to achieve specific goals. The model's theoretical foundation is based on a combination of existing concepts found in the game development literature and business models for the game industry. It is worth noting that most studies in the literature discuss one or two of the factors mentioned above in the context of game development organizations and their impact on game

performance. This study proposes to investigate empirically the influence and association of key factors in game development organizations and game business performance. Figure 5.1 presents the theoretical research model of this study to be empirically investigated. The theoretical model evaluates the relationships of different independent variables emerging from organizational concepts such as organizational management, theory, and behaviour in the context of game development organizations on the dependent variable of game business performance within the organization. This study mainly investigates and addresses the following research question:

Research Question: What is the impact of key business factors on overall game business performance in the DGI?

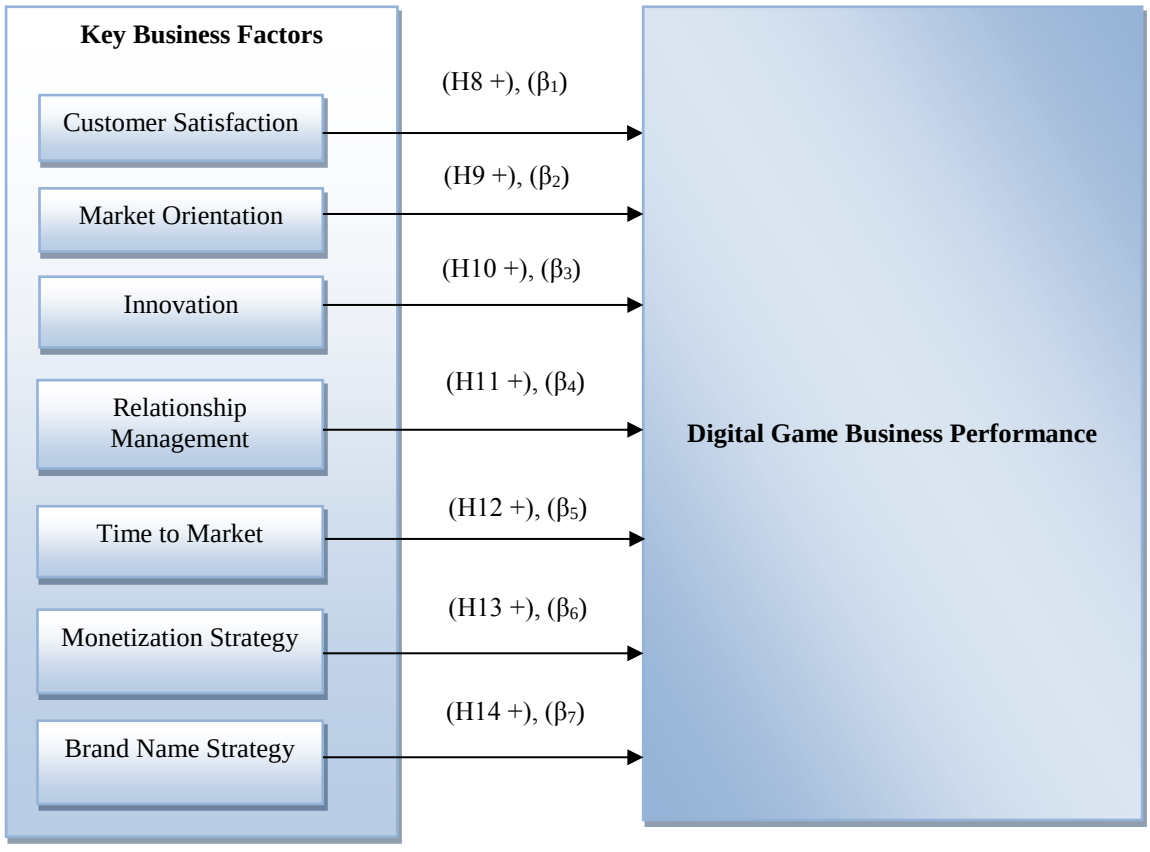

Figure 5.1 Research Model

The research model includes seven independent variables: customer satisfaction, market orientation, innovation, relationship management, time to market, monetization strategy, and brand name strategy, and one dependent variable: the business performance of the digital game. The multiple linear regression equation of the model is given as Equation 5.1:

$$\text{Business performance of game} = \beta_0 + \beta_1 f_1 + \beta_2 f_2 + \beta_3 f_3 + \beta_4 f_4 + \beta_5 f_5 + \beta_6 f_6 + \beta_7 f_7, \quad (5.1)$$

where β_0, β_1, β_2, β_3, β_4, β_5, β_6, β_7 are coefficients and f_1–f_7 are the seven independent variables.

5.4 Research Methodology

Digital game development organizations are involved in various business activities such as game development, publishing, distribution, and finally customer engagement. The targeted respondents of this study were employees of game development organizations or independent studios. Some organizations handled all these activities by themselves, whereas some of them outsourced publishing or distribution activities. Initially, we joined various game development community forums and started blogs about a data collection request for an empirical study (Data collection strategies and resources are attached in Appendix III). A survey questionnaire was also created using the Survey Monkey Web site, and personalized emails were sent to various organizations. The respondents were from multinational companies in Asia, Europe, and North America, and statistics about them are illustrated in Figure 5.2. Participant organizations agreed to take part in the study based on mutual agreement that their identities would be kept confidential. The size of the participating organizations varied from micro to large scale. Micro-sized organizations consisted of 3–5 employees, small ones of 5–99, medium ones of 100–499, and large ones of 500+ team members belonging to various departments within the organization. Figure 5.3 show the number of respondents by organization size.

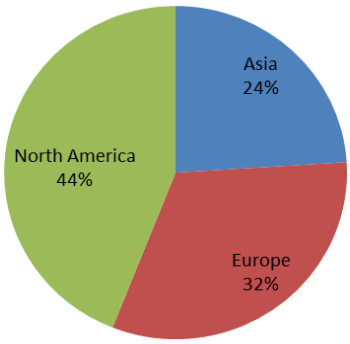

Figure 5.2 Percentage of Respondents by Continent

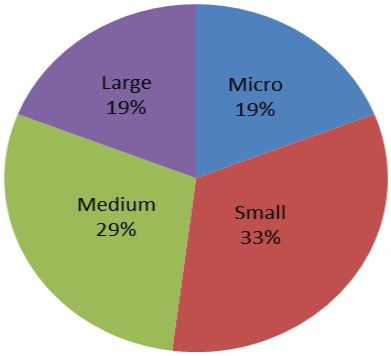

Figure 5.3 Percentage of Respondents by Organization Size

The participating organizations mainly developed games for different platforms such as kiosks and standalone devices, the Web, social networks, consoles, PC/Macs, and mobile phones. The game genres implemented in most of their projects included action or adventure, racing, puzzles, strategy/role playing, sports, music-based, and other categories. The participant organizations distributed the surveys within various departments; the survey respondents had been employed in that particular organization for at least three years. The survey respondents worked in various capacities from game development to middle and senior management and played a role in either policy-making or implementation of organizational strategies. The total number of survey respondents

was 61, including a minimum of two and a maximum of five responses from each organization.

5.4.1 Measuring Instrument

This study gathered data on the key business factors and the perceived level of game performance identified in the research model depicted in Figure 5.1. To learn about these two topics, the questionnaire presented in Appendix V was used as a data collection instrument. First, organizations involved in the game development business were asked to what extent they practiced the identified key business factors within their organization. Second, they were asked about the business performance of their games in the digital game industry. The five-point Likert scale was used in the questionnaire, and with each statement, the respondents were required to specify their level of agreement or disagreement. Thirty-three items were used to measure the independent variables (the key factors), and for the dependent variable (game performance), eight items were used. The literature related to key business factors was reviewed in detail to ensure a comprehensive list of measuring items for each factor from the literature. A multi-item, five-point Likert scale was used to measure the extent to which each key business factor was practiced within the organization. The Likert scale ranged from (1) meaning "strongly disagree" to (5) meaning "strongly agree" and was associated with each item. The items for each identified factor were numbered 1 to 33 in Appendix V and also labelled sequentially. Game business performance was the dependent variable and was measured for at least the past three years in the context of organizational financial strength, market growth, cost savings, and reduced development time based on a multi-item five-point Likert scale. The designated items for the dependent variable were numbered separately from one to eight and labelled sequentially. All the items specifically written for this study are presented in Appendix V.

5.4.2 Reliability and Validity Analysis

A reliability and validity analysis was performed for the measuring instrument that was specifically designed for this empirical study. This analysis was based on the most common approaches used in empirical studies similar to developer's perspective

measuring instrument. First, Cronbach's alpha coefficient was calculated on a sample dataset which excluded assessment items from each category if they affected the desired value of Cronbach's alpha coefficient. The responses to question 6 on market orientation, question 12 on innovation, question 22 on time to market, question 24 on monetization strategy, and question 33 from brand name strategy were excluded from the investigation based on their effect on Cronbach's alpha coefficient. The reliability analysis for the seven factors is reported in Table 5.1, with Cronbach's alpha coefficient ranging from 0.61 to 0.76. A number of researchers as already discussed in section 4.4.2 has reported satisfactory value criteria for Cronbach's alpha must be greater than 0.55. Hence, all developed variable items for this study could be considered reliable.

For the analysis of convergent validity, principal component analysis (PCA) (Comrey & Lee, 1992) with seven factors was used, with the results shown in Table 5.1. The eigenvalues (Kaiser, 1970) were used as a reference point to determine the construct validity of the PCA-based measuring instrument. For this empirical investigation, the Kaiser Criterion (Kaiser, 1960) was used, which states that any value greater than one for any component is to be retained. The eigenvalue analysis showed that out of the seven variables, six together formed a single factor, whereas brand name strategy loaded on two factors, and both eigenvalues were greater than one. The reported convergent validity of this study has been considered as adequate.

Table 5.1 Cronbach's Alpha Coefficient and PCA of Seven Variables

Business factor	**Item no.**	**Coefficient α**	**PC eigenvalue**
Customer satisfaction	1–4	0.71	1.49
Market orientation	5–8	0.67 (Q6)	1.57
Innovation	9–13	0.74 (Q12)	1.01
Relationship management	14–19	0.60	1.16
Time to market	20–23	0.64 (Q22)	1.61
Monetization strategy	24–28	0.61 (Q24)	1.25
Brand name strategy	29–33	0.76 (Q33)	1.79

5.4.3 Inter-rater Agreement Analysis

In most cases, there were one or two respondents from each organization. Inter-rater agreement analysis (Landis & Koch, 1997) was performed to address the issue of conflicting opinions from the same organization. Inter-rater agreement concerns the level of agreement in the ratings provided by different respondents for the same process or software engineering practice (Emam, 1999). Hence, inter-rate agreement analysis was performed to identify the level of agreement among different respondents from the same organization. To evaluate inter-rater agreement, the Kendall coefficient of concordance (W) (von Eye & Mun, 2005) is usually preferred for ordinal data over other methods like Cohen's Kappa (1960). "*W*" represents the difference between the actual agreement drawn from data and perfect agreement. Values of Fleiss Kappa and the Kendall's W coefficient can range from 0 (representing complete disagreement) to 1 (representing perfect agreement) (Lee *et al*., 2001). Therefore, the Kappa (Emam, 1999) standard includes four levels: < 0.44 means poor agreement, 0.44 to 0.62 represents moderate agreement, 0.62 to 0.78 indicates substantial agreement, and > 0.78 represents excellent agreement. In this study, the observed Kappa coefficients fall into the *substantial* category and range from 0.63 to 0.68. Table 5.2 reports the Kappa and Kendall statistics for five organizations.

Table 5.2 Inter-Rater Agreement Analysis

Organizations	**Kendall's Statistic**		**Kappa Statistic**	
	Kendall's Coefficient of Concordance (*W*)	**$\chi 2$**	**Fleiss Kappa Coefficient**	**Z**
A	0.72	58.20*	0.68	8.20*
B	0.65	52.90*	0.63	7.98**
C	0.71	57.42*	0.67	8.04*
D	0.63	51.32*	0.62	7.54*
E	0.74	60.14**	0.69	9.01**

*Significant at $p<0.05$ **Insignificant at $p>0.05$

5.4.4 Data Analysis Techniques

Various statistical approaches were used in this research for data analysis. Initially, this activity was split into three phases to estimate the significance of hypotheses H8–H14.

Phase I involved parametric statistics and normal distribution tests. In Phase II, partial least squares (PLS) was used as a nonparametric statistical approach. Due to the small sample size, both parametric and non-parametric approaches were used to address threats to external validity. Multiple items were used in the measuring instrument for each independent variable and the dependent variable, with respondents' ratings for each variable aggregated to obtain a composite value. In phase I, tests were conducted for each hypothesis H8–H14 using parametric statistics such as the Pearson correlation coefficient and the one-tailed *t*-test. In phase II, non-parametric statistics such as the Spearman correlation coefficient were used to test hypotheses H8–H14. In phase III, tests were carried out for research model hypotheses H8–H14 based on the PLS technique. The PLS technique was used in Phase III to increase the reliability of the results and deal with the limitation of small sample size. The main reasons for the small sample size were first, that most games on the market are developed by one to three developers, but this study targeted game development companies with more than three employees, and second, some companies declined to respond to the survey due to their busy schedule. For statistical calculations, the Minitab 17 software was used.

5.5 Data Analysis and Results

5.5.1 Phase I of Hypothesis Testing

Parametric statistics were used in this phase to test hypotheses H8–H14. The Pearson correlation coefficient was examined between the independent variables (key business factors) and the dependent variable (game performance) of the research model, as illustrated in Figure 5.1. To accept a hypothesis, the level of significance was selected so that if the *p*-value was less than 0.05, the hypothesis would be accepted, and if the *p*-value was greater than 0.05, the hypothesis would be rejected (Westfall & Young, 1993). The calculated results for the Pearson correlation coefficient are listed in Table 5.3. Hypothesis H8 was accepted because the Pearson correlation coefficient for customer satisfaction and game performance was positive (0.50) at $p<0.05$. For hypothesis H9 concerning market orientation and game performance, the Pearson correlation coefficient was also positive (0.57) at $p<0.5$, and therefore hypothesis H9 was also accepted. Hypothesis H10 concerning innovation and game performance was rejected due to its

higher *p*-value (0.93). Hypothesis H11 concerning relationship management and game performance was also rejected based on its negative Pearson correlation coefficient (-0.16) at $p< 0.05$. Hypothesis H12 concerning time to market and game performance was accepted based on its positive correlation coefficient (0.61) at $p<0.05$. Hypothesis H13 regarding monetization strategy and game performance was also accepted due to its positive Pearson correlation coefficient (0.25) at $p<0.05$. The last hypothesis (H14) between brand name strategy and game performance was also found to be significant (0.79) at $p<0.05$ and was therefore accepted. Hence, in summary, hypotheses H8, H9, H12, H13, and H14 were accepted and found to be statistically significant. Hypotheses H10 and H11 were not supported statistically and were therefore rejected.

Table 5.3 Hypothesis Testing Using Parametric and Non-Parametric Correlation Coefficients.

Hypothesis	Key Business Factors	Pearson correlation coefficient	Spearman correlation coefficient
H8	Customer satisfaction	0.50*	0.55*
H9	Market orientation	0.57*	0.57*
H10	Innovation	0.01**	0.13**
H11	Relationship management	-0.16**	-0.16**
H12	Time to market	0.61*	0.55*
H13	Monetization strategy	0.25*	0.27*
H14	Brand name strategy	0.79*	0.78*

*Significant at $p<0.05$ **Insignificant at $p>0.05$

5.5.2 Phase II of Hypothesis Testing

Phase II involved testing hypotheses H8–H14 based on the nonparametric Spearman correlation coefficient. The observations made in this phase for the Spearman correlation coefficient are also reported in Table 5.3. Hypotheses H8 was accepted because of its positive Spearman correlation coefficient (0.55) at $p<0.05$. The Spearman correlation coefficient for market orientation and game performance (hypothesis H9) was also positive (0.57) at $p<0.05$ and was also found to be significant. The relationship between innovation and game performance (hypothesis H10) was not found to be statistically significant due to its Spearman correlation coefficient (0.13) at $p>0.05$ and was rejected. For hypothesis H11, the Spearman correlation coefficient was negative at $p<0.05$, and therefore H11 was rejected. Hypothesis H12 concerning time to market and game

performance was accepted due to its positive coefficient (0.55) at $p<0.05$. Hypothesis H13 concerning monetization strategy and game performance was also accepted due to its positive Spearman correlation coefficient (0.27) at $p<0.05$. The last hypothesis (H14) between brand name strategy and game performance was also found to be significant (0.78) at $p<0.05$. Hence, in summary, hypotheses H8, H9, H12, H13, and H14 were accepted and found to be statistically significant. Hypotheses H10 and H11 were not supported statistically and were therefore rejected.

5.5.3 Phase III of Hypothesis Testing

Phase III included hypothesis testing based on the partial least squares (PLS) technique. PLS was used for cross-validation and to overcome some limitations associated with the results obtained from the parametric and non-parametric statistical approaches used in Phases I and II. Hypotheses H8–H14 were tested for direction and significance. To examine PLS for each hypothesis, the dependent variable (game performance) was designated as the response variable and the individual business factors as the predicate variable. The observed structural test results for the hypotheses are reported in Table 5.4 and include the observed values of R^2, the path coefficient, and the F-ratio. The path coefficient for customer satisfaction (H8) was observed to be 0.78, R^2 was 0.24, and the F-ratio was 19.10, and hence H8 was found to be significant at $p<0.05$. Market orientation (H9) had a positive path coefficient of 1.04, $R^2 = 0.32$, and F-ratio = 28.51 and was also found to be statistically significant at $p<0.05$. Innovation (H10) had a path coefficient of 0.02, a very low R^2 of 0.01, and an F-ratio of 0.01 and was found to be insignificant at $p<0.05$. Relationship management (H11) had a negative path coefficient of -0.27, a low R^2 of 0.01, and an F-ratio of 1.69 and was judged to be insignificant because the p-value was greater than 0.05. Time to market (H12) (path coefficient: 1.16, R^2: 0.37, and F-ratio: 35.52) had the same direction as proposed. Monetization strategy (H13) (path coefficient: 0.51, R^2: 0.64, and F-ratio: 4.04) and brand name strategy (H14) (path coefficient: 0.94, R^2: 0.62, and F-ratio: 100.38) was found to be significant at $p<0.05$.

Table 5.4 PLS Regression Results for Hypothesis Testing

Hypothesis	Key Business Factors	Path coefficient	R^2	F-Ratio
H8	Customer satisfaction	0.78	0.24	19.10*
H9	Market orientation	1.04	0.32	28.51*
H10	Innovation	0.02	0.01	0.01**
H11	Relationship management	-0.27	0.01	1.69**
H12	Time to market	1.16	0.37	35.52*
H13	Monetization strategy	0.51	0.64	4.04*
H14	Brand name strategy	0.94	0.62	100.38*

*Significant at $p<0.05$ **Insignificant at $p>0.05$

5.6 Research Model Testing

The linear regression equation for the research model is given by Equation 5.1. The research model was tested to provide empirical evidence that business factors play a considerable role in digital game performance in the market. The test procedure examined the regression analysis, the model coefficient values, and the direction of the associations. The dependent variable (game performance) was designated as the response variable and the other independent variables (all the key business factors) as predicate variables. The regression analysis model results are reported in Table 5.5.

Table 5.5 Linear Regression Analysis of the Research Model

Model coefficient name	Model coefficient	Coefficient value	t-value
Customer satisfaction	β_1	0.23	1.67*
Market orientation	β_2	0.66	3.35*
Innovation	β_3	0.18	1.20**
Relationship management	β_4	-0.14	-1.05**
Time to market	β_5	0.02	1.10*
Monetization strategy	β_6	0.13	1.68*
Brand name strategy	β_7	0.69	4.13*
Constant	β_0	7.35	2.01*
R^2	0.74	**Adjusted R^2**	0.71
F-ratio	21.16*		

*Significant at $p<0.05$ **Insignificant at $p>0.05$

The path coefficients of five of the seven variables (customer satisfaction, market orientation, time to market, monetization strategy, and brand name strategy) were positive and found to be statistically significant at p<0.05. The path coefficient of innovation was positive, but was found not to be statistically significant at p<0.05. The

path coefficient of relationship management was negative and made this factor insignificant in the research model. The overall R2 value of the research model was 0.74, and the adjusted R2 value was 0.71 with an F-ratio of 21.16, which was significant at $p<0.05$.

5.7 Discussion

Today's digital era has attracted many people to play games and to develop their own games for profit. This research aims to help game development organizations understand the interdependencies and relationships between key business factors and game performance in the market. This research offers an opportunity to explore empirically the association between key business factors and digital game performance. This is the first empirical investigation of business factors in relation to game performance, and the results support the theoretical foundations and provide first evidence that key business factors play an important role in digital game performance.

Customer satisfaction in the DGI refers to meeting the customer's expectations by providing a functional game, addressing the availability issue for online games, and offering good customer service and expert advice on games. The customer satisfaction variable for business performance measurement in the DGI has not yet been explored in the literature. Basically, game development organizations must value their customers or players by meeting their expectations. This study has found a positive association between customer satisfaction and digital game performance. Organizations can use appropriate measures to track their customers' purchasing behaviour and focus more on providing customer service. To implement better customer service, organizations need to understand their game players, implement player-specific platform services, and take feedback strongly into consideration. Most literature reviews have focused on the relationship between business performance and customer satisfaction in different industries. To be successful in the competitive DGI market, game development organizations must take all these strategies into account to explore their relationship with their customers. By adopting best practices, organizations will be able to understand their customers or players, and instead of aiming for one-hit wonders, attracting new customers and retaining existing ones will become the main indicators of customer

satisfaction. Important factors affecting customer retention include their initial play experience, the level of game addictiveness, the fit between organizational targets and the market, and finally, the ability of the organization to correct all issues that harm retention. Customer satisfaction data in an organization are also helpful for continuous improvement, which affects the organization's business performance on a long-term basis.

Market orientation was also found to have a positive impact on digital game performance. In the DGI, market orientation is a vast and complex topic. Game development organizations need to focus mainly on two artifacts while developing their games. First, the marketing strategy artifact is a kind of guideline that describes your targets, and second, the marketing plan artifact is a detailed description of your targets and how you will execute them. The organization must develop the marketing strategy at the beginning of the game development process because most of the decisions about game development such as monetization, game design, languages, and demographic locations of game availability will impact the marketing strategy. For market-driven games, one important decision about marketing is whether the organization will publish the game by itself or transfer it to a publisher. In each case, the marketing plan execution will be different. A publisher will take into account the target audience, locations, and platforms, and the marketing plan will be executed by the publisher. However, if the organization publishes the game on their own, it must also consider its target audience, the game business model, geography, budget, platforms, and marketing channels. The impact of market orientation on business performance was explored by Adewale *et al*. (2013), who reported that market orientation is a significant joint predicator of business performance in terms of return on investment, market share, and profitability. Business performance as a market orientation variable can be measured in terms of monetization, packaging, and promotion strategies as well as calculations of individual customer revenue and profitability.

The DGI appears to consider innovation as a basic source of competiveness. Most organizations see innovation in games as bringing new things to the market and being different from competitors. Innovation in game development can involve application of new ideas at the game level, storyboard production, use of new technology, or the

creative artistry of the game, with the aim of attracting more gamers and thus creating value in terms of business performance. Not one single study has addressed the issue of innovation in the DGI. Innovation in the game industry can also refer to an innovative business model of the game development process that addresses all innovation categories, as described by Johannessen (2013) and Lawson and Samson (2001). On the contrary, the findings of this empirical investigation do not support a statistically positive relation between innovation and digital game performance. The direction of association was positive, but the required statistical level of confidence was not supported.

It has also been assumed here that the user integration approach in the DGI enables organizations to use their users as a resource. It is important to consider users as a resource because especially in the computer game industry, users are the revenue producer, and the business totally depends on their positive playing experience. More user involvement enables the organization to retain its users/customers. The question now arises of how game users who are also players can become involved in parts of the game development process. One approach to user integration is through virtual community membership. Nohria and Ghoshal (1997) argue that "the real leverage lies in creating a shared context and common purpose and in enhancing the communication densities within and across the organization's internal and external boundaries". This argument also supports the concepts of customer socialization and community participation in the game development process. However, this user integration approach is cost-effective for any organization. In such communities, customers can participate based on their broad communities of interest. They can be a part of game development by sharing their playing experiences, being involved in idea generation, becoming co-creators or testers of games, or in other ways. Use of online communities in the development process constitutes an important source of innovation and also enables organizations to implement constructive relationships with their users.

In successful game development, relationship management plays a significant role. Integrating players into the development process and maintaining excellent working relationships with them helps developers to improve the performance and functionalities of their games. However, the assumption that relationship management also helps the

organization to understand its customers' needs better and remain up-to-date about market trends was not found to be significant in this study. Empirical investigation found a negative association and also insufficient statistical support for a significant confidence level. Hence, the study was not able to find any impact or association between relationship management and digital game performance.

Because the DGI is flourishing, competition is very tough between digital game organizations. The organization which achieves competitive advantage using time-to-market processes will have a positive impact on business performance. This hypothesis was also supported by empirical investigation. Hence, game launch timing is important to capture major market share. The time-to-market approach in a game development organization develops a publishing schedule for the game and provides essential guidelines for development schedules to the developers. The game launch schedule is a crucial business decision that has profound and long-lasting impact on the business performance of an organization in retaining and capturing the market.

In the DGI, fulfilment of financial objectives or monetization strategy depends on economically optimizing the pricing scheme for customers, the cost structure, and the target customer segment. In this empirical investigation, a positive association was found between monetization strategy and digital game performance. The pricing scheme can be a one-time payment, pay per session, pay per play, or subscription-based or bundled pricing. The cost structure is based on the complete picture of the entire budget for game development, including marketing and distribution costs. The overall cost of each phase until delivery to the user directly impacts the overall profitability of the organization. However, it is difficult to measure the cost impact of each phase on overall business performance (Zulkiffli & Perera, 2011). In this situation, the impact of monetization can be measured by using the overall profitability of the organization as a measure of business performance. As for the target customer segment, it is important to understand the needs of target customer groups to ensure that games are properly priced, marketed, and packaged to achieve business success.

Recently, in the DGI, use of successful game development brands that are useful to particular market segments has helped organizations connect with their target audience. This empirical investigation found a positive association and impact of brand name strategy on overall game performance. In particular, brand name strategy has become marketing strategy in branded games. Although branded game development costs the organization more, it pays off after publication by attracting large numbers of new and repeat users. An effective brand name strategy helps in defining game development and execution, ensuring that the game gets appropriate promotion in the marketplace, and positioning the game for its target audience.

The findings of this study will help game development organizations look for contributing key success factors from a business perspective and provide the justification to include these factors in the assessment methodology.

5.7.1 Limitations and Threats to External Validity

The first limitation of this study was the selection and choice of independent variables. Seven independent variables were included to investigate their association with and impact on digital game performance. However, other key factors may exist that have a positive impact on digital game performance, but this study was limited to the seven variables because of their presence in the literature. In addition, other key factors may exist, such as environmentally based, regionally based, or political factors, which have a positive impact on digital game performance, but are not considered in this study. Furthermore, this study has focused only on business factors in digital game performance.

The second notable limitation of the study is the small sample size. Most game industry developers who follow either agile practices or poor development practices were unable to respond to the questionnaire and did not respond. The vast majority of game developers work in one- to three-person teams and did not have the required level of experience (three years) and were therefore excluded from this empirical investigation. Most respondents refused to answer the questionnaire because they were too busy in the game development process or launching their games in the market. Some game development organizations are also hesitant to disclose their business performance.

Therefore, data collection from the game industry was limited, resulting in small sample size. The number of respondents from one organization was beyond our control because the organization's upper management was responsible for distributing the survey within a company. The main effect of small sample size is on its statistical power, Type II error, significance, and distribution (Chow *et al*., 2008). Therefore, the important thing is to avoid strong statements when drawing conclusions. The results of studies with small sample size can be difficult to replicate or generalize (Bryman, 2008), but they do provide some interplay between variables. Well-designed small studies seem to be acceptable because they provide quick results, but they need to be interpreted carefully (Heckshaw, 2008). The low sample size constraint of this study makes the results difficult to generalize. However, the results of this study are useful in providing a foundation for designing a larger confirmatory study, which is the future objective of this work.

Biased decision-making was the third limitation of this study. Although multiple responses were collected from each company to address the bias issue, it nevertheless remained a core issue. Respondents were asked to consult available documentation within their company to fill out the survey. Accepted psychometric principles were used to design the assessment items, and inter-rater agreement analysis was performed for conflicting opinions from the same organization, but the measuring instrument was still based on individual subjective assessment.

In spite of its specific and general limitations, this study has contributed to the field of digital games and has helped game development organizations to understand the business dimension of digital games.

5.8 Conclusion

This research has facilitated a better understanding of the business perspective of digital games. The main objective of this research was to investigate empirically the effect of business factors on the performance of digital games in the market and to try to find answers to the research questions posed in this study. Empirical investigation results demonstrated that business factors play an important role in digital game performance.

The results of the study strongly indicate that customer satisfaction, time to market, monetization strategy, market orientation, and brand name strategy are positively associated with the performance of a digital game organization. The empirical investigation found no strong association or impact between relationship management or innovation and digital game performance.

This study is the first of its kind in the field of digital games. It will help and enable organizations to achieve a better understanding of the effectiveness of business factors and their role in terms of game performance in the market. Game development organizations need to consider these various business factors over and above their current efforts to improve the performance of their developed games in the market (Aleem *et al*., 2016). This study has provided the empirical evidence and justification to include business factors in evaluating the game development process maturity. More details will follow in Chapter 7.

Chapter 6

6 Consumer Perspective for Game Development: An Empirical Investigation[4]

Contemporary digital game development companies offer a variety of games for their consumers' diverse tastes. Another important game development choice is considering the consumer perspective to produce quality digital games. Game development is a complex task, and measuring the consumer experience of games poses an additional challenge. This study attempts to provide a better understanding of the consumer perspective as a factor in digital game success. It focuses mainly on an empirical investigation of the effect of consumer factors on the digital game development process and finally on the quality of the resulting game. A quantitative survey was developed and conducted to identify key consumer factors. For this study, the developed survey was used to test the research model and hypotheses. The results provide evidence that game development organizations must deal with multiple key consumer factors to remain competitive and handle high pressure in the digital game industry.

6.1 Research Background

Consumer is a person who purchases a game for personal use and is here synonymous with the term 'player'. One of the main concerns in game development is ensuring consumer satisfaction. In other words, whether a commercial game is able to retain its consumers can be determined only at the end of the development process. Kotler (1994) explained that consumer preference is very important and a main concern for development of successful products, but that ensuring consumer satisfaction within the digital game development process is a crucial aspect (Fabricatore *et al*. 2002).

[4]Parts of this chapter were submitted in following Journal:

S. Aleem, L.F. Capretz and F. Ahmed, (2016d). A consumer's perspective on digital games: An empirical investigation, Computer Game Journal, Springer, Submitted, 38 pages.

Hence, to obtain insight into consumer preferences for the digital games they want to play, it becomes important to know the factors that influence their buying decisions and playability preferences. Generally, game development companies can benefit from general usability evaluation methods, but there are significant differences between general software applications and digital games (Jorgensen, 2004). Therefore, game players should not be considered as identical to users of other software. An integral part of a game is the design of meaningful challenges, which is obviously a different task from developing easy-to-use software or minimizing cognitive load. Hence, playability is considered as somewhat different from general game usability (Järvinen *et al*., 2002; Ermi and Mayra, 2005).

Nacke (2009) stated that the most important quality factors considered by consumers for digital games are usability and playability. Usability (ISO/IEC 2011) can be described as the level, to which a digital game is learned, understood, used, and remains attractive to the consumer under specific conditions. Playability (Järvinen *et al*., 2002) is used to evaluate digital game play or interaction based on certain criteria. Normally, usability of any game is evaluated at a very late stage of the game development process, whereas playability is evaluated using early prototypes or iterative cycles during development. The key playability factors along with the usability factors increase the gamer's tendency to play the game repetitively. This study focuses on identifying those key factors, from a consumer perspective, which provide game development companies with stable revenues, leading to competitive advantage.

In today's world, digital game consumers are seeking more realistic and interactive elements in digital games. However, current game development process is unable to accommodate this requirement. Exploring diverse consumer preferences for digital games provides a significant benefit for the game development process by generating valuable insights. Consequently, it is necessary to assess key success factors from a consumer perspective and to search for a new approach that will include consumer needs in the game development process. This study will help identify key factors empirically from the

consumer perspective, an effort that will ultimately help improve the game development process. To identify key factors, a quantitative survey was conducted, and the results are reported here. The survey was used to test the research model and five hypotheses. Finally, the results show that consideration of key factors from a consumer perspective is an important game development choice.

6.1.1 Digital Game Consumer Perspective: Related Work

A game is nothing without players. Play is an integral element of any digital game. The literature demonstrates that researchers have taken into account the various perspectives of digital game consumers, especially in the processes of game development and design. Sotamaa *et al.* (2005) investigated the role of players in game design. They emphasized the importance of players' role in developing a good-quality digital game. The primary focus of their research was on the evaluation method and secondly on integrating elements of play into game design by introducing an active dialogue between player and developer. Song and Lee (2007) identified key evaluation factors for game design, especially for massively multi-player online role-playing games (MMORPGs), through usability evaluation. They identified 54 key factors after conducting experiments on commercially available MMORPGs and divided them into four categories. The first one was the game interface, which included feedback, control, metaphor, consistency, flexibility, recognition, aesthetics and minimalist design, affordance, help, and natural mapping. The second was game play, which included goals, rewards, learning, pace, pressure, challenges, empathy, re-playability, fairness, balance, difficulty, and perceptual motor skills. Game narrative was the third category and involved evocative space, embedded narrative, enactment of stories, emergent narratives, curiosity, interaction between gamers, and narrative and modeless operation. The last category was game mechanics, which included factors such as physics, immediate display, and vividness. They extended current game evaluation methods and has identified implications for improving digital game quality at any design stage. The study was conducted on a group of students from Korea, and therefore the validity of the results is subject to cultural limitations.

Sanchez *et al*. (2009) highlighted the importance of the playability factor for video game development and emphasized that it must be taken into account throughout the game development process. They stated that to analyze video game quality, usability alone is not enough, but playability must also be considered. Usability captures only the use of the game, but playability goes beyond that, especially in the case of digital games. They defined playability as "a set of properties that describe the player experience using a specific game system whose main objective is to provide enjoyment and entertainment by being credible and satisfying, when the player plays alone or in company". Therefore, playability is not limited to subjective factors like fun and entertainment, but needs to cover other consumer dimensions such as satisfaction and credibility. The playability of a digital game can also achieve set goals with effectiveness and efficiency depending on the context of use, and the game also offers fun and satisfaction. Based on their analysis, they proposed seven attributes to characterize video-game playability: learnability, satisfaction, effectiveness, motivation, immersion, socialization, and emotion. Consideration of playability factors while designing a game will help to improve the quality of the final product, i.e., the video game.

Schoenau-Fog (2011) developed a survey to investigate the components and the triggers of player engagement in digital games. As a result of this survey, the proposed categories were structured into four components: objective (extrinsic or intrinsic), activities (exploring, interfacing, socializing, story or character experience, etc.), accomplishment (progression, completion, or achievement), and affects (abortion, positive, or negative). These components included categories that supported the player engagement process. The highlighted categories must be included when investigating key aspects of the player's engagement process. The main limitation of the study was that it was limited to one group and one game with open-ended questions.

Fernandez *et al*. (2012) discussed video-game evaluation from a model-driven development perspective. They presented a usability evaluation method that can be used in all stages of development. The proposed method used the ISO/IEC 25010 (SQuaRE) standard and defined attributes and metrics especially for the video game domain. The attributes were appropriateness, recognizability, ease of use, learnability, helpfulness,

attractiveness, and technical accessibility. This method of evaluation is limited to the early stage of model-driven development.

Most of the related work done in the past was limited in scope, and validation of the proposed models is still an open question. This study will capture the important factors about consumers' preferences about what they expect to have in a game. Ultimately, identified factors will help developers to consider them while developing games and finally contributing to development of good-quality digital games.

6.2 Literature Review and Proposed Hypotheses

In the past, researchers highlighted the concept of a consumer-centred approach to the game development process. Many attempts were made to propose methods to capture consumer perspectives, but very few considered the importance of consumer preferences during the game development process. The following five important factors were identified from the literature as elements that can directly or indirectly contribute to the development of good-quality digital games from the consumer perspective.

6.2.1 Consumer Engagement

Consumer engagement is an important aspect of any successful product and is also considered critical for digital game success. Charlton and Danforth (2007, 2010) defined engagement as "a high degree of involvement in computer usage". One of the main issues highlighted in their research was the psychological behaviour of "addiction" to computer-related activities, from which consumers can suffer. They stated that this type of behaviour was related only to personality variables (i.e., low emotional stability or high extraversion) and was not considered as an engagement factor.

Several studies have been carried out by researchers to investigate the consumer engagement concept in digital games. Basically, this concept is closely related to the consumer's level of motivation in term of presence, immersion, or perceived realism (Boyle *et al*., 2012). "Presence" is the most popular concept in terms of consumer engagement and is well adapted to the digital game environment. Stanney and Salvendy (1998) defined presence as "the subjective experience of being in one place or

environment even when one is located at another". Lee (2004) proposed three dimensions of presence: spatial presence (associated with distant or virtual objects), social presence (associated with distant or virtual social actors), and self-presence (associated with a represented self or virtual actor). Retaux (2003) suggested a method to evaluate variations in presence using video recording during a single game session and authenticated it by case study. The concept of immersion is a "psychological state characterized by perceiving one's self to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences" (Stanney & Salvendy, 1998; Witmer & Singer, 1998). Based on game narrative factors, Qin *et al*. (2009) proposed a survey questionnaire for immersion and validated it for seven factors in the game narrative: concentration, curiosity, empathy, comprehension, challenge, familiarity, and the skills and control of corresponding players. Jennett *et al*. (2008) proposed an experimental method to evaluate a player's level of immersion by recording eye movements. The researchers agreed that immersive tasks within the game help a player to pay attention to important game tasks. Malliet (2006) referred to as *perceived realism* the subjective realism that a game consumer experiences with respect to the virtual world.

Ribbens and Malliet (2010) proposed that the perceived realism of a video game depends on many factors from the virtual world, such as freedom of choice, realism of the simulation, character involvement, authenticity of subject matter, character involvement, character authenticity, perceptual pervasiveness, and social realism. To identify that consumers of digital game consider engagement an important factor for their favourite game, consumer engagement was selected as a dependent variable in our research model, as shown in Figure 6.1. Hence, Hypothesis 15 can be stated as follows:

Hypothesis 15: The consumer engagement factor is important for the success of a digital game in the DGI.

6.2.2 Consumer Enjoyment (feeling of accomplishment, interest, curiosity)

Consumer enjoyment has been viewed as a central component of games, especially digital games. The enjoyment factor in games can be described as the positive response of an individual to the game content and its media technology (Vorderer *et al*., 2004). Enjoyment is also seen as a central concept in *human-computer interaction* (HCI) and is a frequently assessed dimension when measuring user experience (Blythe and Hassenzahl 2005).

The concept of enjoyment within digital games is interpreted differently across genres, individuals, content, and platforms. It is important to study how it is discussed by researchers because this will provide insight into our understanding of the digital game enjoyment factor from a consumer perspective. Similarly, Sweetser and Wyeth (2005) also stated that the definition of game enjoyment is vague in the literature because it is not well differentiated from other related psychological concepts. Fang *et al.* (2010) studied enjoyment and referred to it as a positive reaction of the player during a particular game session. They developed a questionnaire based on three dimensions of enjoyment: affective (linked to the player's affective state and emotions), behavioural (linked to the player's behaviour during the game session), and cognitive (linked to the player's judgments about the game elements). The enjoyment factor for web sites has been well operationalized and conceptualized (Lin *et al*., 2009), but this concept cannot be applied to digital games because the central goal of a game is enjoyment, whereas web sites have utilitarian goals. Boyle *et al.* (2012) also considered enjoyment as a key subjective experience for the engagement process in digital games. Takatalo *et al*. (2010) provided an overview of the enjoyment factor as a subjective experience. Most researchers have equated enjoyment with the flow experience (Sweetser and Wyeth, 2005; Weber *et al*., 2009), given that flow is linked to the subjective experience of challenging activities based on a euphoric state of involvement and concentration. Some researchers have also argued that enjoyment can occur elsewhere than in the flow experience (Jennett *et al*., 2008; Takatalo *et al*., 2010; Nakamura and Csikszentmihalyi, 2002). Fang *et al*. (2013) developed a questionnaire based on different components of flow to measure flow in

video games. Brockmyer *et al*. (2009) proposed a game engagement questionnaire to measure engagement in video game-playing and considered enjoyment as a multi-dimensional construct that combines positive affect, competence, challenge, and absence of frustration, whereas flow is an involvement construct including boredom and immersion.

Mekler *et al*. (2014) performed a systematic review to analyze measures and operationalization of enjoyment in digital entertainment games. They also proposed that flow is different from enjoyment and may occur independently of cognitive involvement and challenge. They also considered enjoyment as a valence of the player experience. Hence, to determine whether enjoyment is an important factor for any consumer of digital games, it was selected as another independent variable in digital game success, and the following hypothesis was offered:

Hypothesis 16: Consumer engagement has a positive and significant effect on digital game success.

6.2.3 Game Characteristics (interactive features, bug reporting, feedback, game challenge)

An understanding of game characteristics, particularly of game content, is very important from both developer and consumer perspectives in digital games. Characteristics of games include a user interface (output/input techniques), rules like game challenges or levels of difficulty, interactive features, skill requirements, reward/effort ratio, and game narrative. All these characteristics of games have been studied by many researchers, and most game characteristics have been studied independently. The output techniques for digital games involve auditory and visual information. Typically, the output interface consists of certain objects within action scenes such as avatars, targets, or enemies and a moving complex background. Usually, the main action scene contains a heads-up display to provide contextual information. Auditory information is also included within the digital game to facilitate the consumer experience. Wolfson and Case (2000), Caroux *et al.* (2013; 2011), and Sabri *et al*. (2007) performed experiments to show that the

background and arrangement of contextual elements like heads-up displays have an impact on the performance of the digital game consumer.

Several studies have investigated the impact of output techniques, such as the influence of auditory information, the representation of the virtual world, and the quality of displayed information, sound, and music on the player experience in digital games (Yannakakis *et al*., 2010; McCall and Braun, 2008; Nacke *et al*., 2010; Bracken and Skalski, 2009; Hou *et al*., 2012; Skalski and Whitbred, 2010). The input techniques in digital games can involve devices such as a controller, joystick, computer keyboard, or mouse, or combinations of these, plus other input methods based on touch, motion, gaze, tangibles, or brain control. Researchers have also widely studied the impact of input techniques on consumers' experience (Lin *et al*., 2012; Bianchi-Berthouze, 2013; McGloin *et al*., 2011; Silva and El Saddik, 2013; Vickers *et al*., 2013; Van de Laar *et al*., 2013). Game challenge or level of difficulty is another important characteristic of digital games. Few studies in the digital game literature have discussed the impact of challenge characteristics. Qin *et al*. (2010) studied how varying the level of difficulty impacts consumer immersion. Liu *et al*. (2009) provided a comparison between two systems of dynamic difficulty where challenges were based on either the consumer's level of anxiety or his/her performance. The results of the study showed that the consumer's experience was better when it was based on level of anxiety. Shaker *et al*. (2013) also investigated dynamic challenges in games based on the consumer's experience. The challenge of a digital game should be varied and gradually increased to maintain the level of interest within the game. When a consumer develops mastery, the game should provide more challenges. The match between the challenge and the consumer's perceived skills for an activity is an important precursor of flow. If the difficulty level of the challenge is higher than the perceived skill of the consumer, it results in anxiety, or if it is lower, it results in apathy (Johnson and Wiles, 2003).

Another important characteristic of game play is the game narrative. Digital games generally include a story line, and Choi *et al.* (2013) showed that fantasy in a story line enhances motivation and immersion in video games. The author proposed four scale factors to evaluate the fantasy state in games: identification, analogy, imagination, and

satisfaction. Park *et al.* (2010) also evaluated the role of narrative in video games and showed that it increases player presence. They compared the game with a situation in which the player saw a presentation of the technical aspect totally disconnected from the game narrative. Based on a literature review of the importance of game characteristics, this study has considered game characteristics as another independent variable that is considered important by its consumer and involved in digital game success. Hence, the following hypothesis is proposed:

Hypothesis 17: The characteristics of a game are important for the success of the digital game.

6.2.4 Ease of Use (level of guidance)

Ease of use reflects "the degree to which a person believes that using a particular system would be free of effort" (Brown and Licker, 2003; Davis, 1989; Gentry and Calantone, 2002; Venkatesh *et al*., 2003; Vijayasarathy, 2004). Therefore, ease of use for digital games means that the consumer can easily manipulate the controls within the game to take actions which help in achieving the goals of the game. Ease of use in digital games also include attributes like control consistency and internal and external navigational consistency.

Davis and Sajtos (2008) and Newman (2002) argued that ease of use in digital games results in a higher level of interactivity by consumers. Ease of use is considered as a fundamental driver, especially with marketing-related products like digital games. Davis and Lang (2012) explored the relationship between a user's game purchase, usage behaviour, and ease of use. They conducted interviews based on a structured questionnaire, using four competing models of digital game types: all games (the original model), massively multiplayer online role-playing games (MMORPGs) and role-playing games (RPGs) generally, sports/simulation/driving games, and action/adventure/fighting games. To determine whether the ease of use factor in a digital game impacts purchasing behaviour, ease of use was considered as an independent variable for this study, and hence the following hypothesis was proposed:

Hypothesis 18: Ease of use has a positive and significant impact on the success of digital games.

6.2.5 Socialization

Digital games give rise to meaningful and engaging social interactions. Socialization has now become an important feature of digital games in today's world. Socialization is not a game characteristic that provides flow or immersion, but rather provides an opportunity to promote the social dimension of digital games. It enables a game consumer to socialize with his/her friends and share game experiences. Sanchez *et al.* (2009) studied the usability and playability of video games and proposed that the socialization attribute of video games has certain properties. The properties of socialization include: social perception (including the degree of social activity as understood by its consumer); awareness, meaning that consumers have a sense of sharing objects or being part of a "team"; personal implications, meaning that each consumer knows how his/her action leads to group or individual victory; sharing, including an understanding by the consumer of how to manage resources or common objectives within a group; communication, which provides mechanisms to support successful information exchange; and interaction, including ways to support interaction among consumers.

The social interaction feature has also been considered as another independent variable involved in digital game success; to determine whether is it considered mandatory by game consumers, and the following hypothesis was presented:

Hypothesis 19: Social interaction is an important attribute for digital game success.

6.3 Research Model

The main objective of the proposed research model is to analyze the associations and interrelationships among the important factors of digital games from a consumer perspective and their influence on digital game performance in the DGI market. The concepts found in the game development literature and in studies, addressing the consumer perspective on digital games provided the theoretical foundation for the proposed research model. Most considered one or two consumer factors in digital game

success or performance and examined their impact. This study has empirically investigated the associations and influences of key factors from a consumer perspective and digital game performance in the DGI. The theoretical research model used for empirical investigation is presented in Figure 6.1. This model assesses the association of various independent variables emerging from game development and the consumer satisfaction literature on the dependent variable, the success of the final product, i.e., the digital game, in the DGI. Overall, the goal of this study is to investigate and address the following research question:

Research Question: What are the key consumer factors that influence the buying decision and provide a motivation to play digital games, and what is their impact on overall digital game success in the DGI?

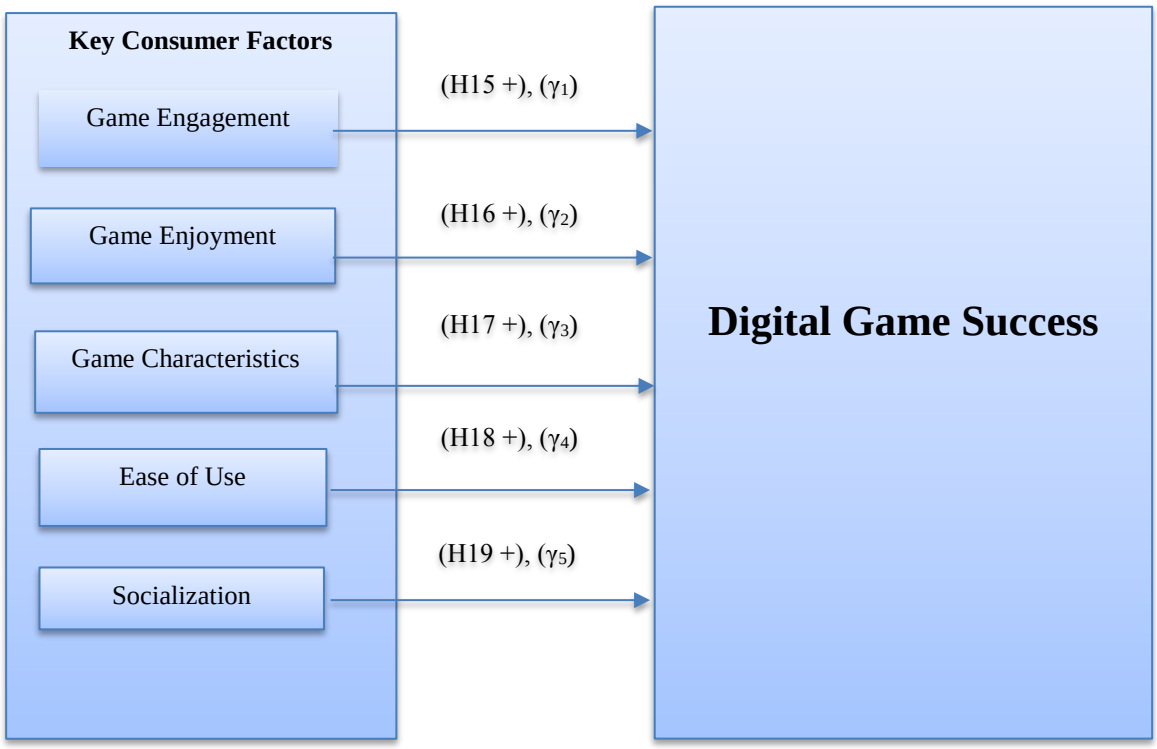

Figure 6.1 Research Model

The research model consists of five independent variables: game engagement, game enjoyment, game characteristics, ease of use, and socialization, and one dependent variable, digital game success. The following multiple linear regression equation represents the research model and is given below as Eq. 6.1:

$$\text{Digital game success} = \gamma_0 + \gamma_1 f_1 + \gamma_2 f_2 + \gamma_3 f_3 + \gamma_4 f_4 + \gamma_5 f_5, \qquad (6.1)$$

where γ_0, γ_1, γ_2, γ_3, γ_4, γ_5 are coefficients and f_1–f_5 are the five independent variables.

6.4 Research Methodology

The development and growth of digital games have been phenomenal. Nowadays, every home has one or more gamers. The targeted respondents were players or consumers of digital games. Initially, we started blogs in game development communities for data collection. A structured survey questionnaire was also developed. The questionnaire was placed on various blogs on the Internet, and some personalized emails were sent to digital game groups on social media such as LinkedIn and Facebook. After two and one-half months of investigation, 469 responses had been collected, of which 389 (82.94%) were valid. Participants completed the overall questionnaire under the agreement that their identities would be kept confidential. First, we analyzed the basic information from the collected data related to each player's region, the game platform(s) used by the player, and the game genre(s) liked by the player. The respondents came from Asia, Africa, Europe, South America, Australia, and North America, and statistics describing them are illustrated in Figure 6.2.

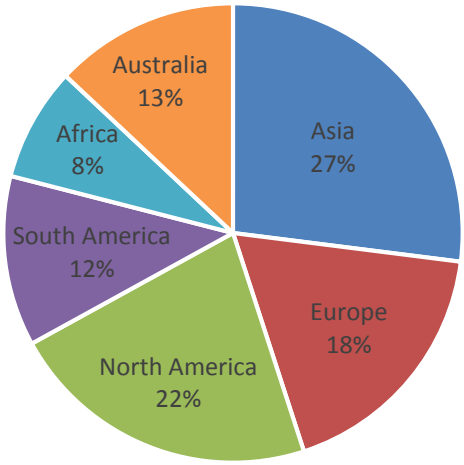

Figure 6.2 Percentages of Respondents by Region

The participants in the survey played games on different platforms such as kiosks and standalone devices, the web, social networks, consoles, PC/Macs, and mobile phones. Figure 6.3 shows the different platforms used and the percentage of respondents using each. The game genres played by the respondents included puzzles, action or adventure, racing, sports, music-based, strategy/role playing, and other categories. The total percentage of respondents playing each game genre is shown in Figure 6.4. The participants considered for this study were those who played games at least weekly.

6.4.1 Measuring Instrument

Data were collected for this study to analyze the key consumer factors and the perceived level of game success as identified in the research model depicted in Figure 6.1. The data collection instrument developed for this study was a structured questionnaire and is presented in Appendix VI.

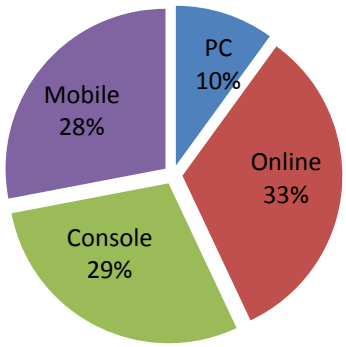

Figure 6.3 Percentages of Respondents for Each Game Platform Used

Consumers who play games at least on a weekly basis were considered for this study and were first asked to what extent they considered the identified key factors to be important for their preferred digital game. Second, they were asked about game performance and its relation to success in the DGI. The questionnaire as developed used the five-point Likert scale, and for each statement, the respondents were required to state their level of agreement or disagreement. Twenty-two items were developed to evaluate the independent variables (the consumer key factors), and five items were used for the dependent variable (game performance).

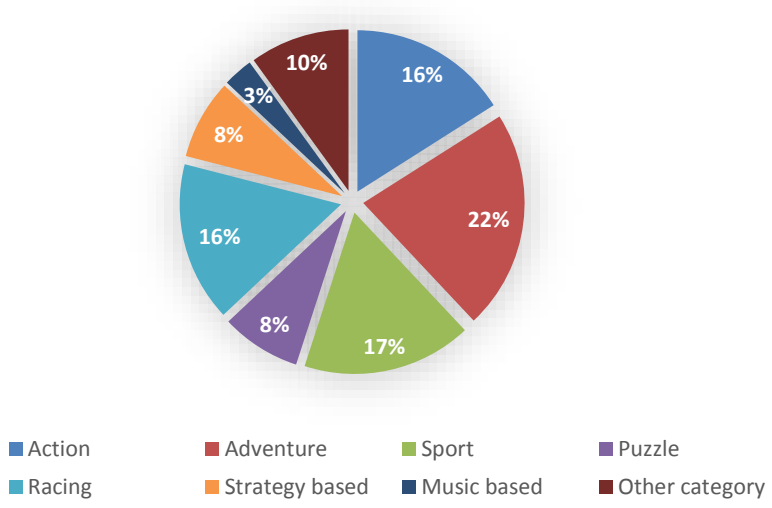

Figure 6.4 Percentages of Respondents Based on the Game Genres They Play

The comprehensive list of measuring items for each factor was derived after a detailed review of the literature related to consumer factors for digital games. The five-point Likert scale used for the questionnaire ranged from (1) meaning "strongly disagree" to (5) meaning "strongly agree" and was linked with each item. The measuring items in the questionnaire were numbered sequentially from 1 to 22. The dependent variable, game success, was measured for consumer's enjoyment, attention, game attributes, ease of use, and socialization based on a multi-item five-point Likert scale. The measuring items for the dependent variable were numbered sequentially and separately from one to five. All items were specifically written for this study and are presented in Appendix VI.

6.4.2 Reliability and Validity Analysis

For this empirical study, analyses of both reliability and validity were done for the specifically designed measuring instrument and based on the most commonly used approaches. To carry out an internal consistency analysis, the reliability of multi-scale measurement items for the five consumer factors was evaluated using Cronbach's alpha coefficient (Cronbach, 1951). First, the sample dataset was evaluated using Cronbach's alpha; if any assessment item affected the Cronbach's alpha of its related category, it was excluded from the measuring instrument. All the assessment items were found reliable in the sample test. After this, the whole dataset was evaluated. The reliability of the five consumer factors was reflected by Cronbach's alpha ranging from 0.65 to 0.85 as given in Table 6.1.

Table 6.1 Cronbach's Alpha Coefficient and PCA of Five Variables

Consumer factors	Item no.	Coefficient α	PC eigenvalue
Game engagement	1–5	0.71	1.49
Game enjoyment	6–9	0.85	1.57
Game characteristics	10–15	0.74	1.01
Ease of use	16–19	0.70	1.16
Socialization	20–21	0.65	1.61

Hence, all the variable items developed for the measuring instrument could be considered reliable. To analyze validity, a principal component analysis (Comrey & Lee, 1992) was

conducted for the five consumer factors, with results reported also in Table 6.1. Campbell and Fiske (1959) considered that if the scale items were highly correlated and if in a given assembly, they moved in the same direction, then convergent validity had occurred. To determine the construct validity of the PCA-based measuring instrument, the eigenvalues (Kaiser, 1970) were used as a reference point. For empirical investigation in this study, the Kaiser Criterion (Kaiser, 1960) was used. The Kaiser Criterion aims to keep any value greater than one for any component. Eigenvalue analysis indicated that of the five variables, four formed a single factor, whereas the game characteristics loaded onto two factors, both with eigenvalues greater than one. The reported convergent validity of this study is therefore considered as adequate.

6.4.3 Data Analysis Techniques

For this empirical research, various statistical methods were used to carry out data analysis. Initially, data analysis was divided into three phases to assess the significance of hypotheses H15–H19. Parametric statistics and normal distribution tests were conducted in phase I. Partial least squares (PLS) analysis was used in phase II as a non-parametric statistical approach. Both approaches were used to address the question of external validity threats. In the measuring instrument, for each dependent and independent variable, multiple items were used. A composite value was obtained by aggregating respondents' ratings for each dependent and independent variable. Pearson's correlation is a statistical approach that measures the linear relationship between two continuous random variables. It does not depend on data normality, although it does assume finite covariance and variance. On the other hand, Spearman's correlation describes a monotonic relationship between two continuous random variables and is also robust to outliers. The number of respondents was sufficient to carry out data analysis, although in the area of research, this number of respondents is still considered as a small sample. To address this concern, both parametric and non-parametric statistical approaches were used. The Pearson correlation coefficient with the one-tailed *t*-test was evaluated for each hypothesis H15–H19 in phase I. In phase II, the Spearman correlation coefficient (a non-parametric statistic) was used to test hypotheses H15–H19. Phase III consisted of PLS-based techniques for testing the research model developed from H15–H19. The PLS

technique was used in phase III to increase the reliability of the results. For statistical calculations, the Minitab 17 digital was used.

6.5 Data Analysis and Results

6.5.1 Phase I of Hypothesis Testing

The Pearson correlation coefficient (a parametric statistical approach) was used to examine and test hypotheses H15–H19. It was examined between the key factors from a consumer's perspective (independent variables) and digital game success (dependent variable) in the research model, as illustrated in Figure 6.1. The significance level based on the *p*-value was used to accept or reject each hypothesis. A *p*-value less than 0.05 was considered good enough to accept the hypothesis; in the case of a value greater than 0.05, the hypothesis would be rejected (Westfall &Young, 1993). Table 6.2 shows the hypothesis testing results for the Pearson correlation coefficient. Hypothesis H15 was accepted because the Pearson correlation coefficient for game engagement and game success was positive (0.65) at $p<0.05$. For hypothesis H16, concerning game enjoyment and game success, the Pearson correlation coefficient was also positive (0.75) at $p<0.05$, and therefore hypothesis H16 was also accepted. Hypothesis H17, regarding game characteristics and game success, was accepted due to its smaller *p*-value (0.04). Hypothesis H18, concerning ease of use and game success, was also accepted based on its positive Pearson correlation coefficient (0.79) at $p<0.05$. Hypothesis H19, concerning socialization and game success, was rejected based on its *p*-value greater than 0.05 (0.29). In short, hypotheses H15, H16, H17, and H18 were accepted and found to be statistically significant. Hypothesis H19 was not supported statistically and was therefore rejected.

6.5.2 Phase II of Hypothesis Testing

The Spearman correlation coefficient (a nonparametric statistical approach) was used in phase II to test hypotheses H15–H19. The results for the Spearman correlation coefficient are also reported in Table 6.2. The Spearman correlation coefficient for hypothesis H15 was found statistically significant (0.65) at $p<0.05$, and therefore H15 was accepted. The Spearman correlation coefficient for game enjoyment and game success (hypothesis H16)

was also found to be positive (0.74) at $p<0.05$ and statistically significant. The relationship between game characteristics and game success (hypothesis H17) was found statistically significant due to its Spearman correlation coefficient (0.56) at $p<0.05$ and was accepted. For hypothesis H18, the Spearman correlation coefficient was positive at $p<0.05$, and therefore H18 was accepted. Hypothesis H19 concerning socialization and game success was rejected due to its low coefficient (0.30) at $p>0.05$. Hence, in short, hypotheses H15, H16, H17, and H18 were accepted and found statistically significant. Hypothesis H19 was not supported statistically and was therefore rejected.

Table 6.2 Hypothesis Testing using Parametric and Non-Parametric Correlation Coefficients.

Hypothesis	Key Consumer Factors	Pearson correlation coefficient	Spearman correlation coefficient
H15	Game engagement	0.65*	0.65*
H16	Game enjoyment	0.75*	0.74*
H17	Game characteristics	0.55*	0.56*
H18	Ease of use	0.79*	0.78*
H19	Socialization	0.29**	0.30**

*Significant at $p<0.05$ **Insignificant at $p>0.05$

6.5.3 Phase III of Hypothesis Testing

The partial least squares (PLS) approach was used in phase III to test the hypotheses. It was used to overcome the limitations associated with the parametric and non-parametric statistical approaches used in phases I and II and also to cross-validate the results of phases I and II.

Table 6.3 PLS Regression Results for Hypothesis Testing.

Hypothesis	Key Consumer Factors	Path coefficient	R^2	F-Ratio
H15	Game engagement	0.65	0.34	18.10*
H16	Game enjoyment	0.95	0.29	18.51*
H17	Game characteristics	1.16	0.37	35.52*
H18	Ease of use	0.94	0.62	100.38*
H19	Socialization	0.02	0.01	0.01**

*Significant at $p<0.05$ **Insignificant at $p>0.05$

For direction and significance analysis of hypotheses H15–H19, PLS was used. The dependent variable (game success) was selected as the response variable and the individual consumer factors designated as the predicate variable. The structural test results of phase III, including the observed values of R^2, the path coefficient, and the *F*-ratio, are presented in Table 6.3. Game engagement (H15) had a positive path coefficient of 0.65, an $R^2 = 0.34$, and an *F*-ratio = 18.10 and was found statistically significant at $p<0.05$. The path coefficient value for game enjoyment (H16) was observed to be 0.95, R^2 was 0.29, and the *F*-ratio was 18.51, and therefore H16 was also found significant at $p<0.05$. The game characteristics hypothesis (H17) had a positive path coefficient of 1.16, a low R^2 of 0.37, and an *F*-ratio of 35.52 and was judged significant because the *p*-value was less than 0.05. Ease of use (H18) had a path coefficient of 0.94, an R^2 of 0.62, and an *F*-ratio of 100.38 and was found significant at $p<0.05$. Socialization (H19) had a path coefficient of 0.02, an $R^2 = 0.01$, and an *F*-ratio = 0.01 and was therefore found insignificant at $p>0.05$.

6.6 Research Model Testing

The linear regression equation for the research model is presented in Eq. 6.1. The proposed research model was evaluated to provide empirical evidence that consumer factors are substantially important and must be considered to develop good-quality digital games. The test procedure analyzed the model coefficient values, the regression analysis, and the direction of the associations. The dependent variable (digital game success) was designated as the response variable and the other independent variables (all the key consumer factors) as predicate variables. The results of the regression analysis model are reported in Table 6.4.

The path coefficients of four of the five variables (game engagement, game enjoyment, game characteristics, and ease of use) were positive and were found statistically significant at $p<0.05$. The path coefficient of socialization was positive, but was found not to be statistically significant at $p<0.05$, which made this factor insignificant in the research model. The overall R^2 value of the research model was 0.76, and the adjusted R^2 value was 0.78 with an *F*-ratio of 22.36, which was significant at $p<0.05$.

Table 6.4 Linear Regression Analysis of the Research Model.

Model coefficient name	Model coefficient	Coefficient value	*t*-value
Game engagement	α_1	0.33	1.76*
Game enjoyment	α_2	0.78	3.98*
Game characteristics	α_3	0.70	3.65*
Ease of use	α_4	0.20	0.72*
Socialization	α_5	0.16	1.09**
Constant	α_0	0.45	1.09*
R^2	0.76	**Adjusted R^2**	0.78
***F*-ratio**	22.36*		

*Significant at $p<0.05$ **Insignificant at $p>0.05$

6.7 Discussion

Nowadays, everybody seems to be addicted to playing games. Game players or consumers can help to identify key factors that enhance digital game quality. Now it is time to understand the consumers' perspective and learn what they expect from a game and how the developed game can become successful in the market. The observed results support the theoretical assertions made here and provide the very first evidence that consideration of key consumer factors while developing games is important for the success of any digital game.

The engagement factor for digital games is a complex topic. Researchers have approached this factor from different, yet overlapping perspectives. For example, some have used the presence concept to describe a kind of psychological state in which a player experiences the virtual world as a real world (Lee, 2004; Lombard and Ditton, 1997). However, some have questioned how presence contributes to the player's experience and finally leads to enjoyment (Tamborini & Skalski, 2006). Arguably, similar concepts have been explored under different names along with their own scholarly foci and rationales, such as absorption (Slater & Rouner, 2002), immersion (Hubbard, 1991), and realism (Shapiro, Pena-Herborn, and Hancock, 2006). Several studies have discussed the concept of engagement in digital games (Caroux *et al*., 2015) and have proposed various methods for evaluating the engagement process. Schoenau-Fog (2011) also proposed a player engagement process for digital games. Usually, the term *game engagement* in digital games refers to the consumer's experience during game

play and is strongly related to the level of motivation expressed by the consumer. The consumer engagement variable for measuring the success of digital games in the DGI has not yet been explored in the literature. The game engagement factor in the digital games considered by this study consists of presence, immersion, and perceived realism as experienced by game consumers. This study has explored the multi-faceted concept of consumer engagement in digital games from a consumer's perspective. It has found a positive association between the game engagement factor and the success of a game in the DGI market. In the game development process, it is important that developers also consider the engagement factor within the development process and balance it with other development issues.

The game enjoyment factor has been found to have a positive impact on digital game success. Consumers of digital games are motivated to play games because they want to experience enjoyment, and the literature has shown that enjoyment is a positive reaction of a player during a game play session. The enjoyment factor is important to consider in the game development process. Game developers have mainly been using usability guidance tools as heuristics to develop games that have an enjoyment factor. However, what developers think about the enjoyment factor in a game may not necessarily match consumers' expectations. It is important to consider the consumer perspective on the digital game enjoyment factor and analyze what consumers think is important about this factor.

In developing games, the game characteristics are very important and can influence the consumer's experience, as has been shown in the literature. This hypothesis was also supported by empirical investigation. Research into game characteristics must also take consumer perspective into consideration and analyze how much weight consumers assign to each characteristic. These issues are often discussed by game players and designers, but are seldom written about in any formal way. By emphasizing these basic player-centric concepts, this study may help persuade developers that they may find solutions to design problems by looking at what game consumers feel about game characteristics.

The ease-of-use factor plays a significant role in the game development process. In digital games, ease of use consists of all attributes of the digital game that help its consumer to control and operate the game easily, within or outside the gameplay. Ease of use is the most talked about and least understood aspect of digital games. In this empirical investigation, a positive association was found between the ease-of-use factor and digital game success. The literature has also shown that digital game consumers prefer to use and purchase digital games that are easy to use (MAC or PC and/or games on a console such as their iPad, mobile phone, Sony Playstation, Microsoft Xbox, or Nintendo Wii).

It is commonly assumed that the social interaction attribute of digital games is crucial to their success. It is also assumed that it is helpful to document the gaming experience with the participation of virtual communities, either for MMPROG or for single-player games. Very few researchers have studied the socialization attribute of digital games. Because of all the assumptions used, it is important to study the consumer perspective on the socialization attributes of digital games and to identify what consumers think about these attributes. The findings of this empirical investigation do not support a statistically positive relation between socialization and digital game success. The direction of the association was positive, but the required statistical level of confidence was not supported. For these reasons, the hypothesis that socialization factors are considered very important by consumers for the success of digital games was statistically rejected. The findings of the study will help game development organizations to look for contributing key success factors from a consumer perspective.

6.7.1 Limitations and Threats to External Validity

For software engineering processes or product investigations, various empirical approaches are used, such as case studies, metrics, surveys, and experiments. However, certain limitations are associated with empirical studies and with this study as well. Easterbrooks *et al.* (2007) suggested four criteria for the validity of empirical studies: internal validity, construct validity, external validity, and reliability. Wohlin *et al.* (2000) stated that generalization of experimental results to industrial practice by researchers is mostly limited by threats to external validity. For this study, measures were taken to address external threats to validity. The random sampling method was used to select

respondents from around the world. Open-ended questions were also included in the questionnaire.

The selection of independent variables was one of the limitations of this study. To analyze the association and impact of factors for digital game success, five independent variables were included. However, other key factors may exist that have a positive association with and impact on digital game success, but due to the presence of the selected five variables in the literature, they were included in the study. In addition, other key factors may exist, such as regionally or environmentally based choices, which may have a positive impact on digital game success, but were not considered in this study. Furthermore, the focus of this study was only on consumer factors for digital game success.

In software engineering, the increased popularity of empirical methodologies has raised concerns about ethics. However, this study has adhered to all the applicable ethical principles to ensure that it would not violate any experimental ethics guidelines. Regardless of its limitations, this study has contributed to the game development process and has helped game development organizations understand the consumer dimension of digital games.

6.8 Conclusion

Game development is a complex task, and measuring the consumer experience of games poses an additional challenge. The results of this empirical investigation have demonstrated that consumer key factors are very important and play a key role in the success of any digital game. The results showed that game engagement, game enjoyment, game characteristics, and ease of use are positively associated with digital game success in the DGI market. The empirical investigation found no strong association or impact between socialization and digital game success. To improve the current game development process and develop good-quality games, it is important for developers to consider the preferences of consumers as well as of others. This study has provided the empirical evidence and justification to include factors from the consumer perspective in evaluating the game development process maturity.

Chapter 7

7 A Digital Game Maturity Model[5]

Game development is an interdisciplinary concept that embraces artistic, software engineering, management, and business disciplines. This research facilitates a better understanding of important dimensions of digital game development methodology. Game development is considered as one of the most complex tasks in software engineering. The increased popularity of digital games, the various challenges faced by game development organizations in developing quality games, and severe competition in the digital game industry demand a game development maturity assessment.

Consequently, this chapter presents a DGMM to evaluate the current development methodology in an organization. The framework of this model consists of assessment questionnaires, a performance scale, and a rating method. The main goal of the questionnaires is to collect information about current processes and practices. The measuring instrument of a DGMM consists of factors selected from three empirical studies that examine the perspectives of developers, business, and consumers, as described in Chapters 4, 5, and 6 respectively. In general, this research contributes towards formulating a comprehensive and unified strategy for game development maturity evaluation. Two case studies were conducted and their assessment results reported. These demonstrate the maturity level of current development practices in two organizations.

7.1 Main Audience for a DGMM

From a game development perspective, development processes must evolve to facilitate new requirements, rapid development, and predictable and repeatable releases. The complex tasks in these development processes require a solid set of best development practices and their exemplary execution.

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[5]Parts of this chapter were submitted in following journal:
S. Aleem, L.F. Capretz and F. Ahmed, (2016e). A Digital Game Maturity Model, Entertainment Computing, Elsevier, Accepted with minor corrections, 37 pages.

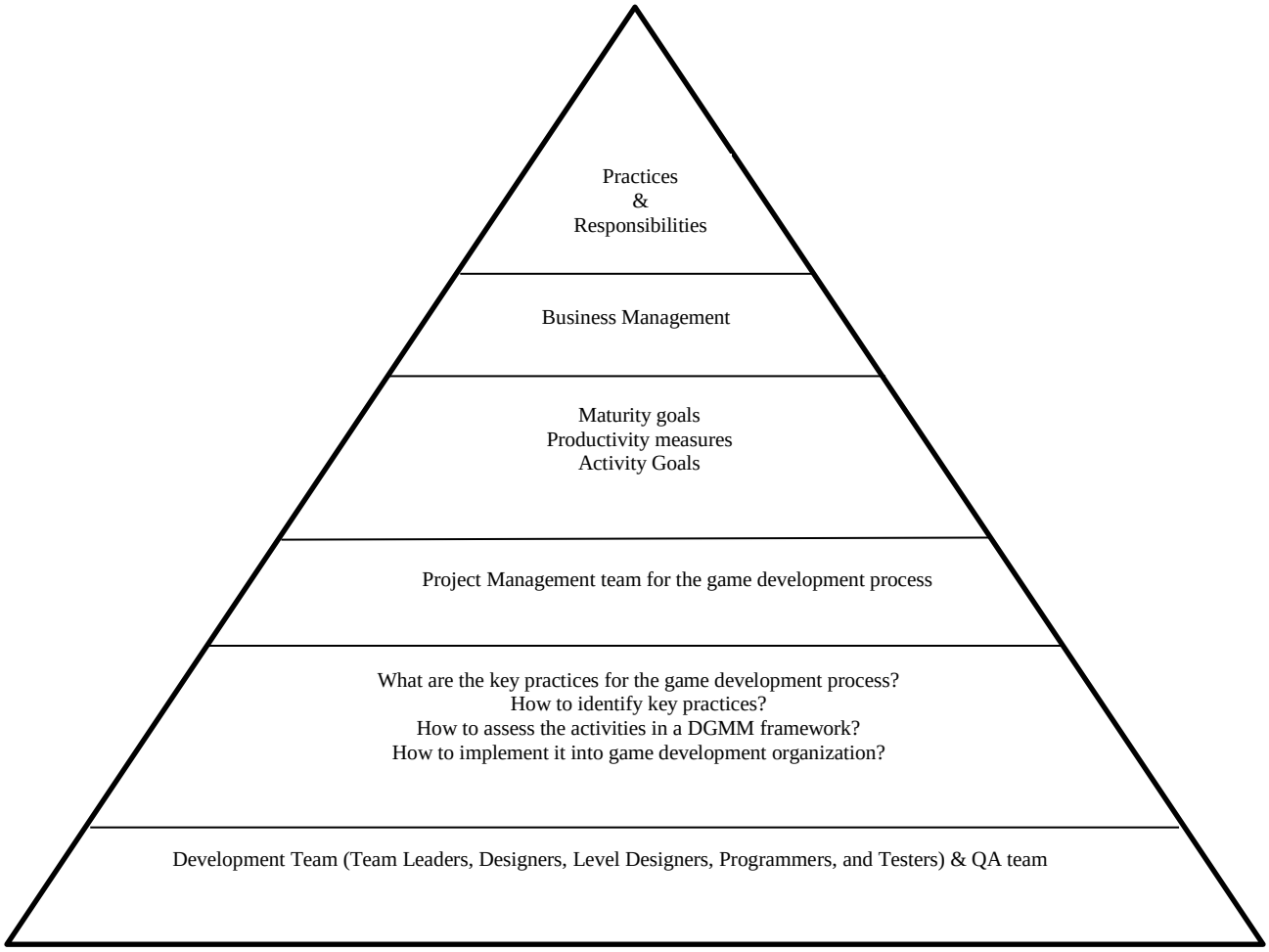

Figure 7.1 Three Main Audiences for a DGMM.

A DGMM aims to establish a comprehensive set of key practices to evaluate digital game development processes. It describes the assessment methodology for development processes and determines the current maturity level for any game development process in any organization. Furthermore, it is also structured in a way that helps to determine how various key game development process activities are carried out. The maturity assessment assumes strong coordination among the three main audiences (business management, project management, and the development team), as depicted in Figure 7.1. The pyramid in the Figure 7.1 describes benefits of the application of DGMM for the three audiences. For business management audience, this maturity model will help them to identify their maturity goals, productivity measures or activity goal for their current practices. For project management and development team audience, this DGMM will help them to

identify their key practices for the game development process, how to assess their current practices and how to implement good practices in game development process. Consequently, a DGMM is the first study of its kind in the field of game development.

7.2 General Scope of a DGMM

The assessment of game development processes is an essential activity to improve current development practices in an organization. Basically, a software engineering maturity model is used for two purposes. First, it provides a strategy to conduct assessment, and second, it provides guidelines to improve current processes. Game development, like any other task, needs some time to show progress or improvements. However, it is not easy to develop an effective and efficient progress plan unless it is based on comprehensive assessment results. Figure 7.2 represents a comprehensive framework for a game development process assessment exercise for a game development organization. Overall, the game development process involves many key process activities.

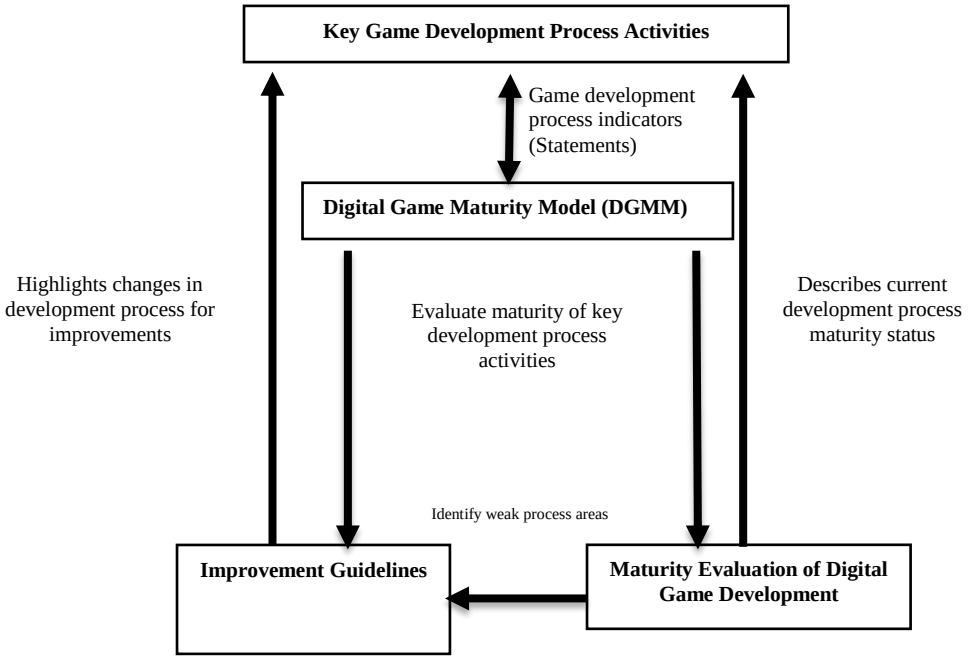

Figure 7.2 Scope of a DGMM.

In Figure 7.2, presented DGMM uses the key development activities to develop a comprehensive framework consisting of maturity levels and questionnaires to conduct the

assessment. Furthermore, a DGMM assesses the current level of game process activities in an organization. The assessment process results in a set of recommendations based on identifying current process weaknesses that need improvement. However, the proposed DGMM does not provide any guidelines for current process improvements, which may be considered as a future project.

7.3 Configuration of a DGMM

The functional configuration of a DGMM consists of eighteen key process activities, i.e., activities essential for the game development process. Specifically, Table 7.1 describes the domains and hierarchy of a DGMM. In this study, the term, *game development process activities*, is used to refer to practices that contribute to the management and development of any game project. The eighteen key development process activities used in this model, as mentioned above, are divided into four dimensions: game design strategy, game development methodology, game playability and usability, and finally the business performance dimension.

The *game design strategy* dimension mainly covers GDD management, TCM, RMM, GP, and RM[1]. The *game development methodology* dimension includes three important process activities, QA, AM, and GED. Chapter 4 described an empirical study performed from a developer's perspective of key game development practices and selected certain key practices for the Game Design Strategy and Game Development Methodology dimensions that had been found important for game development. The *business performance* dimension of a DGMM includes MO, TM, RM[2], MS, I, and SC. Chapter 5 investigated key business factors for game performance in the DG market. The selected key practices in the *business performance* dimension are important key factors for the business performance of any game. The *game playability & usability* dimension covers TM, MS, FFA, and EU. Chapter 6 discussed an empirical investigation from a consumer's perspective of successful game development factors and selected key practices for the *game playability and usability* dimension that have a positive impact on digital game success. The empirical studies carried out to capture various perspectives on key factors in the game development process and their presence in the literature provide the motivation to include the eighteen key process activities under the four DGMM

dimensions. These eighteen important key practices are the foundation of the assessment questionnaires, which consist of "*statements*". These statements describe the effectiveness of the particular activities as they contribute to game development and management.

Table 7.1 Configuration of a DGMM.

Dimensions	Activity ID (AID)	Game Development Process Activities (GDPA)
Game Design Strategy	1	Game design document management (GDD)
	2	Team configuration and management (TCM)
	3	Requirements management and modelling (RMM)
	4	Game prototyping (GP)
	5	Risk management (RM^1)
Game Development Methodology	6	Quality architecture (QA)
	7	Assets management (AM)
	8	Game engine and development (GED)
Game Playability & Usability	9	Test management (TM)
	10	Maintenance support (MS)
	11	Fun factor analysis (FFA)
	12	Ease of use (EU)
Business Performance	13	Market orientation (MO)
	14	Time to market (TM)
	15	Relationship management (RM^2)
	16	Monetization strategy (MS)
	17	Innovation (I)
	18	Stakeholder collaboration (SC)

7.4 Framework of a DGMM

To define maturity model, ranking is considered an important part of the process assessment methodology. As discussed earlier, many software process assessment models such as CMMI (Lisandra & Roberto, 2003), SPICE (Emam & Melo, 1997), and BOOTSTRAP (Simila *et al*., 1994) use ranking to define their proposed maturity models. The proposed DGMM also uses ranking to define the maturity level. In ascending order, these levels are: *Ad-Hoc*, *Opportunistic*, *Consistent*, *Organized*, and *Optimized*. An assessment questionnaire was developed for each maturity level. For each level, the

questionnaire contains a number of statements that are divided into eighteen GDPAs. The maturity level of the game development process within an organization is determined by the extent to which the three audiences identified earlier agree with each statement in the questionnaire. Assessment questionnaires for each maturity level in this study were designed and written specifically for a DGMM.

The methodology for assessing the current GDPA aims to establish a comprehensive strategy for evaluating the current GDPA maturity level in a game project. Furthermore, it is designed to identify the systematic way in which various GDPAs are performed during the game development project life cycle. In general, a DGMM attempts to coordinate the game development process with identified GDPAs. Table 2 shows a DGMM framework. Each maturity level is defined by a set of statements that cover all eighteen GDPAs used in this study. The total number of statements differs for each maturity level and GDPA. Abbreviations will be used for the GDPAs in the rest of the chapter. These includes *game design document management* (GDD), *team configuration and management* (TCM), *requirements management and modelling* (RMM), *game prototyping* (GP), *risk management* (RM^1), *quality architecture* (QA), *assets management* (AM), *game engine and development* (GED), *test management* (TM), *maintenance support* (MS), *fun factor analysis* (FFA), *ease of use* (EU), *market orientation* (MO), *time to market* (TM), *relationship management* (RM^2), *monetization strategy* (MS), *innovation* (I), and *stakeholder collaboration* (SC). The characteristics of game development organizations are described in the following sub-section. Specifically, each game development organization will be described in terms of the GDPA maturity scale and the measuring instrument designed for a DGMM. A DGMM measuring instrument uses the following symbols and abbreviations:

GDPA = Game Development Process Activity,

ML = Maturity Level (an integer),

S = Statement,

GN = Game development activity Number (integer),

SN = Statement Number (an integer).

Table 7.2 DGMM Framework

Maturity level	GDPAs and number of statements in assessment questionnaire																		
	GDD	TCM	RMM	GP	RM[1]	QA	AM	GED	TM	MS	FFA	EU	MO	TM	RM[2]	MS	I	SC	Total
Ad-Hoc	2	1	3	1	1	2	1	2	2	1	2	2	2	2	3	2	1	1	31
Opportuni-stic	5	2	4	2	2	3	4	3	3	2	3	3	3	3	3	2	3	1	51
Consistent	4	3	4	2	3	4	3	3	5	2	2	3	4	2	3	3	3	1	54
Organized	4	4	3	4	3	4	2	3	4	2	4	3	4	2	2	3	2	1	54
Optimized	4	2	3	3	3	3	2	2	3	2	2	2	3	2	2	3	1	1	53

7.4.1 Ad-Hoc (Level I)

The Ad-Hoc level is the initial level of a DGMM, which indicates that the game development organization does not have an organized and stable methodology for game development. If an organization is at the Ad-Hoc level, there is a lack of understanding of best practices for game development. Furthermore, there is no evidence that the organization develops games using specified software engineering practices or performs various development-related activities in a co-ordinated way. Instead, the organization develops different games independently and performs their development activities on an Ad-Hoc basis. Moreover, there is no protocol established to reuse assets for other game projects, nor is there evidence of following a requirement and management strategy or a game development methodology. The organization does not perform any assessment of game playability and usability, nor does it have the technical resources and skills to manage game development projects properly. The following assessment questionnaire shows the GDPA maturity of a game development organization at Level 1 in terms of key GDPAs.

GDPA 1.1 GDD Management

S.1.1.1 There is no evidence of developing a GDD.

S.1.1.2 The requirements gathering process is *ad-hoc*, and the skills and resources to develop a GDD are absent.

GDPA 1.2 Team Configuration & Management

S.1.2.1 There is no established team configuration and management strategy.

GDPA 1.3 Requirements Modelling and Management

S.1.3.1 The development team is not using any specific notation language to model game requirements.

S.1.3.2 There is a lack of knowledge of requirements modelling.

S.1.3.3 No market analysis is performed to gather requirements.

GDPA1.4 Game Prototyping

S.1.4.1 No prototype is developed at the end of the pre-production phase.

GDPA 1.5 Risk Management

S.1.5.1 No risk management is performed at any phase of game development.

GDPA 1.6 Quality of Architecture

S.1.6.1 The management team lacks an understanding of game architecture evaluation attributes.

S.1.6.2 There is no evidence that the development team performs a systematic architecture evaluation.

GDPA 1.7 Asset Management

S.1.7.1 There is no evidence of any planned asset management for the various game assets.

GDPA 1.8 Game Engine Development & Management

S.1.8.1 The development team is totally dependent on commercially available game engines.

S1.8.2 The development team does not have enough skills and technical knowledge to manage or develop a game engine.

GDPA 1.9 Test Management

S.1.9.1 There is no proper plan for game testing.

S.1.9.2 No testing is performed to ensure adherence to functional and non-functional requirements.

GDPA 1.10 Maintenance Support

S.1.10.1 No maintenance support is provided by the development team to its customers.

GDPA 1.11 Fun Factor Analysis

S.1.11.1 The game engagement and enjoyment factor is not considered important for game success.

S.1.11.2 No market analysis is performed to enhance the fun factor in games.

GDPA 1.12 Ease of Use

S.1.12.1 There is no proper plan to analyze the usability factor.

S.1.12.2 The development team does not have enough knowledge and skills to improve game usability.

GDPA 1.13 Market Orientation

S.1.13.1 The project team does not consider that market orientation is an important factor in the game business.

S.1.13.2 There is no evidence that the development team performs market analysis of the game type and the target audience.

GDPA 1.14 Time to Market

S.1.14.1 The time to market factor is not considered important for game launch.

S.1.14.2 The development team does not conduct any market reviews to update game publishing time.

GDPA 1.15 Relationship Management

S.1.15.1 The developed game has complex gameplay, and goals are not clearly defined

S.1.15.2 There is no evidence of feedback mechanisms.

S.1.15.2 The developed game has too many short-term players and cannot retain players for a long time.

GDPA 1.16 Monetization Strategy

S.1.16.1 There is no evidence that management has developed a monetization strategy.

S.1.16.2 The game revenue model is not successful in convincing players to buy virtual assets.

GDPA 1.17 Innovation

S.1.17.1 There is no evidence of any research and development component.

GDPA 1.18 Stakeholder Collaboration

S.1.18.1 No collaboration exists among stakeholders for game development-related decisions.

7.4.2 Opportunistic (Level II)

The next DGMM maturity level has been defined as Opportunistic. At this level, the management and development teams realize the importance of best practices related to game development and show interest in adopting them. In addition, the management team makes efforts to collect data for requirements analysis, playability, and usability factors on an occasional basis. The development team is also interested in acquiring knowledge and skills related to appropriate development methodologies. Both the management and development teams agree that a proper game assessment strategy for game playability and usability is important and also recognize the importance of assessing current practices. However, the organization lacks systematic planning and strategy for its revenue model and market analysis. The organization does not maintain any kind of documentation related to the pre-production, production, and post-production phases of game development. Moreover, there are no clear guidelines for relationship management and team collaboration. At this earlier stage of a DGMM, an organization is concentrating on understanding how to develop quality games that will be successful and attract more consumers. This is why this stage has been called “opportunistic”: an organization at this level sees the opportunity to build its understanding about best practices and to acquire enough resources and skills to move to the next level. Overall, an organization at this level understands the importance of adopting best practices for game development and is in the process of establishing defined protocols for GDPAs. The following set of statements must be satisfied by an organization in Level 2.

GDPA 2.1 GDD Management

> **S.2.1.1** Management believes that a well-defined game design document is helpful in the game production phase.
>
> **S.2.1.2** The project team agrees to follow design principles for game play, mechanics, and documentation.
>
> **S.2.1.3** Game designers believe that dictionaries of design terms are important in transforming the GDD from pre-production to the production phase.

S.2.1.4 The technical and creative team agrees that a vocabulary of game design terminology and the development of visual languages for design modelling are important in the pre-production phase.

S.2.1.5 No formal game design document is developed at the end of the pre-production phase.

GDPA 2.2 Team Configuration & Management

S.2.2.1 The project manager and the team lead agree that a development team organized by discipline can perform its assigned tasks more effectively than one organized by features.

S.2.2.2 There is no formal protocol established for collaboration among development team members.

GDPA 2.3 Requirements Modelling and Management

S.2.3.1 Project managers and team leaders understand that requirements modelling helps in understanding game development requirements.

S.2.3.2 The development team is making efforts to acquire technical knowledge and understanding to develop media design documents, game feature plans, and technical design documents.

S.2.3.3 The development team is committed to analyzing market data for new game trends and consumer requirements.

GDPA2.4 Game Prototyping

S.2.4.1 The development team is committed to following a formal prototyping method because it is considered crucial for successful game development.

S.2.4.2 The development team believes that a high-fidelity game prototype provides a higher degree of sophistication and is therefore closer to the final product than a lower-fidelity prototype.

GDPA 2.5 Risk Management

S.2.5.1 The project manager believes that risks related to game development must be identified in the pre-production phase.

S.2.5.2 The management team is committed to acquiring knowledge and resources related to game development risk identification strategy.

GDPA 2.6 Quality of Architecture

S.2.6.1 The development team is acquiring knowledge and skills to model game architecture properly.

S.2.6.2 The development team is committed to establishing clear guidelines and methodology for game architecture.

S.2.6.3 Quality and functional attributes are not well defined.

GDPA 2.7 Asset Management

S.2.7.1 The management team is committed to developing a proper strategy for game asset creation and management.

S.2.7.2 The project manager believes that realism and performance analysis must be part of the asset creation process.

S.2.7.3 The project manager agrees that realism and control investigation of assets must be performed before asset creation.

S.2.7.4 There is a need for proper asset management tool to manage various game assets.

GDPA 2.8 Game Engine Development & Management

S.2.8.1 The development team has adequate resources and skills to use and manage game engine modules.

S.2.8.2 The project manager is committed to providing training to the development team for game engine development.

S.2.8.3 The development team uses commercially available game engines to develop games.

GDPA 2.9 Test Management

S.2.9.1 The project team recognizes the need for a game testing plan during the pre-production phase of game development.

S.2.9.2 The project team collects information on how to validate game functional and non-functional requirements through testing.

S.2.9.3 The project manager agrees that test management will give insights into how players play the game and the pros and cons of the game design and will finally be helpful in making a complete, balanced, and fun-to-play game.

GDPA 2.10 Maintenance Support

S.10.1 The development team is working on developing a forum where game consumers can report playability, bugs, errors, and other game-related issues.

GDPA 2.11 Fun Factor Analysis

S.2.11.1 The project team collects data on how to enhance the enjoyment and engagement factor for their games.

S.2.11.2 The management team promotes innovative ideas to develop games that provide many stimuli from different sources with interesting and attractive game play.

GDPA 2.12 Ease of Use

S.2.12.1 The members of the development team are acquiring knowledge and skills to improve ease of use for digital games.

S.2.12.2 The project manager agrees that ease of use is a fundamental driver for the commercial success of digital games.

S.2.12.3 There is a lack of systematic strategy to enhance the level of usability in digital games.

GDPA 2.13 Market Orientation

S.2.13.1 Formal strategy has not been developed yet to perform detailed market analysis of game types and their target audience.

S.2.13.2 Resources to perform market analysis are lacking.

S.2.13.3 No well-defined communication protocol exists for information sharing.

GDPA 2.14 Time to Market

S.2.14.1 The development team occasionally studies and researches development updates.

S.2.14.2 Game publishing is not influenced by the time-to-market factor.

S.2.14.3 The project team agrees that time to market is important for game publishing.

GDPA 2.15 Relationship Management

S.2.15.1 No formal player integration strategy has been established for game development.

S.2.15.2 Feedback mechanisms have been developed to resolve player concerns and issues.

S.2.15.3 Customer profiling is performed on an occasional basis.

GDPA 2.16 Monetization Strategy

S.2.16.1 The revenue model is not well defined.

S.2.16.2 No progressive growth has been observed in the last two years.

GDPA 2.17 Innovation

S.2.17.1 No well-defined policy for research and development (R&D) has been established.

S.2.17.2 Innovative ideas are considered important for new game development projects.

S.2.17.3 The development team occasionally studies and reviews development updates and searches for innovative ideas.

GDPA 2.18 Stakeholder Collaboration

S.2.18.1 Project managers and development team agrees that collaboration among all stakeholders is important to identify game requirements completely.

7.4.3 Consistent (Level III)

An organization at level III is consistently trying to define policies and strategies for game development projects. Moreover, the organization is able to establish an infrastructure for game development projects by completing identified GDPAs. Interest in developing a strategic plan shows that the organization is committed to developing good-quality products and trying to address the challenges faced by the game development team. An organization that can develop a strategy for game design documents, establish protocols, and acquire enough resources and skills for requirements modelling and management is exhibiting sufficient knowledge of the domain. Subsequently, such an organization in the production phase is committed to developing a game architecture that fulfils quality attributes and is trying to manage game assets effectively. To ensure the required game playability and usability, game testing, fun factor analysis, and maintenance support are considered mandatory GDPAs by the

organization. The organization is trying to develop business strategies and documentation and in process of establishing clear guidelines for carrying out the game development process. Accordingly, the management and development teams have acquired enough training in development methodologies. Overall, the organization is able to understand game requirements and development methodologies, playability and usability factors, and digital game business performance indicators. Accordingly, it is trying to be consistent in its GDPAs for the development process. In the following measuring instrument, the set of statements describes the maturity level of an organization at level III.

GDPA 3.1 GDD Management

S.3.1.1 The design team is committed to and in process of developing dictionaries for design terms.

S.3.1.2 The design team is developing design guidelines and concepts.

S3.1.3 The development team is acquiring knowledge about design principles for game play, mechanics, and documentation.

S.3.1.4 The design team is in process of developing a strategy to produce a GDD.

GDPA 3.2 Team Configuration & Management

S.3.2.1 Sub-teams are organized on a discipline basis.

S3.2.2 There is an established protocol for collaboration among development team members.

S.3.2.3 The team leader is committed to involving all team members in prioritizing the various tasks for each sprint or milestone.

GDPA 3.3 Requirements Modelling and Management

S.3.3.1 The development team has the required resources and technical knowledge to model and manage requirements.

S.3.3.2 The development team is able to develop a strategy for producing the media design, feature plan, and technical design document.

S3.3.3 The requirements document clearly identifies the structural layout of the game architecture.

S.3.3.4 Team leaders collect and analyze data from the market and gather requirements for customer profiling on a regular basis.

GDPA3.4 Game Prototyping

S.3.4.1 The development team has developed multiple prototypes because games are highly visual, functional, and interactive applications. Hence, they believe that a single prototype is in most cases insufficient to capture all aspects of a game.

S.3.4.2 The development team is acquiring resources and skills to develop a proper strategy for game prototyping.

GDPA 3.5 Risk Management

S.3.5.1 Risks related to game usability and playability, supportability, performance, budgeting, and scheduling are identified during the pre-production phase.

S.3.5.2 Strategies are developed to manage risks related to development strategy, staffing, budgeting and scheduling, inadequate specifications, and the fun factor of games.

S.3.5.3 The management team is able to perform reactive risk management.

GDPA 3.6 Quality of Architecture

S.3.6.1 The project manager is in process of establishing clear guidelines and a well-documented methodology for game architecture.

S.3.6.2 The management team has acquired sufficient technical knowledge to develop and evaluate game architecture.

S.3.6.3 Game prototyping is used to analyze the interconnection among the various game play modules.

S.3.6.4 The management team is committed to using best software engineering practices to evaluate game architecture.

GDPA 3.7 Asset Management

S.3.7.1 There is a consistent strategy for game asset management.

S.3.7.2 An asset management system has been implemented for storing and managing all game assets.

S.3.7.3 The project team has adequate resources and skills to analyze any new asset management tool that is introduced and to acquire it if it provides better asset management.

GDPA 3.8 Game Engine Development & Management

S.3.8.1 The selected game engine is able to handle diverse type of input and output.

S.3.8.2 The game engine is able to provide resource and asset management.

S.3.8.3 Integration of all technological aspects is done easily by the development team.

GDPA 3.9 Test Management

S.3.9.1 A game testing plan is established and well documented during the pre-production phase.

S.3.9.2 Internal testers have acquired sufficient knowledge to assess functional, playability, and usability requirements.

S.3.9.3 External testers participate in game testing to identify the playability and usability of specific game projects.

S.3.9.4 Game testing has provided evidence to remove unsuccessful parts of a game design.

S.3.9.5 Testing is usually started during the pre-production phase to avoid later-stage modifications.

GDPA 3.10 Maintenance Support

S.3.10.1 The project team is committed to improve maintenance support for developed games.

S.3.10.2 A log has been maintained regarding issues faced by game consumers who report errors or bugs in a purchased game.

GDPA 3.11 Fun Factor Analysis

S.3.11.1 A strategic plan has been defined to gather consumer requirements and perform market analysis to enhance the consumer playing experience in terms of game workload, rewards, full control, skill level, and storyline.

S.3.11.2 The project team is in process of defining metrics to perform fun factor analysis.

GDPA 3.12 Ease of Use

S.3.12.1 There is a well-defined strategy and clear guidelines for developing game tutorials.

S.3.12.2 The development team includes game tutorials to provide internal and external consistency to game consumers.

S.3.12.3 The project team is in process of defining metrics to measure ease of use.

GDPA 3.13 Market Orientation

S.3.13.1 Market analysis is performed occasionally.

S.3.13.2 A communication protocol for dissemination of market intelligence has been defined.

S.3.13.3 A market orientation strategy is developed during the pre-production phase.

S.3.13.4 Game concepts are influenced by competitors.

GDPA 3.14 Time to Market

S.3.14.1 The management team performs regular market reviews and development updates.

S.3.14.2 Development schedules are adjustable based on market updates.

GDPA 3.15 Relationship Management

S.3.15.1 The development team participates in online game communities to support and identify player issues.

S.3.15.2 Management is trying to define player integration strategies for game development.

S.3.15.3 Data mining techniques are used to extract, manipulate, and produce data quickly for consumer profiling.

GDPA 3.16 Monetization Strategy

S.3.16.1 A well-defined revenue model has been developed.

S.3.16.2 Sales revenue has been growing over a time period.

S.3.16.3 The defined model is able to reduce debt.

GDPA 3.17 Innovation

S.3.17.1 Management believe that R&D investment yields positive results in the near future.

S.3.17.2 Management is in process of defining an R&D policy.

S.3.17.3 The development team uses innovative ideas successfully for development and game level repositioning.

GDPA 3.18 Stakeholder Collaboration

S.3.18.1 Collaboration among all stakeholders is performed on an occasional basis.

7.4.4 Organized/Predictable (Level IV)

The fourth level of a DGMM is referred to as "organized and predictable". An organization is considered to be at this level if it has been successful in developing well-defined guidelines for game development activities and the project team has acquired all resources and technical skills to address issues in the game development process. The management team is able to develop requirements models that help to visualize the interconnections among the various game modules, player interaction patterns, procedures, rules, resources, conflicts, boundaries, outcomes, rewards, and goals. The members of multidisciplinary teams can collaborate and identify bottlenecks in the development phases. Moreover, the management team takes a proactive stance with regard to risk management and innovation. Once developed, game projects can retain and satisfy their customers, and their revenue model fits into the organization financial model. Market analysis is performed by the organization on a regular basis for the time to market factor. Furthermore, defined metrics are used to analyze the fun factor and ease of use in games. Proper test and asset management strategies are in place. Overall, the GDPAs in such an organization are streamlined, quantifiable, and well documented for any game project, and the organization is considered to be at level IV of a DGMM. The resulting set of statements listed below applies to an organization at level IV.

GDPA 4.1 GDD Management

S.4.1.1 The development team has adequate resources to develop the GDD.

S.4.1.2 The GDD offers clear guidelines for the transformation from pre-production to the production phase.

S.4.1.3 Dictionaries for design terms serve as a basis for communication among professionals and for project documents.

S.4.1.4 The development team is following proper game design guidelines and benchmarking existing ones.

GDPA 4.2 Team Configuration & Management

S.4.2.1 After each milestone, team members meet and discuss the progress of each project on a regular basis.

S.4.2.2 Team management helps in identifying topics of interest and production bottlenecks effectively.

S.4.2.3 All stakeholders are involved in the decision process for any significant change in game design or architecture during the production phase.

S.4.2.4 The development plan is well documented and communicated to all team members.

GDPA 4.3 Requirements Modelling and Management

S.4.3.1 The requirements document for the game covers the scope of the final game.

S.4.3.2 Game requirements are well documented and clearly identified.

S.4.3.3 The requirements model helps to visualize the interconnections among the various game modules, player interaction patterns, procedures, rules, resources, conflicts, boundaries, outcomes, rewards, and goals.

GDPA4.4 Game Prototyping

S.4.4.1 The selected prototyping tool provides flexibility and stability to make adjustments after feedback.

S.4.4.2 The development team follows a software prototyping lifecycle that includes requirements identification for the final models, textures, particle systems, materials, level geometry and lighting, audio, and animation.

S.4.4.3 The prototyping strategy helps to identify various options for balancing game mechanics and aesthetics.

S.4.4.4 Game prototyping provides an early insight into how the final game will be played.

GDPA 4.5 Risk Management

S.4.5.1 Risk assessment is considered mandatory during the pre-production phase of game development.

S.4.5.2 Risk-related tasks are clearly identified by the management team for each milestone.

S.4.5.3 Management is able to perform proactive risk management.

GDPA 4.6 Quality of Architecture

S.4.6.1 Game architecture quality attributes such as performance, correctness, usability, testability, security, and scalability are well defined and documented.

S.4.6.2 The development team is using specific defined qualitative metrics to measure the quality of game play.

S.4.6.3 Game play is divided into modules, and there is a separation of concerns because each can be modified separately without impacting other modules.

S.4.6.4 Game play modules are extensible because they can be plugged into other game projects.

GDPA 4.7 Asset Management

S.4.7.1 The asset management system groups different assets, provides version control, and simplifies workflow.

S.4.7.2 The asset management system can handle any size of graphics, video, and sound files.

GDPA 4.8 Game Engine Development & Management

S.4.8.1 Multi-platform development is supported by the selected game engine.

S.4.8.2 The game engine is capable of integrating other embedded tools to enhance or extend its current capabilities.

S.4.8.3 The selected development tool enables developers to manage, visualize, and maintain transformations so that they can be helpful in game development.

GDPA 4.9 Test Management

S.4.9.1 The project has a defined road map for testing during each phase of game development to test different game modules.

S.4.9.2 The game is tested for performance under various loads.

S.4.9.3 The testing unit learns from previous game testing experiences and avoids repeating the same mistakes.

S.4.9.4 A well-established game testing management plan with quantifiable metrics has been implemented to perform testing regularly.

GDPA 4.10 Maintenance Support

S.4.10.1 The development team has developed an appropriate maintenance support unit for consumers.

S.4.10.2 The project team monitors the maintenance support unit for effective and efficient consumer support.

GDPA 4.11 Fun Factor Analysis

S.4.11.1 A strategic plan has been fully implemented to enhance the consumer play experience.

S.4.11.2 The project team regularly monitors the outcome of innovative ideas for consumer engagement and enjoyment.

S.4.11.3 Consumer feedback is regularly collected with regard to their game play experience to enhance the market presence of the game.

S.4.11.4 Management team uses defined metrics for fun factor analysis.

GDPA 4.12 Ease of Use

S.4.12.1 The project team analyzes consumer feedback to make sure that consumers can easily manipulate the game controls to take actions which help in achieving game goals.

S.4.12.2 Consumer feedback about game ease of use is regularly collected and maintained.

S.4.12.3 The project team is using well-defined metrics to measure ease of use in particular games.

GDPA 4.13 Market Orientation

S.4.13.1 Market analysis is performed on a regular basis to identify target audiences and in-demand games.

S.4.13.2 New projects are in line with consumer requirements.

S.4.13.3 Competitor analysis is performed to develop new market plans.

S.4.13.4 Skills and resources are adequate to perform market analysis.

GDPA 4.14 Time to Market

S.4.14.1 Games are launched in response to competitor actions.

S.4.14.2 The timing of game launch helps in increasing market presence.

GDPA 4.15 Relationship Management

S.4.15.1 The organization performs consumer profiling for profitability analysis and retention modelling on a regular basis.

S.4.15.2 Developed games are able to retain their existing consumers and attract new ones.

GDPA 4.16 Monetization Strategy

S.4.16.1 Developed games are able to acquire more consumers for less investment.

S.4.16.2 To attract new consumers, cross-platform offerings are in place.

S.4.16.3 The revenue model for developed games fits into the financial model of the organization.

GDPA 4.17 Innovation

S.4.17.1 Reactive and proactive innovation measures for game development are supported by management.

S.4.17.2 An R&D roadmap is successfully used for game development.

GDPA 4.18 Stakeholder Collaboration

S.4.18.1 All stakeholders collaborate on a regular basis, but it is not considered mandatory to involve them in game development-related decisions.

7.4.5 Optimized (Level V)

The highest level of a DGMM is referred to as “optimized”. At this level, the GDPAs play an important role in the business performance of the games developed by the organization. There is strong evidence that management and development teams collaborate closely to manage and develop games effectively. Stakeholders are involved in all game development-related decisions. The organization learns from its past game development experiences and on this basis is in process of optimizing its current GDPAs. Hence, training and attaining knowledge about new technologies and skills related to game development is a continuous process in the organization. Game requirements are reviewed and revised on a regular basis when required. The development team has adequate resources and skills to develop its own game engines for game development or to enhance the capabilities of existing ones by adding middleware. A developed testing plan is able to keep track of functional and non-functional requirements test outcomes and uses the results to improve game quality and playability. A blend of playability and usability methods in addition to innovative ideas are used to enhance the consumer playability experience in term of challenges, storyline, game-level curiosity, full control, and feeling of independence. Moreover, the revenue model contributes to strengthening the financial position of the organization. The measuring instrument for a DGMM at level V is illustrated below.

GDPA 5.1 GDD Management

S.5.1.1 Defined game design guidelines and concepts are followed for all new game development projects.

S.5.1.2 The GDD is well understood by all stakeholders.

S.5.1.3 The GDD is available to all development team members at the beginning of the production phase.

S.5.1.4 A log is maintained to record development team members' complaints regarding GDD transformation issues.

GDPA 5.2 Team Configuration & Management

S.5.2.1 Team configuration and management demonstrate a positive impact on game development activities.

S.5.2.2 Team members are satisfied with the communication and collaboration protocol.

GDPA 5.3 Requirement Modelling and Management

S.5.3.1 The target market segment is fully captured by the identified requirements of a particular game.

S.5.3.2 Game requirements are reviewed and revised on a regular basis when required.

S.5.3.3 The quality attribute of games is accommodated by identified requirements.

GDPA5.4 Game Prototyping

S.5.4.1 Prototyping helps in improving and developing the final game efficiently.

S.5.4.2 Prototyping helps in identifying game mechanics, rules, and algorithms.

S.5.4.3 The developed prototype refines the created content of the game and also balances the gameplay.

GDPA 5.5 Risk Management

S.5.5.1 Risk assessment is helpful in reducing associated development risks.

S.5.5.2 There is a backup plan to handle identified risks and explore other solutions that would reduce or eliminate risk.

S.5.5.3 The development team always has a functional and technical design specification with a complete risk assessment document before the start of the production phase for all projects.

GDPA 5.6 Quality of Architecture

S.5.6.1 The management team is continuously improving the evaluation process for game architecture quality.

S.5.6.2 Game architecture documents are reviewed and updated regularly to avoid future bottlenecks.

S.5.6.3 Game architecture includes robustness features that enable the game to be functional in unexpected circumstances.

GDPA 5.7 Asset Management

S.5.7.1 The asset management system can reduce duplication of assets and remove outdated assets from the asset library.

S.5.7.2 Assets created for a game fit into the game concept and have a positive effect on game appearance.

GDPA 5.8 Game Engine Development & Management

S.5.8.1 The development team has adequate resources and skills to develop its own game engines for game development or to enhance the capabilities of existing ones by adding middleware.

S.5.8.2 Game engines are reused for different game projects.

GDPA 5.9 Test Management

S.5.9.1 The selected testing approach ensures game performance and quality.

S.5.9.2 The testing team experiments with innovative techniques on a regular basis to improve the game testing process.

S.5.9.3 A developed test plan keeps track of functional and non-functional requirements test outcomes and uses the results to improve game quality and playability.

GDPA 5.10 Maintenance Support

S.5.10.1 The maintenance support system team regularly examines, maintains, and improves the support system for effective and easy reporting service.

S.5.10.2 The project team is continuously improving the maintenance support system for developed games.

GDPA 5.11 Fun Factor Analysis

S.5.11.1 A blend of playability and usability methods in addition to innovative ideas are used to enhance the consumer playability experience in term of challenges, storyline, game level curiosity, full control, and feeling of independence.

S.5.11.2 The fun factor analysis strategic plan is monitored on a regular basis, and improving it is a continuous strategic effort of the project team.

GDPA 5.12 Ease of Use

S.5.12.1 Consumer feedback indicates satisfaction and ability to navigate conveniently between menus.

S.5.12.2 The defined strategy to enhance consumer experience related to ease of use metrics is regularly reviewed and updated.

GDPA 5.13 Market Orientation

S.5.13.1 The organization is able to gain competitive advantage by using its market orientation strategy.

S.5.13.2 Developed game concepts are aligned with the requirements of the target market.

S.5.13.3 Developed games are able to maximize their consumers' playing time.

GDPA 5.14 Time to Market

S.5.14.1 Games are published before competitors' games.

S.5.14.2 Being first to market helps to retain existing consumers and attract new ones.

GDPA 5.15 Relationship Management

S.5.15.1 Developed games are able to retain their consumers for a long time.

S.5.15.2 The development team follows a balanced player- and game-centred strategy.

GDPA 5.16 Monetization Strategy

S.5.16.1 The revenue model contributes to strengthening the financial position of the organization.

S.5.16.2 The organization successfully achieves its financial objectives.

S.5.16.3 Return on investment increases over a period of time.

GDPA 5.17 Innovation

S.5.17.1 Past innovative measures taken by the development team have resulted in improved game development and management processes.

GDPA 5.18 Stakeholder Collaboration

S.5.18.1 All stakeholders are involved in game-related decisions.

7.5 Performance Scale

The maturity level of an organization is determined by its ability to perform key GDPAs. A five-level scale is used here to rate the maturity level of an organization. A quantitative rating is used to indicate the level of agreement with each statement in the questionnaires and more specifically the way in which the organization fulfils specific maturity-level requirements. Table 7.3 depicts the ordinal rating used to measure each dimension's GDPAs. The ordinal ratings of a DGMM include "not applicable", "slightly applicable", "partially applicable", "largely applicable", and finally, "completely applicable". Specifically, the rating of "not applicable" is included in a DGMM to increase the flexibility of the methodology. To be consistent with already accepted, validated popular scales such as the BOOTSTRAP methodology (Wang & King, 2000), the proposed performance scale and the threshold have been structured accordingly. However, based on the design of a DGMM questionnaires, the linguistic expressions have been slightly adjusted. Overall, the adapted rating methodology and questionnaires are based on the self-assessment approach. This method enables an organization to evaluate its GDPAs by expressing its extent of agreement with the statements.

Table 7.3 Performance Scale

Scale	Linguistic expression of proposed performance scale	Linguistic expression of BOOTSTRAP	Rating threshold (%)
4	Completely applicable	Completely satisfied	≥ 80
3	Largely applicable	Largely satisfied	66.7–79.9
2	Partially applicable	Partially satisfied	33.3–66.6
1	Slightly applicable	Absent/poor	≤ 33.2
0	Not applicable	-	-

7.6 Rating Method

The rating methodology is adapted from the BOOTSTRAP algorithm (Wang & King, 2000), as previously mentioned. The rating method consists of a number of different

terms such as *Development Performance Rating* (DPR_{DPA}), *Number of Applicable Statements* (NA_{DPA}), *Passing Threshold* (PT_{DPA}), and *Development Maturity Level* (DML). Each of these terms is described below in detail.

Let $DPR_{DPA}[a,b]$ be the rating of the a^{th} DPA at the b^{th} maturity level. Subsequently, based on the performance scale described in Table 7.3, $DPR_{DPA}[a, b]$ can be rated as follows:

$DPR_{DPA}[a,b]$ = 4 if the extent of applicability of the statement is 80%
= 3 if the extent of applicability of the statement is from 66.7% to 79.9%
= 2 if the extent of applicability of the statement is from 33.3% to 66.6%
= 1 if the extent of applicability of the statement is less than 33.3%
= 0 if the statement is not applicable at all.

The a^{th} statement is considered agreed upon at the b^{th} maturity level if $DPR_{DPA}[a,b] \geq 3$. The number of applicable statements NA_{DPA} at the b^{th} maturity level is defined by the following expression:

$NA_{DPA}[b]$ = Number of $\{DPR_{DPA}[a,b] \mid \text{Applicable}\}$

= Number of $\{DPR_{DPA}[a,b] \mid DPR_{DPA}[a,b] \geq 3\}$.

A particular maturity level is considered to be achieved if 80% of the statements in the corresponding questionnaire are applicable to the organization's current status. Table 7.4 shows the passing threshold for each maturity level, i.e., 80%, rounded to the nearest integer. Hence, if $N_{DPA}[b]$ is the total number of statements at the b^{th} maturity level, then PT_{DPA} at the b^{th} maturity level is defined as follows:

$PT_{DPA}[b] = N_{DPA}[b] * 80\%$.

The *Game Maturity Level* (GML) is defined as the highest maturity level at which the number of applicable statements is equal to or greater than PT_{DPA} and is defined as follows:

$GML = \max\{ b \mid NA_{DPA}[b] \geq PT_{DPA}[b]\}$.

Table 7.4 Rating Thresholds.

Game Maturity Level	Total questions	Passing threshold (80%)
Ad-Hoc	31	25
Opportunistic	51	41
Consistent	54	43
Organized	54	43
Optimized	53	42

7.7 Case Studies

7.7.1 Assessment Methodology

A DGMM presented here was applied to two game development organizations to assess their game development processes. The names of the organizations participating in this study are kept confidential for reasons of privacy. Participating organizations were informed that this assessment formed part of a research study and that subsequently neither the identity of the organization nor that of any individual would be disclosed in any publications.

The participating organizations are referred to as “Organization A” and “Organization B” in this study. Organization A is a famous mobile game development company and has released a number of popular games. They are using agile practices for game development. Organization B is another large game development company involved in developing games for various platforms such as mobile, desktop, and Internet. Their game development process is a kind of waterfall with iteration. Table 7.5 summarizes the assessment results in detail for Organizations “A” and “B”.

The assessment questionnaires were designed to assess key process areas and the current maturity level of game development practices. Individuals from participating organizations were requested to select a Likert scale value from 0 to 4 to indicate their extent of agreement with each statement in the questionnaire, as depicted in Table 7.5. As mentioned in the rating methodology, a statement is considered applicable if the performance rating (according to the method shown in Table 7.3) is either equal to or

greater than 3. The respondents to the assessment questionnaires were either project managers or members of the development team. All communication with the respondents was carried out either through the survey link or through emails. Participation by respondents was voluntary, and no compensation was offered to them. Both case studies are discussed in detail in the subsequent section. There were multiple responses from each organization, meaning that the chance of bias in the data sample was limited. A number of respondents from each organization, including both project managers and development team members, provided their observations about development practices. In addition, to avoid any chance of biased responses, an inter-rater agreement analysis was performed.

Table 7.5 Summary of Case Study Assessment Results

Digital Game Maturity Level	Total questions	Passed Threshold 80%	Organization "A" NA_{DPA}	Organization "B" NA_{DPA}
Level 1 (Ad-Hoc)	31	25	29	27
Level 2 (Opportunistic)	51	41	42	43
Level 3 (Consistent)	54	43	44	40
Level 4 (Organized)	54	43	24	34
Level 5 (Optimized)	53	42	18	24

7.7.2 Organization "A"

Participating organization "A" is one of the leading mobile game development organizations in North America and has developed a number of mobile games. These games include racing, adventure, puzzle, and various role-playing games. Organization "A" can be classified as a medium-sized organization based on its number of employees. Most of the study participants from Organization "A" had roles that involved policy-making or strategic implementation.

7.7.2.1 Data Analysis

Once the survey was completed, the NA_{DPA} (number of applicable statements) for each level was calculated. NA_{DPA} was 29 for Level 1, 42 for Level 2, 44 for Level 3, 24 for Level 4, and 18 for Level 5. Therefore, Organization "A" passed the rating threshold of

80% for Level 3, and consequently, Organization “A” is at the “Consistent” level of a DGMM.

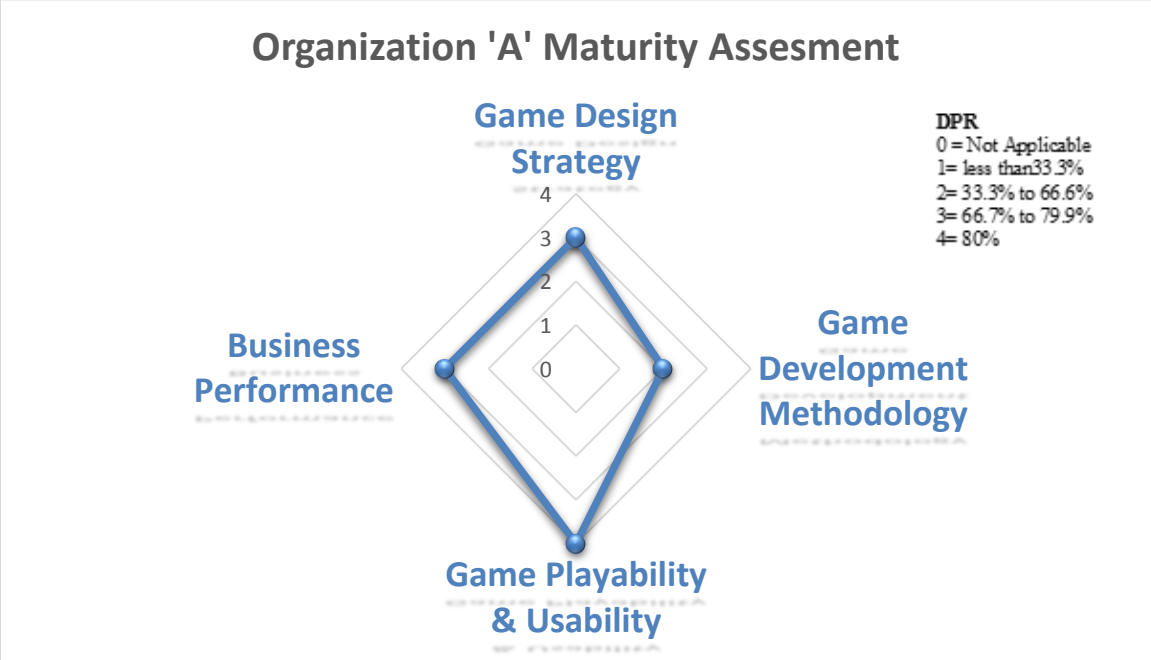

Figure 7.3 Organization “A” DGMM Level 3 Responses

In order to get insight into their development practices, we have further analyzed data by using radar charts for each dimension based on their agreement to the statements from 0 to 4 at level 3. Figure 7.3 depicts the responses average for each DGMM dimensions at level 3. It showed clearly that organization ‘A’ needs to improve specifically its game development methodology dimensions practices, and also have to look into game design strategy dimension and business performance practices. This will also help them in order to identify their gaps and an idea how they can achieve higher level. In order to dig further into each dimension, for example Figure 7.4 depicts the game design strategy spiral chart for all levels of DGMM based on respondents’ responses average.

Figure 7.4 Responses for Game Design Strategy Dimension Process Activities for all levels of DGMM of Organization A

It clearly shows that under game design strategy dimension, organization 'A' needs to improve its risk management practices to move from level 3 to 4. Moreover, they need to improve their overall game design strategy dimension practices to achieve higher level.

7.7.3 Organization "B"

Organization "B", the second participating organization, is another game development organization in North America that has developed a number of games for various platforms such as mobile, desktop, and Internet. The games can be categorized as role-playing games, adventures, racing games, and puzzles. Organization "B" can be classified as a large organization based on its number of employees. Most of the study participants from Organization "B" had also roles that involved policy-making or strategic implementation.

7.7.3.1 Data Analysis

Once the survey was completed, the NA_{DPA} (number of applicable statements) was calculated for each level. NA_{DPA} was 27 for Level 1, 43 for Level 2, 40 for Level 3, 34

for Level 4, and 24 for Level 5. Therefore, Organization “B” passed the rating threshold of 80% for Level 2, and consequently, Organization “B” is at the “Opportunistic” level of a DGMM. In order to analyze data, same strategy is used to get insight into their development practices and identify gaps. Figure 7.5 showed the responses averages for each dimension at level 2.

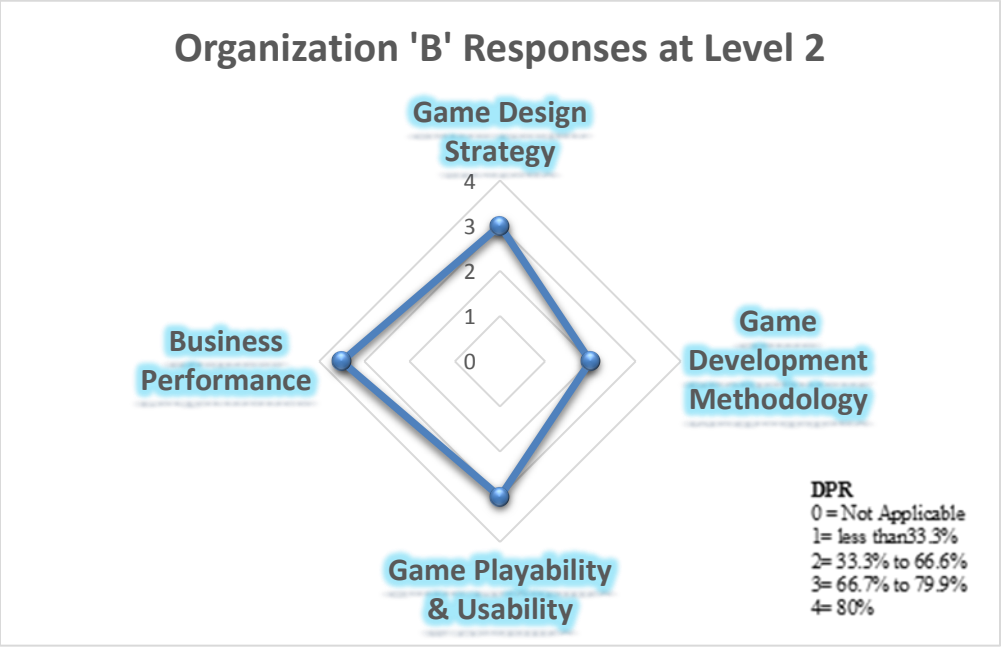

Figure 7.5 Organization “B” Responses at Level 2

It clearly shows that Organization “B” needs to improve its game development methodology practices to achieve higher levels. Furthermore, they need to improve their development practices for other dimensions. Moreover, Figure 7.6 depicts the game design strategy dimension results for all levels.

Figure 7.6 Responses for Game Design Strategy Dimension process activities for all levels of DGMM of Organization B.

The results clearly depict that "Organization B" needs to improve their GDD management, TCM, RMM and Risk Management practices in order to improve their practices for game design strategy dimensions.

7.7.4 Inter-Rater Agreement Analysis

In research such as this, there is generally more than one respondent from each organization, which can create a conflict of opinion about game development practices. To address the issue of conflicting opinion from the same organization, an inter-rater agreement analysis (Landis & Koch, 1997) was performed. Inter-rater agreement measures the level of agreement in the ratings provided by different respondents for the same process or software engineering practice (Emam, 1999). In this case, inter-rater agreement analysis was carried out to identify the level of agreement among different respondents from the same organization. To evaluate inter-rater agreement, the Kendall coefficient of concordance (*W*) (von Eye & Mun, 2005) is usually preferred for ordinal data rather than other methods like Cohen's Kappa (1960). *W* represents the difference between the actual agreement as drawn from the data and perfect agreement. Values of

Fleiss Kappa and the Kendall's *W* coefficient can range from 0 (representing complete disagreement) to 1 (representing perfect agreement) (Lee *et al*., 2001). Therefore, the Kappa (Emam, 1999) standard includes four levels: < 0.44 means poor agreement, 0.44 to 0.62 represents moderate agreement, 0.62 to 0.78 indicates substantial agreement, and > 0.78 represents excellent agreement. In this study, the observed Kappa coefficient fell into the substantial category, ranging from 0.63 to 0.68. Table 7.6 reports the Kappa and Kendall statistics for both organizations; both measures fall into the "substantial" category.

Table 7.6 Inter-Rater Agreement Analysis of Organizations "A" and "B".

DGMM level	Organization A				Organization B			
	Kendall's Coefficient of Concordance		*Fleiss Kappa statistics*		*Kendall's Coefficient of Concordance*		*Fleiss Kappa statistics*	
	Coef.	***X^2***	***Coef.***	***Z***	***Coef.***	***X^2***	***Coef.***	***Z***
Ad-Hoc	0.65	52.91*	0.69	8.91*	0.85	53.44*	0.75	4.49*
Opportunistic	0.72	58.10*	0.67	7.99*	0.71	55.31*	0.67	5.03*
Consistent	0.63	52.13*	0.66	8.20*	0.89	55.62*	0.64	4.88*
Organized	0.71	56.74*	0.62	7.66*	0.98	47.66*	0.78	5.29*
Optimized	0.73	57.20**	0.63	7.01**	0.88	53.48**	0.80	5.01*

Significant at $p<0.01$*; Significant at $p<0.05$**.

7.8 Discussion

In software engineering, maturity models make it possible to obtain comprehensive insight into current development processes, their related activities, and their current maturity level. This information can be useful in streamlining current strategic plans and improving future activities. Furthermore, maturity models enable an organization to position itself and provide motivation to adopt good practices and strive for the next level.

Game development proved to be an incredibly challenging research topic because game technology, including game platforms and engines, changes rapidly, and coded modules are very rarely used in another game project. However, the recent success of the digital game industry has imposed further stress along with game development challenges and highlights the need to adopt good game development practices. This will enable

organizations to meet player demands and be successful in the highly competitive digital game industry. Ultimately, it will make it easier for organizations to meet their financial objectives. To determine the maturity of a current process or a specific area in the game development process that needs improvement, an assessment of process activities must be performed. However, due to the relatively short history and empirical nature of the field, the topic of development strategies and best practices for game development has not been fully explored.

To identify the important dimensions of digital game development methodology, empirical investigations and literatures reviews were carried out to examine the impact of key factors on game development. Based on an examination of key factors, research models have been developed to perform studies. Relationships were then established between key game development factors and the perspectives of different key stakeholders. To assess game development practices, the significant key factors identified from three empirical investigations have been used as a measuring instrument to develop a DGMM. The structure of a DGMM is composed of a four-dimensional assessment framework based on the perspectives of game developers, consumers, and businesses.

Subsequently, a DGMM as developed has been used to assess the maturity level of current development practices by following the developed assessment methodology and conducting case studies. Specifically, the model presented here can be used by an organization to assess its current practices and enable it to discover bottlenecks in its current methodology. Finally, it can be used to improve current processes and provide opportunities to develop successful games. The overall performance of a digital game is dependent on how it handles the usability and playability factors to attract its players, as well as how well developers meet deadlines by following suitable game design and development strategies. Finally, game performance has an impact on the business dimension of an organization. A DGMM presented here will help organizations monitor and evaluate their current practices, leading to successful game development projects. Monitoring and evaluation also help the development and management team to obtain insight into current development practices and to identify specific key process areas to improve. Game development processes are complex and need careful monitoring and

evaluation to meet the organization's objectives. The proposed DGMM provides an early conceptual framework for maturity assessment of game development practices. Further contributions in this particular area are still required from academic and industrial researchers.

7.8.1 Limitations of the Study

The assessment methodology of the proposed DGMM is based on questionnaires and hence is susceptible to certain limitations. Although the proposed maturity model is based on three empirical studies involving five maturity levels and eighteen different key factors, it is always possible that other factors such as game category, organization size, and cultural and economic conditions have been inadvertently excluded. The proposed model assessment methodology is based on subjective responses from project managers and development team members. However, approaches used to ensure reliability and validity form part of the common statistical techniques used by software engineering researchers.

Generally, independent assessors are considered essential in defining the coordination with the internal assessment team. However, the proposed methodology does not consider the role of an independent assessor, and case studies are performed based on self-assessment. The proposed DGMM provides numerical data regarding the maturity level of game development practices and factors within organizations, but it does not provide any guidelines to improve them. Guidelines for process improvement and how to progress from lower to higher levels remain topics for further research.

7.9 Conclusion

To construct the model framework, game development and management have been divided into four dimensions: selecting the game design strategy, development methodology, game playability and usability factors, and finally, business performance. Assessment of game development processes is an important area of research for developing quality games and ultimately for their successful business performance. Currently, no research has been reported in the area of game development methodology assessment. This chapter proposed a DGMM that includes key game development factors

and crucial concepts from software engineering and project management. It is easily applicable to any size of organization, any game genre, and any platform.

Although the model as presented here has certain specific and general limitations, key game development factors have been validated using commonly used statistical approaches. This study provides a comprehensive approach to evaluate current game development practices and give organizations insight into their development activities. This study also provides future directions for research in game development.

Chapter 8

8 Research Implications

Game development has interesting properties such as real-time interaction, emergence, and computationally challenging components that create a new field of study despite its similarity to software engineering. Software engineering practices are also beneficial for the game development industry, but the industry largely still discounts software engineering practices as ultimately unable to meet its needs when working on complex development tasks. To aid in facing the challenges encountered by game development organizations, solutions will have to satisfy developers as well as consumers and must be applicable to general game development. They must not be specific to one game genre or cultural environment. Hence, solutions must incorporate best software engineering practices plus project management skills so that game investors and game players do not need to worry about the quality of their game software product because of its reusability, reliability, or expandability.

This thesis contributes towards instituting a comprehensive approach for game development process maturity, and it addresses the important concerns faced by game development organization by quantifying most of the related key factors as metrics. A DGMM provides a set of best practices for managing complex game projects. This model also enables project managers to identify bottlenecks and areas where experts are needed. The proposed model can be effectively used and tailored for developing any kind of game project. A DGMM framework consists of assessment questionnaires for the five maturity levels, a rating method, and performance scales. In the course of this research, case studies were conducted to demonstrate the methodology for evaluating the maturity level of game development in two organizations.

The proposed model has practical implications for future research. First, other researchers can use this model to assess the maturity level of game development practices in different cultures. At the same time, other researchers can further investigate the model and provide more specific guidelines to improve the game development process. The findings

of this study can be used to develop more advanced models that provide guidelines on how to achieve higher maturity levels.

The findings of this study have implications for national economies as well, because game development organizations have become a strong contributor towards the GDP of most of the countries where they are established. By adopting best practices, they can indirectly improve their GDP contribution to their country's economy. This has substantial research implications for the future growth of DGI.

8.1 Research Contribution

The main objective of this research is to contribute to the available research for the software engineering field in general and specifically to digital game development practices. It provides a practical solution in the form of a DGMM. The defined framework of this thesis was realized by finding answers to the identified research questions, thus providing a unified and comprehensive methodology for assessment of game development practices within any game development organization. The research accomplished and described in this thesis offers a comprehensive strategy for assessing current game development practices.

The main contributions of the research described in this thesis are:

- A systematic literature review was performed to identify the research gaps in the game development life cycle that needs research attention. (Chapter 3)
- Three important perspectives were covered (developer, consumers, and business) to identify important key game development success factors. Three empirical investigations were performed, one for each perspective, and the results were validated using popular statistical approaches. (Chapters 4, 5, and 6 respectively)
- A framework for a *Digital Game Maturity Model*. The proposed model uses the empirically validated key factors as a measuring instrument for game development projects. In particular, five maturity levels have been used to represent the maturity of game development practices in a game development

organization. The research also covered the assessment questionnaire, the rating methodology, and two case studies (Chapter 7).

8.2 Conclusion

The digital game development process and its performance assessment have received relatively very little attention by researchers, and no comprehensive method has been proposed to help an organization identify its strengths and weaknesses in the various activities performed during game development. Accordingly, the main contribution of this thesis is the assessment methodology for game development practices that can be used to evaluate the maturity level of organizations. In Section 1.6, nine research questions were formulated. The research conducted and reported in this thesis provided answers to those nine research questions as presented below.

RQ-1: Is it possible to differentiate clearly between the software development process and the game development process?

RQ-2: Are there any frameworks for the assessment of game development process?

Answers: For research questions (RQ1 & RQ2), all related issues were discussed in Chapter 2.

RQ-3: What are the areas of game development that particularly need researcher's attention?

Answer: This study included a systematic literature review for the game development life cycle (Chapter 3) to assess the state of the art in research on the game development software engineering process and to highlight areas needing further consideration by researchers. The results of this study suggested that the game development software engineering process has many aspects that need further attention from researchers, especially for the game development process assessment methodology.

RQ-4: From the developer's perspective, what are the key game development factors that affect the quality of a game project?

Answer: We empirically investigated the impact of developers' key factors for game development process improvement. The results of this effort have demonstrated that developers' key factors are very important and play a key role in improving the digital game development process. The results showed that team configuration and management, game design document management, quality of game architecture, game test management, and programming practices are positively associated with the enhanced game development process. The empirical investigation found no strong association or impact between game engine development and the enhanced game development process.

RQ-5: What are the key factors that influence the game development process from a business perspective?

Answer: This study investigated the empirical effect of business factors on the performance of digital games in the market to try to find answers to RQ5. The empirical investigation results demonstrated that business factors play an important role in digital game performance. The results of the study strongly indicate that customer satisfaction, time to market, monetization strategy, market orientation, and brand name strategy are positively associated with the performance of a digital game organization. The empirical investigation found no strong association or impact between relationship management or innovation and digital game performance.

RQ-6: Is it possible to identify the key game development factors for game projects from a consumer perspective?

Answer: To answer RQ6, the impact of consumer key factors on game success was analyzed. The results of this empirical investigation have demonstrated that consumer key factors are very important and play a key role in the success of any software game. The results showed that game engagement, game enjoyment, game characteristics, and ease of use are positively associated with digital game success in the DGI market. The empirical investigation found no strong association or impact between socialization and digital game success.

RQ-7: How can the game development processes within a game development organization be assessed?

Answer: A DGMM is presented in Chapter 7 of this thesis, which is intended to assess game development practices for game projects.

RQ-8: Can specific scales be developed to represent the maturity level of a game development practices in a game development organization?

Answer: Five performance scales and a rating methodology for assessing maturity levels were developed in this research and are presented in Chapter 7 of this thesis.

RQ-9: What are the future implications of the development of a DGMM?

Answer: Chapter 8 describes the future implications of the proposed DGMM. This research is expected to be exceedingly beneficial to the digital game industry and to open a new debate about best game development practices and how to improve them by proposing concise game development process improvement guidelines and process assessment tools.

8.3 Future Work

The present work has contributed to the field of software engineering in general and to the game development industry in particular. It has demonstrated that best practices should be adopted and integrated into game development processes to capture various stakeholders' perspectives and would help game development organizations to improve the quality of their final product, i.e., the digital game. It will provide developers with powerful insights into the development process to accelerate the creation of digital games, achieving shorter time to market, lower cost, and high quality, and will also help stakeholders to make correct decisions. The most important research areas for future work in this field are presented below.

- The self-assessment methodology is used to assess the maturity of game development practices within an organization. We plan to enhance the assessment

process by introducing independent assessors as members of the internal assessment team.

- Regarding the factors that were not validated in this study, they need further investigation to determine whether they are relevant for game development assessment.

- The model has been validated based on two case studies from North America. More case studies are required from different regions of the world to improve and generalize this initial model.

These observations suggest that there is a broad field of research ahead.

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Appendices

Appendix 1

List of studies included in the systematic literature study

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Appendix II

Study Data Sheet for Systematic Literature Review

Paper	Venue	Year	Country	Type of Citation	Method	Approach
Pre-production						
Game process development management						
S1	IEEE	2013	Bandung	Conference		Exploratory
S2	ACM	2010	Brazil	Conference		Exploratory
S3	IEEE	2006	Korea	Conference	Survey	Empirical
S4	Conference proceedings	2003	Singapore	Conference		Descriptive
S5	Elsevier	2004	USA	Journal	Case study	Empirical
S6	IEEE	2010	Malaysia	Conference		Descriptive
S7	ACM	2011	Portugal	Conference		Descriptive
S8	Springer	2007	South Africa	Journal		Descriptive
S9	IEEE	2011	UK	Journal		Descriptive
S10	ACM	2012	USA	Conference	Survey	Empirical
S11	ACM	2011	USA	Conference	Case study	Empirical
S12	IEEE	2012	Greece	Conference		Exploratory
S13	IEEE	2012	Brazil	Conference		Exploratory
S14	IEEE	2009	Latvia	Conference	Survey	Empirical
S15	Elsevier	2006	Sweden	Journal		Descriptive
S16	IEEE	2007	USA	Conference	Survey	Empirical
S17	ACM	2009	Brazil	Journal	Survey	Empirical
S18	Taylor & Francis	2015	UK	Book		Descriptive
Game requirement specification						
S19	IEEE	2005	Canada	Conference		Exploratory
S20	IEEE	2010	Canada	Workshop	Case study	Empirical
S21	ACM	2013	USA	Workshop	Survey	Empirical
S22	Taylor & Francis	2003	Sweden	Journal		Descriptive
S23	IEEE	2011	Brazil	Journal		Exploratory
S24	Elsevier	2014	Spain	Journal		Exploratory
S25	Springer	2014	Finland	Journal		Exploratory
S26	ACM	2015	USA	Workshop		Descriptive
S27	Google Scholar	2015	Korea	Conference		Exploratory
Game system description languages						
S28	John Wiley	2007	UK	Journal		Exploratory
S29	Elsevier	2013	USA	Conference		Descriptive
S30	IEEE	2008	Hong Kong	Conference	Survey	Empirical
S31	IEEE	2011	Spain	Conference	Case study	Empirical
S32	Elsevier	2011	China	Journal	Experiments	Empirical
S33	IEEE	2011	Denmark	Conference		Exploratory
Reusability						
S34	IEEE	2009	Canada	Conference		Descriptive

S35	IEEE	2011	Portugal	Journal		Descriptive
S36	IEEE	2013	Hungary	Conference	Case Study	Empirical
Game Design Document						
S37	John Wiley	2008	Netherlands	Journal		Exploratory
S38	IEEE	2012	USA	Conference		Descriptive
S39	Taylor & Francis	2003	Australia	Journal		Exploratory
S40	Elsevier	2006	Taiwan	Journal		Exploratory
S41	IEEE	2013	USA	Conference		Descriptive
S42	IEEE	2010	China	Conference		Descriptive
S43	IEEE	2009	Malaysia	Conference		Exploratory
S44	IEEE	2011	UAE	Conference		Descriptive
S45	Taylor & Francis	2014	New York	Book		Descriptive
S46	DiGRA	2014	Germany	Conference		Descriptive
S47	DiGRA	2015	Germany	Conference		Descriptive
Prototype						
S48	IEEE	2013	Japan	Journal		Descriptive
S49	ACM	2009	USA	Journal		Exploratory
S50	Elsevier	2011	China	Journal		Descriptive
S51	Elsevier	1998	Japan	Journal	Experiment	Empirical
S52	IEEE	2012	Brazil	Conference		Exploratory
S53	Elsevier	2005	UK	Journal	Experiment	Empirical
S54	IEEE	2009	Denmark	Journal		Exploratory
Design tools						
S55	ACM	2008	Sweden	Conference		Exploratory
S56	IEEE	2011	Korea	Conference		Descriptive
S57	IEEE	2010	Brazil	Conference		Descriptive
Risk Management						
S58	IEEE	2014	USA	Conference	Survey	Empirical
Production						
Storyboard production						
S59	IEEE	2010	UK	Journal		Exploratory
S60	IEEE	2013	Finland	Conference		Descriptive
S61	IEEE	2011	UK	Conference		Exploratory
S62	IEEE	2010	China	Conference		Exploratory
Asset creation						
S63	IEEE	2009	USA	Conference		Descriptive
S64	IEEE	2008	Australia	Conference	Survey	Empirical
S65	IEEE	2009	Serbia	Conference		Exploratory
S66	Google Scholar	2014	Slovenia	Conference		Descriptive
S67	ACM	2014	Korea	Conference		Exploratory
S68	IEEE	2015	Canada	Conference		Descriptive
Development platforms						
S69	IEEE	2011	Brazil	Conference		Descriptive
S70	IEEE	2008	China	Conference		Exploratory
S71	IEEE	2007	Brazil	Journal	Case study	Empirical
S72	IEEE	2009	Brazil	Symposium		Descriptive
S73	IEEE	2012	Taiwan	Conference		Descriptive
S74	IEEE	2012	Taiwan	Conference		Descriptive

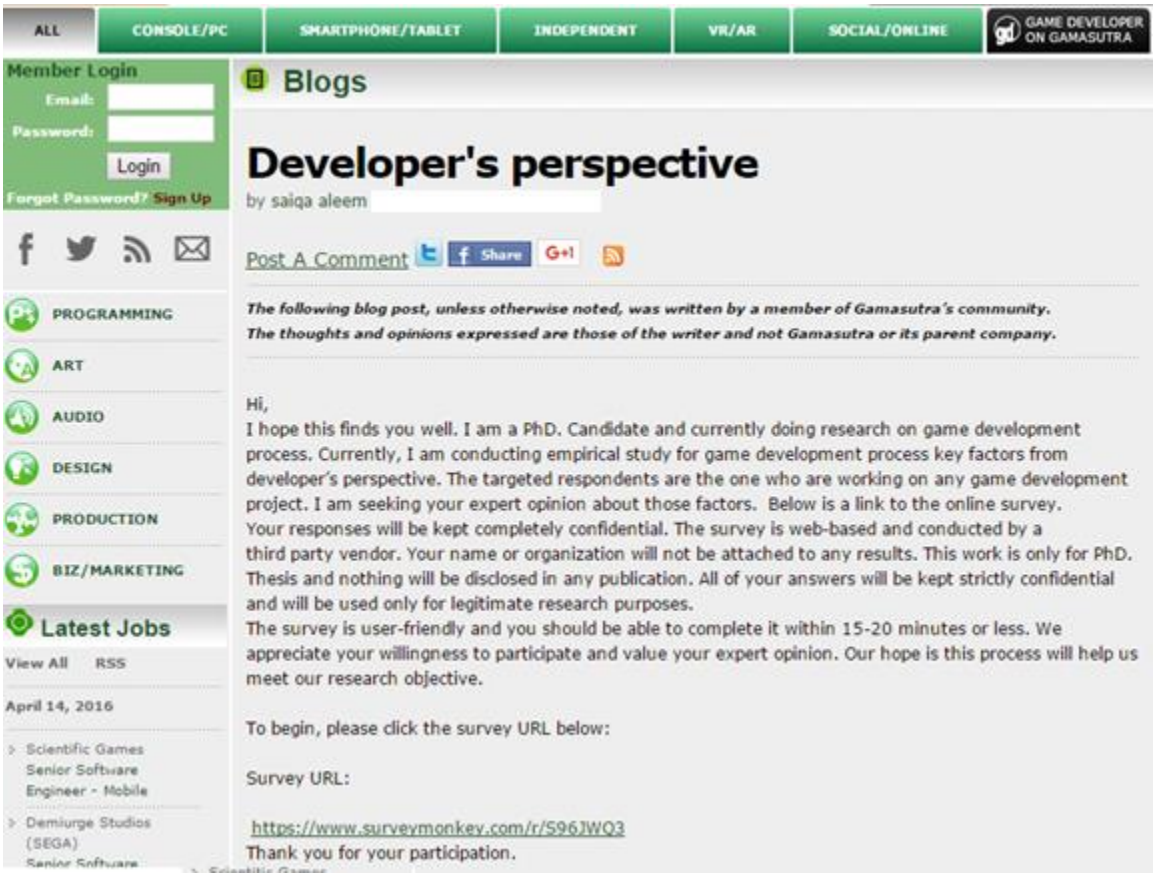
S75	IEEE	2010	UK	Conference		Exploratory
S76	ACM	2004	UK	Conference		Descriptive
S77	Springer	2004	Finland	Journal		Exploratory
S78	IEEE	2010	China	Conference		Descriptive
S79	IEEE	2013	Italy	Conference		Exploratory
S80	IEEE	2010	Spain	Conference		Exploratory
S81	IEEE	2009	Netherlands	Conference	Case study	Empirical
Programming						
S82	IEEE	2009	UK	Conference		Exploratory
S83	IEEE	2010	China	Conference		Exploratory
S84	IEEE	2004	Singapore	Conference		Exploratory
S85	IEEE	2011	China	Conference		Exploratory
S86	ACM	2007	Australia	Conference		Exploratory
S87	IEEE	2010	China	Conference		Descriptive
S88	IEEE	2012	China	Conference		Descriptive
S89	IEEE	2010	China	Conference		Descriptive
S90	IEEE	2012	Ireland	Conference		Exploratory
S91	IEEE	2004	Korea	Conference		Exploratory
S92	IEEE	2007	China	Conference	Experiments	Empirical
S93	IEEE	2012	China	Conference		Exploratory
S94	IEEE	2009	Brazil	Conference		Descriptive
S95	Google Scholar	2014	New York	Book		Descriptive
S96	IEEE	2014	Malta	Journal		Descriptive
S97	Google Scholar	2015	New Zealand	Conference		Exploratory
S98	IEEE	2015	Taiwan	Conference		Exploratory
Formal language description						
S99	Springer	2005	France	Journal		Descriptive
S100	Elsevier	2010	UK	Journal		Descriptive
Game Engines						
S101	IEEE	2011	China	Conference		Descriptive
S102	IEEE	2009	Italy	Conference		Descriptive
S103	IEEE	2013	Thailand	Conference	Case study	Empirical
S104	IEEE	2012	China	Conference		Descriptive
S105	IEEE	2011	China	Conference		Exploratory
S106	IEEE	2011	China	Conference		Exploratory
S107	IEEE	2011	Turkey	Conference		Descriptive
S108	ACM	2009	US	Conference		Exploratory
S109	IEEE	2013	UK	Conference		Exploratory
S110	Google Scholar	2014	UK	Book		Descriptive
S111	Google Scholar	2015	Greece	Conference		Exploratory
Implementation						
S112	IEEE	2008	Egypt	Conference		Descriptive
S113	IEEE	2009	China	Workshop	Experiment	Empirical
S114	IEEE	2010	Mauritius	Conference		Exploratory
S115	IEEE	2010	Portugal	Conference		Descriptive
S116	IEEE	2013	Colombia	Journal		Descriptive
S117	IEEE	2011	Finland	Conference		Exploratory
S118	IEEE	2008	Egypt	Conference		Descriptive
S119	IEEE	2008	Brazil	Conference		Exploratory
S120	IEEE	2007	Taiwan	Conference		Exploratory
S121	IEEE	1999	Japan	Conference	Experiment	Empirical

S122	IEEE	2015	USA	Conference		Descriptive
S123	IEEE	2015	USA	Conference		Descriptive
S124	Google Scholar	2015	USA	Book		Descriptive
Post-production						
Quality Assurance						
S125	IEEE	2007	UK	Conference		Exploratory
S126	IEEE	2002	USA	Conference		Exploratory
Beta Testing						
S127	IEEE	2012	Austria	Conference		Exploratory
S128	IEEE	2012	China	Conference		Exploratory
S129	IEEE	2011	Malaysia	Conference		Exploratory
S130	Elsevier	2012	Netherland	Journal		Exploratory
S131	ACM	2015	Canada	Conference		Exploratory
Heuristic Testing						
S132	IEEE	2013	Oman	Conference		Descriptive
S133	IEEE	2010	Malaysia	Conference		Exploratory
S134	IEEE	2013	Oman	Conference		Exploratory
S135	Springer	2009	USA	Conference		Exploratory
S136	ACM	2004	USA	Conference		Descriptive
S137	DiGRA	2015	Germany	Conference		Descriptive
Empirical Testing						
S138	IEEE	2012	Portugal	Conference	Case study	Empirical
S139	IEEE	2009	Korea	Conference	Case study	Empirical
Testing tools						
S140	IEEE	2010	Korea	Conference		Descriptive
Marketing						
S141	IEEE	2012	USA	Conference		Descriptive
S142	Elsevier	2014	Taiwan	Journal	Survey	Empirical
S143	ACM	2007	Australia	Journal		Exploratory
S144	Elsevier	2006	France	Journal		Descriptive
S145	ACM	2012	USA	Conference	Survey	Empirical
S146	Elsevier	2012	UK	Journal	Survey	Empirical
S147	Elsevier	2009	Taiwan	Journal	Survey	Empirical
S148	IEEE	2009	China	Conferences		Descriptive

Appendix III

Data Collection Strategies & List of Online Sources and their description

This research is highly dependent on data collection from various perspectives. I started blogs on different game communities and established connections with professional developers and team members through social communities. Some of the examples show screenshots of blogs started on online communities and communications with developers.



Blog Screen Shot

List and Description of Online Sources

I started following these sources as of December 2013. My analysis continued until April 25, 2016 (approximately 2 years, 5 months). I have organized online sources according to topical categories.

DGI Industry News Sites

- Gamasutra (www.gamasutra.com)

Gamasutra is the online sister publication to Game Developer Magazine, founded in 1997. It is composed of five sections: Developer Blogs, Features, News, Contractor Listings, and Job Listings. Each article is tagged according to a defined sector (All, Smartphone/Tablet, Social/Online, Console/PC, Independent, Serious) and category (Art, Design, Programming, Art, Design, Biz/ Marketing, Production).

- GamesIndustry.biz (www.gamesindustry.biz)

Gameslndustry.biz was launched in May 2008 by Eurogamer. It provides information and news about the global videogame industry and focuses on business-centred opinion articles, news, interviews, and analysis.

- Develop (www.develop-online.net)

Develop Online is the online sister site of Develop magazine and has been active since July 2007. It is in the United Kingdom and exclusively for the development community. It is composed of sections for Developer's Blogs, Features Articles, News, Job Listings, and Event Listings.

Player News Sites

- Kotaku (www.kotaku.com)

Part of Gawker Media's network of sites, Kotaku provides gamers with news about the game industry and anything broadly related to gamer culture. It includes forums for user discussion.

- Tap-Repeatedly (www.tap-repeatedly.com)

Aimed at game players, Tap-Repeatedly provides feature articles, editorials, news about the industry, and reviews of games.

General Technology News Sites

- Slashdot (www.slashdot.org)

Founded in 1997, Slashdot is a technology-related news website owned by Geeknet, Inc. It features user-submitted current affairs news stories about science and technology-related topics. Each topic is open to discussion by readers, who rank each other's comments in a user-based moderation system.

- TechCrunch (www.techcrunch.com)

Founded in 2005 by Michael Arrington, TechCrunch provides profiles of start-up companies, products, and websites, along with technology news and analysis. It was acquired by AOL in 2010.

Blogs and News Sites founded by Industry Consultants

- Game Theory (www.gametheoryonline.com)

Run by Scott Steinberg, CEO of TechSavvy Global (a strategic consulting and consumer products testing firm), Game Theory provides videos and articles about the game industry. I started following Game Theory in June 2010.

- GAMESBrief (www.gamesbrief.com)

Written by Nicholas Lovell, a consultant on financial and strategic advice for games companies, GAMESBrief is a blog dedicated to the business of games.

- Gabe Zichermann - The Gamification Blog (www.gamification.co)

Founded by Gabe Zichermann to promote gamification, The Gamification Blog provides case studies of gamification and interviews with designers of gamification services.

- What Games Are (www.whatgamesare.com)

A blog about game design, publishing, marketing, and production, What Games Are is written by Tadhg Kelly. Kelly has worked in the games industry for twenty years as a designer, writer, producer, and start-up founder.

Personal Blogs of developers and developer-academics, who reflect on their work processes.

- Pippin Barr (www.pippinbarr.com)

Barr reflects on developing indie games (The Artist is Present, Epic Sax Game, Let's Play, Ancient Greek Punishment) as well as his experiences playing AAA games. Barr works at the University of Malta.

- Digital Chocolate (www.blog.digitalchocolate.com)

Trip Hawkins, founder of Electronic Arts, started this blog in 2009 to reflect on the growth and design of social games, especially those games created by Digital Chocolate, his new start-up. In 2012, Hawkins stepped down as CEO of Digital Chocolate.

- Designer Notes (www.designer-notes.com)

Soren Johnson is a game designer and programmer. He was a once-vocal critic of social games who shifted employment from EA to Zynga in 2011. He has been writing Designer Notes since 2005.

- Applied Game Design (www.bbrathwaite.wordpress.com)

Brenda Brathwaite is an industry veteran who started designing RPG games in the early 1980s. She co-founded the social game company Loot Drop with John Romero in November 2010.

- Shambling Rambling Babbling (www.caseyodonnell.org/blog)

Casey O'Donnell is a professor at the University of Georgia, who previously worked in the game industry. O'Donnell writes anthropological accounts of game developers in the United States and India

- Raph Koster's Website (www.raphkoster.com)

Koster is a MMO game designer and author of A Theory of Fun. He started his website in 1998.

- Videogame Theory, Criticism, Design (www.bogost.com)

Ian Bogost is a professor at Georgia Tech, game designer, and author of multiple books on game studies.

- Lost Garden (www.lostgarden.com)

Daniel Cook is a game designer and artist who has been working in the industry for over 15 years. His blog, started in 2005, features article-length essays on the design process. He is currently the Chief Creative Officer at Spry Fox.

- Chris Hecker's Website (www.chrishecker.com)

Chris Hecker is a game developer and industry speaker, who previously worked with EA Maxis on Spore. He is the founder of the Indie Game Jam and a frequent speaker at game developer conferences

Printed Sources

- Game Developer Magazine

Aimed at working and aspiring game developers, Game Developer's first issue was launched in March 1994. The magazine publishes articles relating to programming, art, audio, quality control, design, and production. Each edition contains at least one post-mortem overview of a game's development and launch.

Additional sources

I relied on additional sources to supplement my data collection. I periodically drew from the following sites, but did not follow them on a systematic basis.

- Gaming News Sources:
    - Rock Paper Shotgun (www.rockpapershotgun.com)
    - The Escapist (www.escapistmagazine.com)
    - IGN (www.ign.com)
    - Casual Gaming.biz (www.casualgaming.biz, now amalgamated with www.develop-online.net)
    - GamePro (www.gamepro.com, now amalgamated with PCWorld.com)
    - Gamezebo (www.gamezebo.com)
    - Gamespot (www.gamespot.com)
    - Game Informer (www.gameinformer.com)
    - Gaming Business Review (www.gamingbusinessreview.com)
    - Joystiq (www.joystiq.com)
    - PC Gamer (www.pcgamer.com)
    - Games Radar (www.gamesradar.com)
    - Inside Facebook (www.insidefacebook.com)
    - All Facebook (www.allfacebook.com)
- Tech Industry News Sources
    - Ars Technica (www.arstechnica.com)
    - Venture Beat (www.venturebeat.com)
    - Forbes (www.forbes.com)
    - Time (www.time.com)
    - New York Times (www.newyorktimes.com)
    - Guardian UK (www.guardian.co.uk)
    - Wall Street Journal (www.wsj.com)
    - Fortune (www.money.cnn.com/magazines/fortune)
    - Huffington Post (www.huffingtonpost.com)

Appendix IV

Measuring Instrument for the Developer's Perspective

This survey attempts to evaluate key success factors in the game development process statistically from a developer's perspective. This survey captures the opinions of game developers who have completed game projects regarding factor collaboration, game design documents, game engines, game asset creation, game architecture, game testing, and programming.

If you are a game developer with at least one team project under your belt, please help us by taking the survey below for the game project you completed most recently and also give your opinion about enhanced the game development process.

Section I – Qualifying questions

1. Please take this survey for the most recent game development project for which you can answer "yes" to ALL the following questions:

☐ There were at least three full-time developers on this team.

☐ I worked on the project for at least one-third of its total duration.

☐ The project was either completed or cancelled sometime within the last three years.

☐ I worked in the development team in some sort of development role, such as a designer, artist, animator, programmer, producer, or sound designer.

This survey should not take more than 10–15 minutes to complete.

Your answers will be kept confidential, but the AGGREGATE data will be released to the public along with our conclusions.

Section II: Background questions

2. What is your region? _____

3. What was the total duration of your game development project? Enter whole numbers.

Years: _____ Months: _____

4. Approximately what is the size of the development team?_____

5. Please describe your primary role in the development process. Please select all that apply.

Artist/animator ☐ Programmer ☐ Designer ☐ Producer ☐

Audio Designer ☐ Other (please specify) ☐

6. The developed game was released for which platform? Select all that apply.

Any desktop ☐ Any handheld device ☐ Any console ☐ Web ☐

Any mobile ☐ Other ☐

7. What was the genre of the developed game?

Please Answer: _____

7. Which software development methodology was used to develop the game?
Please pick the approach that seems closest based on the descriptions below.

☐ Don't know

☐ Waterfall: the project was divided into phases that included upfront planning, requirements, design, development, and testing phases.

☐ Agile: Project leaders evaluated the project priorities on weekly or monthly sprints. Iterative development was focused on individual features, and frequent feedback was emphasized rather than requirements, specifications, or design documents.

☐ Agile using Scrum: the project followed the "Scrum" implementation of Agile. Priorities were determined by self-organizing cross-disciplinary teams. These teams were responsible for their own tasking and held daily scrum meetings to identify the work being done and bottlenecks to development.

☐ Other/Ad-hoc

Section III:

Evaluation of enhanced game development process success factors identified through literature review

The questionnaire objective is to find out which factors have a positive impact on the game development process. Please select the correct scale based on your best knowledge.

key factors for the game development process from a developer's perspective								
Likert scale (1 = strongly disagree; 2= disagree; 3 = neutral; 4= agree; 5 strongly agree)		1	2	3	4	5	N/A
Team Configuration & Management							
1	The team must be organized into sub-teams by discipline (art, programming, design) rather than by features.						
2	Team members must have a similar vision of the game throughout the development process.						
3	There must be support from lead management to the team members.						
4	The entire team should be involved in prioritizing the work to be done for each milestone or sprint.						
5	In case of any significant change in the game design or architecture, then all stakeholders must participate in the decision process.						
6	The development plan for the game should be clear and well communicated to the team.						
Game Design Document Management							
7	There must be a design document available to the team near the beginning of development that clearly specifies the game goals.						
8	Priorities must be given to different components so the team will know which part is more important.						
9	Details about storyboard, script writing, characters, and major and minor goals must be included in the GDD,						
10	The GDD was understandable because it was well written.						
11	Transformation of the GDD from the pre-production phase to the production phase was not problematic.						
Game Engine Development							
12	The development platform and tools must be familiar to game developers.						
13	The selected development tool provided asset and resource management.						
14	The selected game engine was able to handle diverse type of input and output.						
15	Integration of all technological components was easy.						
16	The game engine provided support for multi-platform development.						
17	The development tool enables use of other embedded tools that are helpful in extension of current capabilities.						
18	Reuse of the game engine is highly desirable.						
Game Asset Management							
19	Realism and performance analysis must be a part of asset creation.						
20	Realism and control investigation before asset creation is important.						
21	Integration of sound effects into complex and unexpected scenes can usually be done by using available audio processing libraries.						
22	Asset version control management must be performed to track different versions.						
Quality of Game Architecture							
23	Gameplay was divided into different modules, and each module could be modified and tested independently without impacting other modules.						

24	Different game modules should be easily portable and extensible so that they can be plugged into other game projects.						
25	The game architecture included robustness features that enable a game to be functional under unexpected circumstances.						
Game Test Management							
26	Game testing steps were usually established during the pre-production phase and documented properly.						
27	Game testing was performed throughout the game development process.						
28	A suitable testing approach was selected to test game performance and quality.						
29	The game was tested for performance under various loads.						
Programming Practices							
30	Programming team responsibilities and job roles were carefully matched with their particular programming skills and abilities.						
31	Programming style must be uniform among all programmers.						
32	Good commenting reduces the errors in code and speeds up the code review process.						
33	Standard naming and coding conventions should be used.						
34	Performance and optimization techniques (such as methodological and code optimization and datatype optimization) were applied to the code.						
Enhanced game development process							
1	The game engine should allow rapid prototyping of new levels, behaviour, and scenarios and support dynamic content loading.						
2	Game architecture should be easy to understand, change, reuse, and debug.						
3	The game design document should be developed in a formal way and have all specifications such as executive summary, product, game and art specifications.						
4	Game assets should be created to fit into the game concept and must have a positive effect on the appearance of the game.						
5	Coding priorities must be established as a part of technical design and must be properly documented						
6	Before selection of a programming strategy, issues such as coupling between modules, performance, memory management, and availability of different programming paradigms should be taken into consideration.						
7	All aspects of the game were tested, such as game play, functionality, interaction control, connectivity issues, input controller, and platform compatibility.						
8	The entire team should meet frequently to openly discuss topics of interest, ask questions, and identify production bottlenecks.						
9	Game testing should be performed properly to ensure game performance and quality.						

Appendix V

Key Business Factors Measuring Instrument

SECTION ONE

1.1 Participant details

Full Name (Optional)		Job Title/Position	
Experience (in years)			
Address			
Telephone no. (optional)			
Email			

1.2 Demographics

Country in which the company is located?
Please Specify:

What is the scope of your company?
National ☐ Multinational ☐ Don't Know ☐
Please Specify:

Approximately how many people are employed by your company? (Please tick the appropriate box)
Less than 20 ☐ 20-70 ☐ More than 100 ☐ Not sure ☐
Please Specify:

What type of game genre is developed by your company and what is the target platform for developed games?
Please Specify:

Who are the target audience?
Please Specify:

SECTION TWO

2.1 Evaluation of business performance success factors identified through literature review

The questionnaire objective is to find out which factors have a positive impact on business performance. Please select the correct scale based on your best knowledge.

Business performance key factors for game development companies							
Likert scale (1 = strongly disagree; 2= disagree; 3 = neutral; 4= agree; 5 strongly agree)		1	2	3	4	5	N/A
Customer or player satisfaction							
1	The organization is using a game rating scheme to respond to player requests.						
2	The organization has a good customer service department.						

3	The organization provides expert advice on games.						
4	The organization provides feedback or response to its customers.						
Market orientation							
5	The organization has adequate skills and resource to perform detailed market studies to determine what types of games are in demand and who will be the target audience.						
6	The organization uses appropriate feedback mechanisms to ensure game quality.						
7	The organization always develops a proper marketing plan and strategy to gain competitive advantage.						
8	The organization is able to maximize market size and its growth over time.						
Innovation							
9	The organization is able to use innovative ideas successfully for game development and game level repositioning.						
10	The innovations in games are aligned with existing business goals.						
11	Reactive and proactive innovation in the game development process is supported by management.						
12	Past innovative measures taken by the organization have helped in improving the game development and management process.						
13	The organization believes that R&D investment can yield positive results in the near future.						
Relationship management							
14	The organization has well-established mechanisms for data extraction, manipulation, and production for customer profiling, profitability analysis, and retention modeling.						
15	The organization participates in online gaming communities to identify player concerns.						
16	The organization is able to retain players for long periods.						
17	The organization has established a balanced player- and game-centered strategy for game development.						
18	The organization is able to attract new players and retain existing ones using innovative targeted methods and personalized communication.						
19	The organization is using a user integration strategy for game development.						
Time to market							
20	Games are launched in the market before competitors' games.						
21	The organization regularly studies and researches development updates, market reviews, and game publishing schedules to build awareness of market needs and trends.						
22	The organization publishes games in response to competitors' actions.						
23	Being first in the market helps to retain players and tends to attract new ones.						
Monetization strategy							
24	The organization is able to achieve its financial objectives successfully.						
25	The organization is able to use cost-saving strategies successfully.						
26	The organization is able to acquire more players for less investment.						
27	The organization uses in-depth mechanics to maximize conversion rate and lifetime value in games.						
28	The organization can successfully build cross-platform offerings to reach players/consumers.						
Brand name strategy							
29	The game development process of the organization is unique and different from its competitors in the market.						
30	New games and their latest versions are consistent with brand extensions.						
31	The latest game or its extended version attracts new customers and retains existing ones because it is considered an improvement in a newer or existing game.						
32	The buying decision of the customer is based on brand name loyalty.						
33	Published games have one-to-one competition in the market.						
Game business performance							

1	The organization was able to reduce the development time and cost of games over the last five years.						
2	The organization's sales have improved gradually over the last five years.						
3	The organization's financial analysis shows progressive growth over the last five years.						
4	Players' purchasing decisions are influenced by our brand-name game.						
5	The organization has been able to reduce significantly the number of competitors over the last five years.						
6	The organization is considered as a pioneer in the digital game industry rather than as a follower.						
7	Customer satisfaction and loyalty ratings have increased over the last five years.						
8	The business goals of the organization have been successfully accomplished.						

Appendix VI

Measuring Instrument for Consumer Perspective

SECTION ONE

Please select your region? (Please tick the appropriate box)
Asia ☐ **Europe** ☐ **Africa** ☐ **North America** ☐ **South America** ☐ **Australia** ☐

Which platform do you prefer to play software games? (Please tick the appropriate box)
PC ☐ **Online** ☐ **Mobile** ☐ **Console** ☐

How often do you play software games? (Please tick the appropriate box)
Daily ☐ **Weekly** ☐ **Once in a month** ☐ **Not a regular player** ☐

Which genre do you like to play, like action, racing, puzzles, etc.? (Please tick the appropriate box)
Action ☐ **Adventure** ☐ **Sports** ☐ **Puzzle** ☐ **Racing** ☐ **Strategy based** ☐ **Music based** ☐ **Other category** ☐

SECTION TWO

2.1 Evaluation of key consumer success factors identified through literature review

The questionnaire objective is to find out which factors have a positive impact on software game success. Please select the correct scale based on your best knowledge.

key factors for game development process from consumer perspective								
Likert scale (1 = strongly disagree; 2= disagree; 3 = neutral; 4= agree; 5 strongly agree)		1	2	3	4	5	N / A
Game Engagement							
1	I like to play games that provide lots of stimuli (motivations) from different sources.						
2	I believe that a game must have all the tasks of equal importance.						
3	Game workload is according to my cognitive (skills or abilities), perceptual (being transported into the real world), and memory limits.						
4	I must be consciously aware of my acts in the virtual world.						
5	I prefer to play games in which I feel full absorption in the game play.						
Game Enjoyment							
6	I believe that game play must be interesting and attractive.						
7	I like to play games that maintain my curiosity about all the levels of games.						
8	A good game must provide information about a player's performance and positive competence.						
9	Games must provide encouragement to each player.						
Game Characteristics							

10	Game must have challenges that match the skills of its players.						
11	I like to learn a game in a fun and enjoyable way.						
12	I like to be rewarded according to the efforts and skills I have developed.						
13	Game goals should be provided early and in a clear way as I progress in the game.						
14	I prefer to play games that have a good storyline.						
15	I prefer games that provide a feeling of full control and independence.						
Ease of use							
16	A good game should provide tutorial support.						
17	Control consistency in terms of internal and external navigational support for menus should be included.						
18	I like to play games that have hints and goal support.						
19	I prefer games with subtitles and magnifier support.						
Socialization							
20	I prefer games that support co-operation and competition between players.						
21	I like to participate in online social communities for software games.						
22	I like to play games that support interaction between players.						
Digital Game Success							
1	The software game kept the player's attention and focus all the time.						
2	The software game provided enjoyment that helped the player to feel deep and effortless involvement.						
3	The good characteristics of games in terms of challenges, feedback, clear goals, interactive interface features, and bug reporting attracted players.						
4	The software game provided easy-to-use gameplay so that players felt a sense of control over their actions within the game.						
5	The software game provided socialization attributes that created and supported opportunities for social interaction.						

Curriculum Vitae

Name: Saiqa Aleem

Post-Secondary Education and Degrees:

University of Central Punjab
Lahore, Pakistan
2001–2004 MSCS.

United Arab Emirates University
Al Ain, United Arab Emirates
2011–2013 Ms. in IT.

Honors and Awards:

UAEU Tuition Waiver Scholarship
2011–2013

Western Graduate Research Scholarship from Western University
Doctoral Fellowship
Western Graduate Assistant Scholarship from Western University
2013–2016

Queen Elizabeth II Scholarship (QEII)
2014–2015

Related Work Experience

Teaching Assistant
The University of Western Ontario
2013–2014

Instructor
Zayed University, Abu Dhabi, UAE
2011–2013

Publications related to this research:

1. S. Aleem, L. F. Capretz, and F. Ahmed, (2016a). Game development life cycle: A systematic review. Journal of Software Engineering Research and Development, Springer, Submitted, 28 pages.
2. S. Aleem, L.F. Capretz and F. Ahmed, (2016b). Critical success factors to improve the game development process from a developer's perspective, Journal of Computer Science and Technology, Springer, Submitted, 35 pages.
3. S. Aleem, L. F. Capretz, and F. Ahmed, (2016c). Empirical investigation of key business factors for digital game performance. Entertainment Computing, Elsevier, Vol. 13, pp.25-36 (Impact factor 1.61).

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5. S. Aleem, L.F. Capretz and F. Ahmed, (2016e). A Digital Game Maturity Model, Entertainment Computing, Elsevier, accepted with minor corrections, 37 pages.