MOBILE GAME-BASED LEARNING (mGBL) ENGINEERING MODEL

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by
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ABSTRACT

Mobile game-based learning (mGBL) is a game played on any handheld devices such as mobile phones. It is among the most recent growing research areas whereby its main aim is to use game play to enhance motivation in learning, engage in knowledge acquisition, and improve the effectiveness of learning activities through mobile environment. To fully utilize the potential of mGBL, researchers suggest looking at the most important part, which is the development methodology of mGBL. In relation to this, various game development methodologies have been introduced for different types of game genres and platforms. These methodologies propose different numbers of steps and activities; some focusing only on the learning design; some concentrating on the mobile technologies; and others on the complete life cycle. Although many game methodologies have been introduced, studies show that customized phases and steps to develop games for learning in mobile environment are substantially required. Therefore, the study discussed in this thesis addresses this gap by proposing an mGBL Engineering Model based on a number of games and learning theoretical and developmental foundations. In particular, the study identified the key steps of development methodology to be considered in developing mGBL applications which consist of phases, components, steps, and deliverables. In accomplishing this aim, a design science research methodology was adopted, comprising of five phases; (i) awareness of problem, (ii) suggestion, (iii) development, (iv) evaluation, and (v) conclusion. Subsequently, eight mGBL evaluation dimensions were put forward: visibility, complexity, compatibility, flexibility, clarity, effectiveness, manageability, and evolutionary. Model evaluation was conducted in three phases, namely; expert review, prototype development with heuristics evaluation, and experimental study. Generally, the proposed mGBL Engineering Model was well accepted by the experts contacted in this study. The model was also employed by a game company while developing an mGBL prototype. Here, the findings have implied that the model is useful to follow and it provides an easy guideline for fellow developers. In the experimental study phase, four learning or game methodologies; Analysis-Design-Development-Implementation-Evaluation, Input-Process-Output, Game Life Cycle, and mGBL Engineering Model; were studied and compared by 70 respondents. The findings have indicated that the proposed mGBL Engineering Model scored mean above 7.0 (out of 10) of all dimensions compared to the other three models (scored less than 7.0). The ANOVA results show that there are significant differences between all groups in six dimensions except complexity and compatibility. Although complexity and compatibility dimensions are not significantly different, the scores for the mGBL Engineering Model are higher than the other three models. All these results have demonstrated that the proposed mGBL Engineering Model exhibits useful development indicators for mGBL applications and is indeed a theoretical and practical contribution of the study. In addition, the other significant contributions are the eight evaluation dimensions together with the validated instrument. Furthermore, the artefact produced, which is the mGBL prototype is also a functional contribution.

ABSTRAK

Permainan pembelajaran mudah alih (*mGBL*) merupakan permainan yang dimainkan pada peralatan mudah alih seperti telefon mudah alih. Bidang ini antara bidang penyelidikan yang sedang berkembang di mana tujuan utamanya adalah menjadikan corak permainan sebagai jalan untuk meningkatkan motivasi dalam pembelajaran, penglibatan dalam mendapatkan pengetahuan, dan meningkatkan keberkesanan aktiviti pembelajaran melalui persekitaran mudah alih. Untuk mempertingkatkan potensi mGBL, para penyelidik mencadangkan untuk menumpukan aspek yang paling penting iaitu metodologi pembangunan mGBL. Oleh itu, banyak metodologi pembangunan permainan telah diperkenalkan dengan pelbagai jenis permainan dan platfom. Metodologi tersebut mencadangkan pelbagai langkah dan aktiviti, antaranya ada yang lebih menekankan reka bentuk pembelajaran, ada pula teknologi mudah alih, dan ada juga kepada kitaran hayat. Walaupun banyak metodologi diperkenalkan, kajian menunjukkan bahawa fasa dan langkah yang boleh disesuaikan dalam pembangunan permainan untuk pembelajaran di persekitaran mudah alih adalah sangat diperlukan. Oleh itu, kajian yang dibincangkan dalam tesis ini mencadangkan penyelesaian melalui Model Kejuruteraan mGBL yang berpandukan kepada teori dan asas pembangunan permainan dan pembelajaran. Secara khususnya, kajian ini mencari langkah utama dalam metodologi pembangunan mGBL iaitu fasa, komponen, langkah, dan hasilnya. Bagi mencapai tujuan tersebut, metodologi kajian sains rekabentuk digunakan yang mempunyai lima fasa iaitu (i) kenal pasti masalah, (ii) cadangan, (iii) pembangunan, (iv) penilaian, dan (v) kesimpulan. Selain itu, lapan dimensi penilaian mGBL diketengahkan: keterlihatan, kerumitan, kesesuaian, kelenturan, kejelasan, keberkesanan, pengurusan, dan evolusi. Penilaian model dilakukan dalam tiga cara iaitu; penilaian pakar, pembangunan prototaip dengan pengujian heuristik, dan kajian eksperimen. Umumnya, model yang dicadangkan ini diterima baik oleh pakar-pakar yang terlibat dalam kajian ini. Model ini juga digunakan oleh sebuah syarikat permainan dengan membangunkan prototaip mGBL. Di sini, hasil dapatan menunjukkan bahawa model tersebut berguna untuk diikuti dan memberikan garis panduan kepada para pembangun. Dalam fasa kajian eksperimen, empat metodologi permainan atau pembelajaran; *Analysis-Design-Development-Implementation-Evaluation, Input-Process-Output, Game Life Cycle* dan Model Kejuruteraan mGBL, dikaji dan dibandingkan oleh 70 responden. Hasil dapatan menunjukkan bahawa model cadangan mendapat skor min melebihi 7.0 (dari 10) untuk semua dimensi jika dibandingkan dengan tiga model tersebut (skor kurang dari 7.0). Keputusan ANOVA menunjukkan terdapat perbezaan signifikan antara enam dimensi penilaian kecuali kerumitan dan kesesuaian. Walaupun dimensi kerumitan dan kesesuaian tidak berbeza secara signifikan, skor diperolehi model cadangan ini lebih tinggi. Keputusan ini menunjukkan bahawa model cadangan tersebut boleh diaplikasikan dalam pembangunan mGBL yang menjadi sumbangan secara teori dan praktikal dalam kajian ini. Selain itu, sumbangan lain ialah lapan dimensi penilaian melalui instrumen yang telah ditentu sah. Artifak yang dihasilkan, yang merupakan prototaip mGBL juga merupakan satu lagi sumbangan fungsian.

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LIST OF ABBREVIATIONS

ADDIE	Analysis, Design, Development, Implementation and Evaluation
AI	Appreciative Inquiry
ANOVA	Analysis of Variance
ARCS	Attention, Relevance, Confidence, and Satisfaction
CBT	Computer Based Training
CD	Compact Disk
GBL	Game-Based Learning
GD	Game Design
GLC	Game Life Cycle
GPS	Global Positioning System
ICT	Information and Communication Technology
ID	Instructional Design
IGDA	International Game Developer Association
IPO	Input-Process-Output
ITU	International Telecommunication Union
MCMC	Malaysian Communications and Multimedia Commission
MMORGP	Multiplayer Online Role-Playing Game
mGame	Mobile Game
mGBL	Mobile Game-Based Learning
MMS	Multimedia Messaging Service
PBL	Problem Based Learning
PDA	Personal Digital Assistant
SMS	Short Messaging System
UUM	Universiti Utara Malaysia
VCD	Video Compact Disk

LIST OF PUBLICATIONS

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- **Syamsul Bahrin Zaibon** & Norshuhada Shiratuddin. (2010). Mobile Games Based Learning (mGBL): Application Development and Heuristics Evaluation Strategy, *Malaysian Journal of Learning and Instructions*, 7(1), pp. 37-73.

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LIST OF AWARDS AND RECOGNITIONS

- Award: **Gold Medal** at the Seoul International Invention Fair 2009 (SIIF2009), Korea.
    - Project Title: *1M'sia Mobile Game*.
    - Project Members: Norshuhada Shiratuddin & **Syamsul Bahrin Zaibon**.
- Award: **Gold Medal** at the International Exposition of Research and Invention of Institutions of Higher Learning 2009 (PECIPTA2009), Kuala Lumpur.
    - Project Title: *1Malaysia through Local Content*.
    - Project Members: Norshuhada Shiratuddin & **Syamsul Bahrin Zaibon**.
- Award: **Bronze Medal** at the Malaysian Technology Expo 2009 (MTE2009), Kuala Lumpur.
    - Project Title: *MY Road Traffic Signs mGame*.
    - Project Members: Norshuhada Shiratuddin, **Syamsul Bahrin Zaibon** & Ayman Srour.

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    - Authors: Norshuhada Shiratuddin & **Syamsul Bahrin Zaibon**.

CHAPTER 1

Background of Study

1.1 Introduction

This introductory chapter deliberates on the motivation aspects of the study; the advances of mobile learning (m-learning), the statement of the problem; objectives and significances of the study; and lastly, definition of the terms that are used throughout the study.

1.2 Research Motivations

A few aspects have been brought towards the proposed title of this study. Therefore, this section summarizes some aspects which motivate the study to be conducted.

1.2.1 Current State of Mobile Phone Subscriptions in Malaysia

The ownership of mobile phone is exponentially increasing all around the world. The International Telecommunication Union (ITU) Telecommunication/ Information Technology and Communication (ICT) Indicators Report (ITU, 2008) found indication that ICTs, broadband, and mobile phone uptake advance growth and development in Asia Pacific region. This is due to the fact that mobile technology is naturally portable, flexible to anywhere, possible to connect users to variety of information sources and enable communication everywhere (Smith et al., 1999; Naismith et al.,

2006). In Malaysia, mobile phone subscriptions have reached 31 million in the second quarter of 2010. According to the research conducted by the Malaysian Communications and Multimedia Commission (MCMC), the number of wireless phone users has also exceeded those of the fixed lines (MCMC, 2011). In details, the statistics of mobile phone subscriptions in Malaysia between 2005 and 2010 are listed in Table 1.1.

Table 1.1: Mobile phone subscriptions in Malaysia (MCMC, 2011)

Year	Quarter	Postpaid ('000)	Prepaid ('000)	Total ('000)	Growth Rate (%)	Penetration Rate (%)
2005	1	2,628	13,201	15,829	8.3	60.9
	2	2,787	13,764	16,551	4.6	63.3
	3	2,896	14,655	17,551	6.0	66.8
	4	2,925	16,620	19,545	11.4	74.1
2006	1	2,983	17,607	20,590	5.3	77.7
	2	3,162	18,358	21,520	4.5	80.8
	3	3,292	18,561	21,853	1.5	81.6
	4	3,368	16,096	19,464	-10.9	72.3
2007	1	3,392	17,427	20,819	7.0	77.0
	2	3,485	17,734	21,219	1.9	78.2
	3	3,689	18,380	22,067	4.0	80.8
	4	3,905	19,442	23,347	5.8	85.1
2008	1	4,137	20,116	24,253	3.9	87.9
	2	4,451	20,635	25,086	3.4	90.6
	3	4,926	21,236	26,162	4.4	93.9
	4	5,577	21,548	27,125	3.7	98.9
2009	1	5,859	22,335	28,194	3.9	100.1
	2	6,086	22,459	28,545	1.2	100.8
	3	6,212	23,411	29,623	3.8	104.1
	4	6,265	23,879	30,144	2.6	105.5
2010	1	6,402	24,392	30,794	2.2	107.1
	2	6,488	24,968	31,456	2.1	108.8

As of the first quarter of 2005, there were 15 million mobile phone subscriptions on all mobile networks operating in Malaysia. Then, in the first quarter of 2006, the number had increased to 20.5 million, a 5.3% growth rate and 77.7% penetration

rate nationwide. However, in the fourth quarter of 2006, the growth rate decreased to 10.9% due to the exercise of registering all prepaid users. During the period the Malaysian government forced that every prepaid mobile service users in Malaysia to be registered. The main reason for this directive was aimed at curbing misuses of the prepaid public cellular services and at the same time to address security concerns. Later, the number has continually increased up to 27 million subscriptions and 96.8% penetration rates were recorded in the fourth quarter of 2008. Further, the penetration rate for mobile phone subscription was recorded exceeding 100% in the first quarter of 2009 until the second quarter of 2010 due to multiple subscriptions. These numbers show that there has been a dramatic increase in the usage of Malaysian mobile phones.

In addition, Figure 1.1 shows the trend of penetration rate of mobile phone subscriptions in Malaysia. In general, the graph indicates that the penetration rate was increasing continuously between 1998 and 2010 except in the year 2006. In detail, the percentage of the penetration rate in Malaysia rose from only 9.7% in 1998 to 96.8% in 2008, and up to 108.8% in the second quarter of 2010. Similarly, mobile growth rates have been high across almost all regions and the number of subscribers has grown between 20 to 30 percent globally since 2000 (ITU, 2008). Statistics in the year 2010 show that access to mobile networks is now available to 90% of the world population and 80% of the population living in rural areas (ITU, 2010). Some of the reasons for this trend include the decreasing prices of mobile phones, the variety of services provided by the operators, and the various developments in mobile phone technologies such as GPRS, WAP, and the 3G standard (Abdul Karim, Darus, & Hussin, 2006).

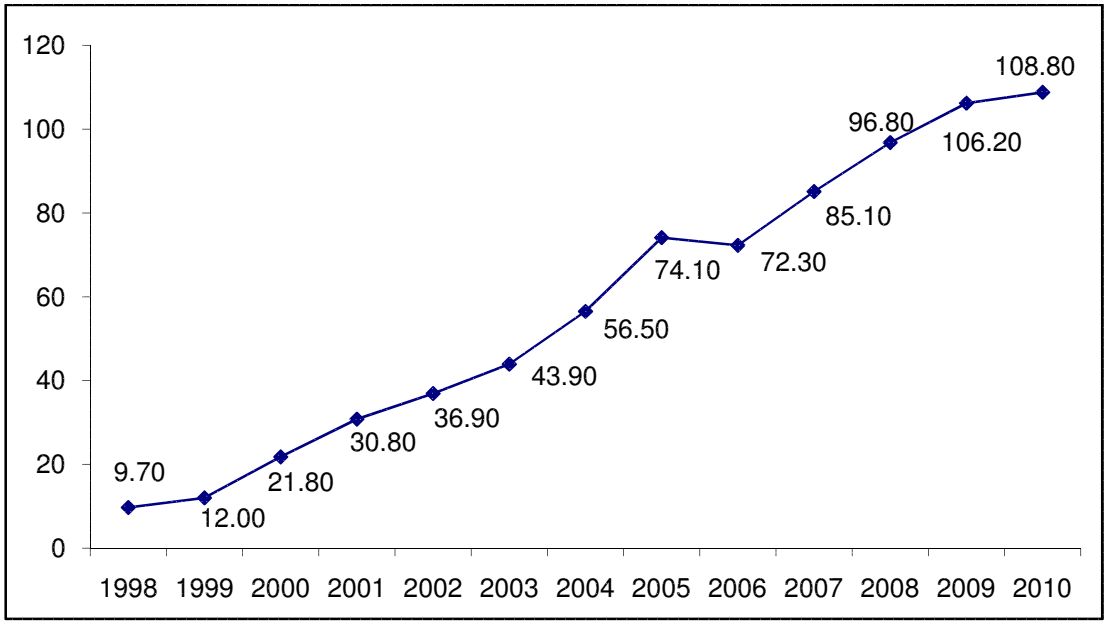


Figure 1.1: Penetration rate of mobile phone subscriptions in Malaysia from 1998 to 2010 (MCMC, 2011)

Based on the empirical evidences, the potential usage of m-learning is huge, specifically mobile game based learning (mGBL) in learning environment. In conjunction, IGDA (2005) indicates that over the last several years the landscape of mobile gaming has changed significantly. First, the potential size of the market for mobile gaming has expanded considerably since 2000. The second change is seen in the available mobile games that keep getting higher. In addition, according to a study by Pyramid Research, the mobile gaming market is predicted to reach $18 billion by 2014, where they expect a 16.6% growth rate annually (Pyramid Research, 2009).

1.2.2 Government Supports and Initiatives

The Malaysian government has proposed an initiative called Malaysian Information, Communications and Multimedia Services 886 (MyICMS 886) Strategy which identifies eight service areas which are targeted at forcing Malaysia in the delivery of advanced information, communications and multimedia services. MyICMS 886 states a number of strategies for the growth of local content and these include

promoting awareness, building competencies in higher education and forming strategic alliances. The purpose is mainly to encourage local companies to create and develop creative local-based contents to be marketed both locally and internationally. In realizing these goals, the Malaysian government and industry players have provided funding incentives specifically for local digital content productions. This includes various digital contents in diverse formats such as broadcasting, film, video, visual arts, digital TV, online games, digital content publishing, and mobile content (Norshuhada & Syamsul Bahrin, 2007).

1.2.3 Advances in Mobile Learning

In recent years, ICT has been treated as providing great solutions for various fields of people errands in social aspects, economics, cultures, and education. The field of education is not an exception and has been revolutionary impacted by ICT. As evidence, there are increasing interests in the use of ICT and educational technologies to promote learning formally or informally. Educational technologies are used as part of the teaching tools diversity to improve student learning activities in educational environments. In the environment, children or students could acquire knowledge and learn anything from the various available devices supported for educational materials. These technologies are not limited to computers and software but all devices that are utilized for teaching and learning such as compact disc (CD), video compact disc (VCD), cameras, mobile phone, personal digital assistance (PDA), global positioning system (GPS) devices, computer-based probes, and electronic tools which have yet to be discovered. With the capability of such technologies there are various types of educational applications readily available in the market such as educational software in CD, web-based or online learning, electronic learning (e-learning), Computer-Based Training (CBT), and most recently m-learning. Although there are many types of educational applications, the main purpose of the designed technologies is to facilitate effective and efficient learning.

M-learning can be described as a learning technique that takes place across locations or gets the advantages of learning opportunities offered by mobile technologies such as mobile phones, smart phones, PDAs and handheld devices. Basically, m-learning combines practices, strategies, tools, applications and resources with proven advances in technologies to support anywhere and anytime learning (Wagner, 2005). The most prominent promises by mobile technologies are students can learn without restrictions to places; in classrooms or outside, with or without teachers' guidance, and during or anytime class period. Many research findings show the potential and effective use of mobile technologies for learning purposes (Naismith et al., 2006; Pachler, 2007). Moreover, there are varieties of m-learning systems (SMS text message, Mobile Games, Mobile Applications) as listed in Table 1.2 that have been successfully implemented.

Table 1.2: Example of M-learning Systems

Application Types	Project Names	Authors
SMS text message	BBC Bitesize Programme	BBC Bitesize (2008)
	M-learning Language System	Thornton and Houser (2004)
	Learning System (Blackboard)	Vassell et al. (2006)
Mobile Game	mGBL project	Mitchell et al. (2006)
	Mathematic Video Game- Skills Area	Lee et al. (2004)
	Virus	Collella (2000)
	MIT Game-To-Teach	Klopfer and Squire (2002)
Mobile Application	Classroom Response System –Educue	Dufresne et al. (1996)
	Ambient Wood	Rogers et al. (2002)
	Butterfly Watching System	Chen et al. (2004)
	Interactive Audio-Visual tour	Proctor and Burton (2003)

Using SMS for m-learning is rather simple, yet effective as a complementary media. With SMS technology, short text messages and educational information can be written and sent quickly with any mobile phone. This offers enormous learning opportunities.

Mobile games used in m-learning environment offer rich and interactive learning experience, in which game play strategies are used to enhance learning by promoting learning through motivation. Through mobile games, the playing activities will engage and stimulate cognitive, as well as promote teamwork among

students, build skills, and interact with problems (Sugar & Sugar, 2002). Mobile applications for m-learning refer to a smaller version of desktop learning systems which are specially developed for mobile devices. The mobile applications are rather complicated than SMS system and usually contain more learning contents stored and managed in a database system.

One of the possible novelties regarding the methods of m-learning, which is discussed in this study, is the use of games. As a matter of fact, Rieber (1996) argues that as human beings by nature, one begins to learn through games and playing from early childhood. Consequently, up until now games are replaced by formal learning at kindergarten. In our modern day, with the new technological advancements in learning, traditional games have been replaced by digital games (computer, console, and mobile games). Hence, digital games have been parts of contemporary learning nowadays (Akilli & Cagiltay, 2006). Furthermore, the method of learning through mobile devices is becoming popular and this is shown by the growing numbers of available m-learning applications (Pachler, 2007; Trifonova, 2003).

Although there are many types of m-learning applications, this study focuses on the mobile game. Mobile game for learning or mGBL is a type of game specifically utilized for learning which is able to run on a mobile phone, smart phone, PDA or handheld devices (Mitchel et al., 2006). Similar to game-based learning (GBL), the main aim of mGBL is to use game play to enhance motivation in order to learn, engage in knowledge acquisition, enhance effectiveness of learning content transfer or benefit from other specific learning outcomes (Pivec, 2005; Goodman et al. 2006). Research on GBL increases dramatically world wide (Corti, 2006) due to the fact that the growing usage and popularity of exploiting game to support learning (Sawyer & Smith, 2008). In relation, Table 1.3 shows that the GBL is the most popular terms searched via Google amongst other game-based concept.

Table 1.3: Popularity of Game-Based Concepts (based on Sawyer & Smith, 2008)

Pre-Cursors	Alternative Names	Popularity
Game-Based Education	Game-Based Learning, Edutainment, Learning Games	10,943,370
Game-Based Production	Game-Based Authoring, Machinima	3,190,010
Game-Based Simulation	Game-Based Simulator, Simulation Game	2,480,860
Game-Based Messaging	Game-Based Advertising, Advergaming	470,620
Game-Based Training	Game-Based Trainer	12,390
Game-Based Application	-	8,630
Game-Based Visualization	Game Visualization	3,980
Game-Based Interface	Game Like Interface, Game-Based UI	3,500
Game-Based Model	-	3,380

Given such issues as the popularity of GBL and their impacts on users, it is advisable to look beyond the practical uses of the mGBL. The most important part is its design and development methodology. Developing a good game is very important in ensuring that the player is motivated enough to keep playing the game until the game goal is achieved (Kramer, 2000; Rollings & Morris, 2004; Prensky, 2001; Gee, 2003; Becker, 2006a; Egenfeldt-Nielsen, 2006).

1.2.4 Summary of Research Motivations

With such huge potentials in mobile contents, high demands in mobile content markets, and supports from the government; there is a possibility of utilizing mobile contents for learning purposes. One of the contents is mobile game that can be exploited as an interesting learning content. Looking at the prospective of mobile games, mGBL is worth to be one of the m-learning contents. Not to mention, there are a lot of advantages of using games for learning (Cisic et al., 2007).

In order to take advantage of the positive aspects of games for learning, the design and development of mGBL as any form of instructional material must be carefully and intelligently designed. Therefore, there is a clear need for a design theory which not only clearly defines how to design an effective educational game, but also focuses on providing the necessary support for implementation in mobile

technologies. To further establish the focus area of study, a preliminary study was conducted, and is as discussed in the next section.

1.3 Preliminary Study

In the process of developing the research focus, a preliminary study was conducted. The analyses of the study further support the justification of the choice of research area.

1.3.1 A Survey on Student Preferences for M-learning

In spite of the various m-learning applications provided through mobile phone services, more studies on mGBL need to be undertaken to comprehend the needs and requirements of the mobile phone users. Therefore, it is important to analyze students' demographic characteristics, their perceptions and thoughts in relation to playing mobile games. Previously, several studies have been carried out to investigate the educational potentials of games (in general, not for mobile platform) from students' points of view. Initially, Quaiser-Pohl et al. (2006) have concluded that gender differences result in different expectations of computer games. Similarly, Chou and Tsai (2007), and Fromme (2003) revealed that different genders prefer to play different types of computer games.

Thus, in a quest of catering for the learning needs among students, this study seeks to understand their preferences in learning through mobile games.

a) Method

The main objectives of this preliminary study are to (i) find out the specific target audiences for mGBL and (ii) their preferences in learning, either using mobile phone or other game devices. Then, basic statistical method was used to assess the student responses which particularly using descriptive techniques. Two months (between August and September 2008) were allocated for collecting data using a

questionnaire with 19 questions consists of demographics background, and close and open-ended questions. The main questions investigate whether the students own any mobile phone and play mobile games, whether they think games can be used for learning, and whether they prefer to learn a subject through mobile games or games on special devices. The questionnaire was developed in Malay language with simple phrases, targeted for respondents between 13 and 17 years old.

The targeted samples were among students at Malaysian secondary schools. They were randomly selected from four schools. In total, the distributions for the data collection were 680 sets, where 591 respondents completed the questionnaire which gives a response rate of about 86.91%. The rate considerably high and makes the result more relevant to the findings of this study.

b) Findings

This section presents the findings of the survey and analysis of the main results which highlights the key issues that arise from the responses obtained. First, the demographic profile of the respondents is exhibited in Table 1.4.

Table 1.4: Demographic profiles of respondents (ages and races)

		Gender		Total
		Male	Female	
Ages	- 13 (Form 1)	71	95	166
	- 14 (Form 2)	12	94	106
	- 15 (Form 3)	30	62	92
	- 16 (Form 4)	65	65	130
	- 17 (Form 5)	47	50	97
Total		**225**	**366**	**591**
Races	- Malay	182	299	481
	- Chinese	22	32	54
	- Indian	18	30	48
	- Others*	3	5	8
Total		**225**	**366**	**591**

About 61.9% of the respondents were female and the remainder male. As for race composition, the majority of the respondents were Malay (81.4%), while the rest

were Chinese (9.1%), Indian (8.1%) and other races (1.3%) such as Aborigines and Siamese. In the first question, the respondents were asked whether they have access to any mobile phone. As depicted in Table 1.5, majority of the respondent with 73.9% have access to mobile phone.

Table 1.5: Having access to Mobile Phone

	Gender		Total
	Male	Female	
Yes	169	268	437 (73.9%)
No	56	98	154 (26.1%)
Total	**225**	**366**	**591**

This result supports a previous statement by Lee (2006) that in 2005, more than two million hand phone users in Malaysia were 19 years old or younger and this number is increasing much faster than among others. A study done by Norbayah and Norazah (2007) also showed similar results. However, it was noted that fewer respondents aged 13 did not have access to mobile phone as compared to other age groups.

Second question asks whether they play mobile games, 437 students answered (see Table 1.6). Most of them (69.8%) reported that they play mobile games (n = 305); of these, 40% players were males, and 60% were females. Based on the statistics, it could be concluded that female students like to play mobile games. The result supports the studies by The Yankee Group United States (Business Wire, 2004), and Hafizullah (2007); which found that female prefers to play mobile games.

Table 1.6: Play Mobile Games

	Gender		Total
	Male	Female	
Yes	122	183	305 (69.8%)
No	47	85	132 (30.2%)
Total	**168**	**268**	**437**

Next, when the students were asked about the purpose of playing games (in general), they were given three options to select: entertainment, education, and combination of both. There were 577 students responded to this question.

As seen in Table 1.7, most of the students stated that they play games for entertainment (50.4%); the next highest category is both (45.8%). Very few students reported playing games for education only. A comparison of males' and females' aims in game playing reveals some differences. For example, males play games more than females for entertainment: 52.0% of the males played games for entertainment, while only 49.4% of females did so. On the other hand, the females scored higher (46.3%) who reported that they play games for both reasons; while 44.8% of the males cited this reason. This suggests that, in order to make the mGBL successful in learning environment, it should embrace both entertainment and education purposes.

Table 1.7: Purpose for Playing Games (all types of games)

Purposes	Gender				Total	
	Male		Female			
Entertainment	115	52.0%	176	49.4%	291	50.4%
Education	7	3.2%	15	4.3%	22	3.8%
Both	99	44.8%	165	46.3%	264	45.8%
Total	**221**		**356**		**557**	

Table 1.8: What do you want to learn from game?

Knowledge	Frequency (n=565)	Percentage
Cultural & Heritage Values	155	27.4
General Knowledge	447	79.1
Tourism	255	45.1
Economic & Business	160	28.3
Medical & Health	136	24.1
School Subject*	223	39.5
Others**	65	11.5

While in Table 1.8, when they were asked about what they want to learn from a game, 79.1% prefer to learn the general knowledge compared to other knowledge

areas. The table also shows that only 39.5% of the students prefer to learn school subject because they may think preferred that mobile phones are not allowed in schools and not really suitable for learning formally in class.

In addition, the students were also asked about the device they prefer for learning either through mobile games or other special devices. Overall, 591 students responded to this question. As shown in Table 1.9, most students (56.5%) prefer learning through mobile game. Broken down by gender, the females (66.7%) considered mobile game to be a more preferred device for learning overall than males did (48.9%). Henceforth, it may be deduced that in general, mobile game is suitable and mobile phone is the most preferred device for learning.

Table 1.9: Preferred Device for Learning

Devices	Frequency	Percent (%)	Gender	
			Male	Female
Mobile games	334	56.5	48.9%	66.7%
Special devices	257	43.5	51.1%	56.7%
Total	**591**	**100.0**	**100.0**	**100.0**

c) Implications of Findings on the Study

Generally, the results in this preliminary study are consistent with the previous studies in the literature (for example Lee, 2006; Norbayah & Norazah, 2007; Business Wire, 2004; Hafizullah, 2007). The results reveal that a majority of the surveyed students have access to mobile phones. Most of them played mobile games, and female students played more than males. The findings also disclose that, in order to make the mGBL successful in learning environment, it should embrace both entertainment and education purposes. In addition, students prefer learning through mobile phone rather than dedicated devices (consoles).

Consequently, this preliminary study provides (i) evidences that there is a huge potential in implementing mobile games for educational purposes, and (ii) indications that exploring this area is indeed timely.

To explore the advantages and benefits of games for learning, it is essential to study on the design and development of these types of game. Hence, this study then determined the problem statement, as described in the following section.

1.4 Problem Statement

As the mobile game industry continues to boom, increasing demand and market have enabled mobile game developers to develop numerous mobile games. In contrast to entertainment-purposed only mobile games, mGBL requires the value-added educational contents and specific learning purposes. Furthermore, mobile game players also continually demand for more mGBL that can motivate them to play while learning and apparently that is also challenging, rewarding, and void of frustration (Amory & Seagram, 2003).

Various game design models and development methodologies have been proposed by a number of researchers and are made available in different genres of games, with each having specific requirements (Kiili, 2005; Quinn, 1994; Amory & Seagram, 2003). However, the research literatures contain very few studies on methodologies of how to develop educational games (Fletcher & Tobias, 2006; Moser, 2002). To date, there is lack of comprehensive development methodologies to create mGBL (refer to the analysis that was conducted and is discussed in Chapter 2).

The current available game design models and methodologies are gathered and can be categorized into two: (1) General GBL Models and (2) Mobile Game Development Methodologies. The separation between the two analyzed categories is based on the differences of definition on the design model and development methodologies. As stated by Vaishnavi and Kuechler (2007), design model is a set of propositions which expresses the relationship between components or concept. On

the other hand, development methodology is a set of steps or guidelines used to perform a task.

The first category, the general GBL models include: Input-Process-Outcome Game Model (Garris et al., 2002), Experiential Gaming Model (Kiili, 2005), Integrated Model for Educational Game Design (Paras & Bizzocchi, 2005), The Fuzzified Instructional Design Development of Game-like Environments (FIDGE) Model (Akilli & Cagiltay, 2006), Four Dimensional Framework (de Freitas & Oliver, 2006), Adaptive Digital GBL Framework (Tan et al., 2007), Games for Activating Thematic Engagement (GATE) (Watson, 2007), The Digital Game Involvement Model (Calleja, 2007), Framework for Designing GBL for Children (Noor Azli et al., 2008), and GBL Model for History Courseware Design (Nor Azan et al., 2009). The above listed models are all game design models which cater to the specifications, concepts, requirements, or components needed to be included when designing GBL. Although this is the case, all of them do not suggest any step-by-step process of game development. Besides, the models also never specify on how to develop games on mobile platforms (refer to Chapter 2 for further details).

The second category, the mobile game development methodologies are: Best Practice for Mobile Game Development (Dholkawala, 2005), Scrum Methodology (McGuire, 2006), Game Development Methodology (Dynamic Ventures, 2007), Game Life Cycle (Janousek, 2007), and Design-Protect-Build-Test-Market-Sell (Edwards & Coulton, 2006). Methodologies in the second category suggest the phases and methodologies for developing mobile games but are not specified for GBL. The drawbacks of all of these methodologies are (i) phases are generic in nature, and (ii) are not suitable for mGBL as there is no instructional design (ID) model or learning theories considered. Most of the methodologies are guidelines and general approaches for developing mobile games and not mGBL (refer to Chapter 2 for further details).

It is acknowledged that, the development of a game is a complicated and often an expensive task, and there has been limited research in game design in general (Bjork et al., 2003) and also in educational game design (Dempsey et al., 1996; Moser, 2002). The literatures also suggest that the development of GBL should be a combination of two models; game development method and ID model (Garris et al., 2002). This is because ID models contain valuable insights and guidelines for the development of instructions. In addition, Moser (2002) states that ID models should be incorporated into new setting especially in different media for designing learning objects to provide necessary element of learning. Each ID model addresses various problems effectively and it would be imprudent to ignore them in an attempt to create any learning based technology (Becker, 2006b). Furthermore the variation of ID models offers different components to cater for any specific context (Gustfason & Branch, 1997; Moser, 2002). Therefore, ID models should be incorporated in mGBL development methodologies.

In addition, IGDA (2005) states that embedding learning content into mobile games can be complicated, because mobile games particularly educational games differ from the application software (Prensky, 2001; Ciavarro, 2006). Another concerning aspect to propose a mGBL development methodology is the restrictions of the mobile platform. The aspects that are considerably important when designing in mobile environment are screen design, interaction, and software or hardware dependent (Lee, 2005; IGDA, 2005). The guidelines on how to align with these restrictions should be clearly specified in the development methodology, so that the game developers, especially the inexperienced ones, will put into consideration these aspects when they produce any mGBL.

1.4.1 Research Gaps

Based on the problems as discussed in the previous section, the following research gaps are extracted:

i) Development methodology to engineer mGBL systematically is highly scarce.
ii) Most of mobile game methodologies exclude the ID models for developing GBL.
iii) Some design restrictions and aspects that should be considered when developing game on mobile platform are not clearly specified in the existing methodologies and models.

Hence, based on these research gaps, there is a need for a comprehensive development methodology which not only clearly defines how to design an effective mGBL, but also focuses on providing necessary supports for implementation to improve its learning effectiveness. It is therefore proposed that in order to engineer a mGBL systematically, it is crucial for developers to refer to a comprehensive mGBL engineering model that incorporates a number of aspects, mainly, the ID, interaction, and technologies in mobile environment.

In this study, mGBL engineering model is defined as the application of a systematic approach that includes processes and methods for the development of a mGBL application. Also, an engineering model is a schematic drawing that includes all components and data needed to fulfil its purpose (Hahn, 2002).

1.5 Research Objectives

The aim of the research is to propose a mGBL engineering model that incorporates ID models and systematic processes. In accomplishing the main aim, the following specific objectives are also formed:

Obj (1) To identify the main components of a systematic mGBL engineering model.

Obj (2) To embed related ID models as part of the components of the mGBL engineering model.

Obj (3) To construct a mGBL engineering model based on (1) and (2).

Obj (4) To evaluate the proposed mGBL engineering model through:

a) expert review.

b) prototype development.

c) groups-treatment experimental design.

Obj (5) To test the hypothesis that the proposed mGBL engineering model is significantly applicable.

1.6 Research Questions

This research attempts to answer the following questions:

i) How to engineer a mGBL in a systematic way?

ii) What are the main components of such mGBL engineering model?

iii) Which ID models should be included in the mGBL engineering model?

iv) Is the proposed mGBL engineering model applicable?

1.7 Research Scope and Limitations

The focus of this study is to develop a mGBL engineering model specifically in these limitations:

i) The domain area of this study is in Malaysian environment. Respondents involved and places of study are located in Malaysia except the expert consultation from various countries.

ii) A mGBL prototype is developed based on these criteria:

   a) Subject area of learning content is general knowledge. This is based on the finding of the preliminary study.

   a) The target audience is for lower Malaysian secondary school (age 13 to 15).

   b) The development tool used for prototype development is Flash.

iii) This study concerns on evaluating the applicability of the proposed model as a mGBL development methodology rather than the learning effectiveness of using the mGBL application.

1.8 Contributions of the Study

This study attempts to propose the intended solutions that contribute generally to the body of knowledge which covers game design area as well as instructional design. The specific contributions of this study can be categorized into theoretical, functional, and practical contributions:

1.8.1 mGBL Engineering Model

This study proposes a model which is called a mGBL engineering model. Game and instructional designers would get benefits from this model, in which they can refer to for developing mGBL applications. The model provides comprehensive methodologies and guidelines from the beginning of mGBL application development until testing stages and ready for marketing. There are 3 phases and 12 components with activities and deliverables included in the model for the development of mGBL

applications. The uniqueness of the model lies in the sets of objectives, activities, and deliverables put forward in each phase and component of the model.

1.8.2 A Prototype of mGBL Application

A prototype of mGBL application has been successfully developed following the proposed mGBL engineering model which acts as a functional contribution of this study. Based on the preliminary study, the chosen content for learning in mGBL was general knowledge. Therefore a local content that could promote the concept of 1Malaysia was included in the learning content of the prototype. Game play and storylines of the prototype were also produced based on the chosen learning content. The mGBL prototype with its concept receives recognition and awards at national and international events.

1.8.3 Instrument to Evaluate mGBL Engineering Model

An instrument for evaluating the mGBL engineering model has been developed. In the instrument, eight evaluation dimensions were proposed namely: visibility, flexibility, manageability, clarity, effectiveness, evolutionary, complexity, and compatibility. These dimensions were collected and combined from previous literatures which consider the criteria of a good development methodology. The instrument was validated and found reliable for evaluating the proposed model. This suggests that the instrument could also be adapted in future studies.

1.8.4 Adapted Heuristics Evaluation for mGBL Application

In evaluating the mGBL application, a set of heuristics are adapted from Korhonen and Koivisto (2006) and Koivisto and Korhonen (2006). A new component is added to the heuristics that deals with learning content in mGBL. In particular, the heuristics evaluation consists of four components: game usability, mobility, playability, and learning content. This adapted version of heuristics is purposely

developed to demonstrate the procedures of evaluating any mGBL application before it is finalized for distribution.

1.8.5 Comparative Analyses of Development Models (Game-based learning, instructional design, and mobile game)

In finding out the theoretical foundation related to the study, three comparative analyses were conducted. These analyses compared and explored the available development methodologies and models, particularly in game-based learning, instructional design, and mobile game development models. These models are proposed by several researchers and developers in terms of the phases and steps to be performed. These should provide significant analysis to other researchers and will further provide research basis for future studies.

1.9 Significances of the Study

The aim of this study is to propose mGBL engineering model which includes phases, components, and activities for developing mGBL application (as described in Chapter 4). The proposed model has its unique characteristics as it provides specific guidelines on developing mGBL encompassing various theories and concepts, such as learning theories and approaches, play and game theories, and AI theory. In addition, this study identifies key aspects for consideration in mGBL development such as ID models, learning models, and mobile technical specifications. The proposed model with its related concept could be significantly utilized for future research by academics, future mGBL development by industries, and future instructional development by instructional practitioners. Consequently, this study contributes generally to the body of knowledge which covers game design as well as instructional design area. In this way, the study closes the knowledge gap identified in Section 1.4.1; i.e., methodology to develop mGBL systematically is highly scarce.

This study is also significant because it explores mobile learning through game that has the potential to improve and revolutionize education for the next generations of students and educators. Studies have shown that the “Net Generation” of students are not interested in conventional learning instructions.Thy require interactions with the contents frequently and quickly, and have exceptional visual literacy skills (Oblinger & Oblinger, 2005; Prensky, 2005). These needs are catered for in the proposed model.

Furthermore, the theories, concepts, and methodologies reviewed and utilized in this study (as described in Chapter 2 and 3) are relevant for game industry developers, educators, and fellow researchers. For example, the context of this study within mobile learning and educational game could improve policy and practice within the learning environment in schools or higher education institutions. It relates to teaching and learning in future learning environment particularly ubiquitous learning.

On top of that, this study supplements the pool of current literatures by presenting a research and theoretical framework that could be adopted to examine potential related theories, concepts, and issues for future studies.

1.10 Research and Theoretical Framework

To ensure the study is systematically conducted, the following research and theoretical framework is followed through. The research framework covered in this study followed the five phases which include awareness of problem, suggestion, development, evaluation, and conclusion. In the first phase, research problem and scope were identified by conducting a preliminary study of m-learning preferences. Besides, theories and concepts were also analyzed in the areas of game-based learning models, instructional design models, mobile game development methodologies, play theories, learning theories, and learning approaches. In the

suggestion phase, the reviewed theories and concepts were used as the basis in determining the characteristics of mGBL, indentifying components of mGBL engineering model, and specifying the mGBL learning model. Expert consultations were conducted to identify the flow and cycle, phases and activities, and components of mGBL engineering model. In the development phase, the proposed mGBL engineering model was developed by combining all the related components as previously suggested. The model was then evaluated in a combination of three stages (i.e., expert review, prototyping, and group treatment experimental study). Finally in the conclusion phase, results from the evaluation phase were analyzed, concluded, and reported in publications. Figure 1.2 illustrates the research and theoretical framework.

1.11 Operational Definition of Terms

The following definitions are to clear up and focus on the terms as they pertain to this study.

a) M-Learning

Mobile Learning (m-learning) happens across locations or that takes advantages of learning opportunities offered by portable technologies (mobile phones, smart phones, PDAs, or other handheld devices).

b) Mobile Game

Mobile game is a digital game that is played on mobile phones, smart phones, PDAs, or other handheld devices.

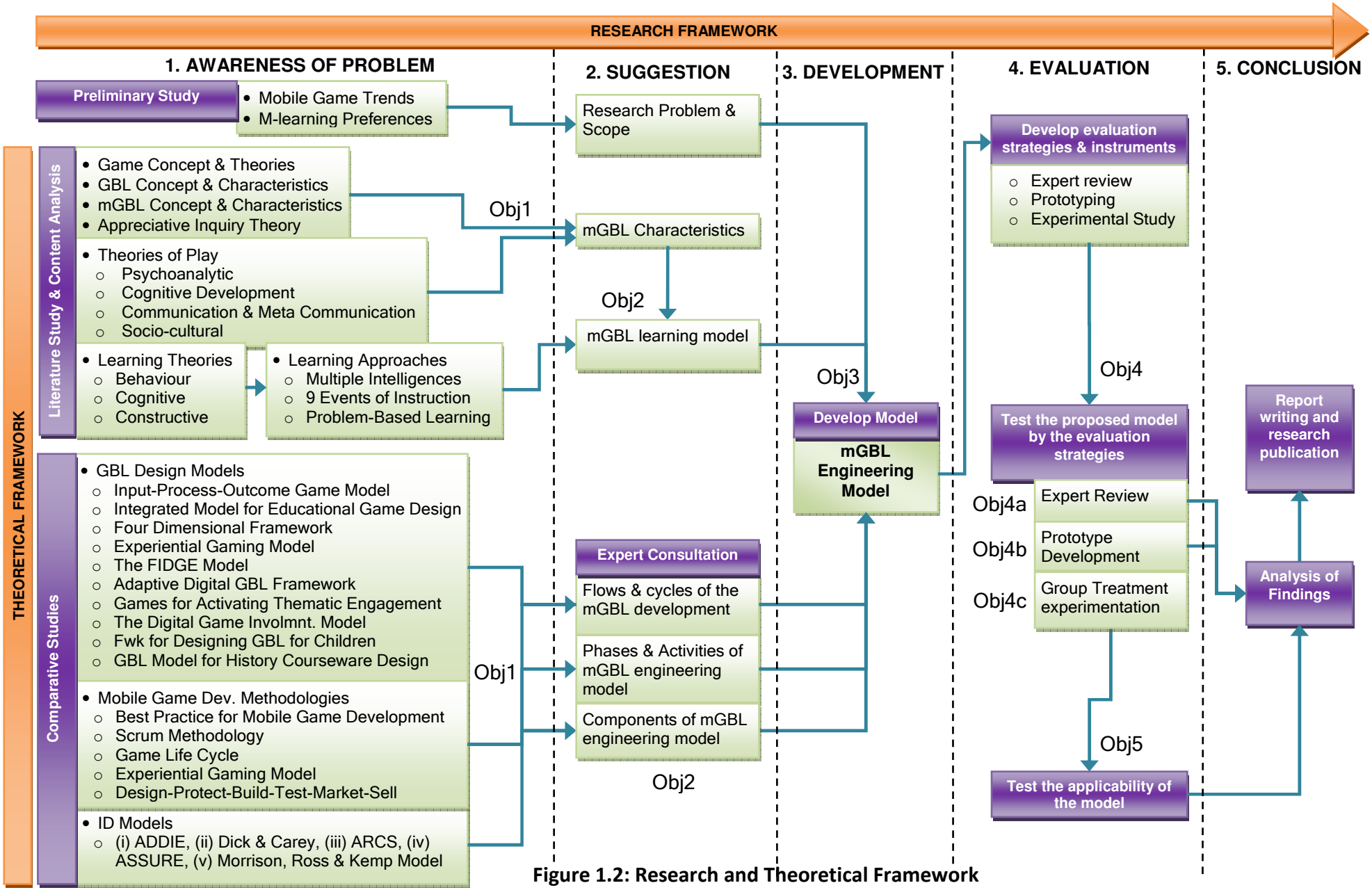


Figure 1.2: Research and Theoretical Framework

c) Digital Game

In Oxford dictionary, a game is defined as an activity engaged in for amusement. Generally, the term “digital game” can be referred to as games played on personal computers, console systems (GameBoy, PlayStation), mobile phones, coins-up machine, portable gaming systems, or web-based system (online, downloadable). In this study, the term “game” is referred to the “digital game”.

d) Applicability

Applicability can be defined as being applicable to the real situation. In this study, the term applicability refers to the ability of the proposed model to be applied and implement at a real situation in developing mGBL.

e) Design Model

As described in Oxford dictionary, a model is a simplified mathematical description of a system or process that is used to assist calculations and predictions. Hevner et al. (2004), and Vaishnavi and Kuechler (2007) define “design model” as a set of propositions which expresses the relationship between components or concept. In this study a design model is defined as a combination of components and processes that makes up a model to design a system.

f) Development Methodology

Hevner et al., (2004), and Vaishnavi and Kuechler (2007) define method as algorithms and practice. While methodology is defined as a set of steps or guidelines used to perform a task. In this study the term “methodology” refers to the steps to develop any application software.

g) Engineering Model

According to Hanh (2002), an engineering model is a schematic drawing as a mechanism that includes all components and data needed to fulfil its purpose. In

this study, “engineering model” is defined as the application of a systematic approach that includes processes and methods to the development of a mGBL. Some researchers use the term “engineering model” interchangeably with “development methodology”. The relationship between the terms “design model”, “development methodology”, and “engineering model” is illustrated in Figure 1.3. Design model is a subset of development methodology and development methodology is a subset of engineering model.

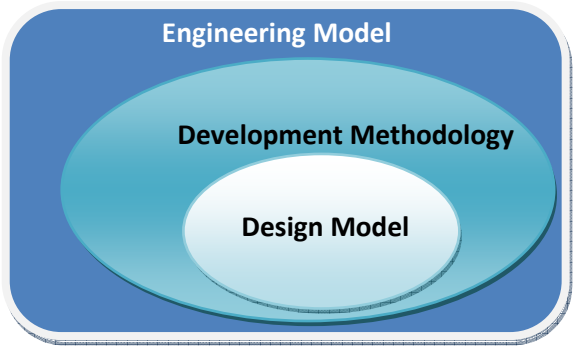


Figure 1.3: Relationship between design model, development methodology, and engineering model

1.12 Thesis Structure

This thesis contains seven chapters in total. This section provides an overview of the contents of each chapter and how it fits into the overall research activities as described in the previous section. The relationship between research activities and thesis chapters can also be seen in Figure 1.4.

The first chapter is the introduction to the thesis, which provides an overview of the research problems and motivations, describes the research questions explored, research objectives formulated, and the research framework followed. This chapter also reports on the preliminary studies conducted in supporting the research problems and objectives. Chapter 2 provides a review of literatures on games and learning, which describes the learning theories, play theories, game theories and

perspectives that have influenced mGBL characteristics. This chapter also provides the background to the thesis and influences for the mGBL design and development. It reviews and analyzes the instructional design models, game-based learning models, and mobile game development methodologies which provide the basis for mGBL development phases and activities.

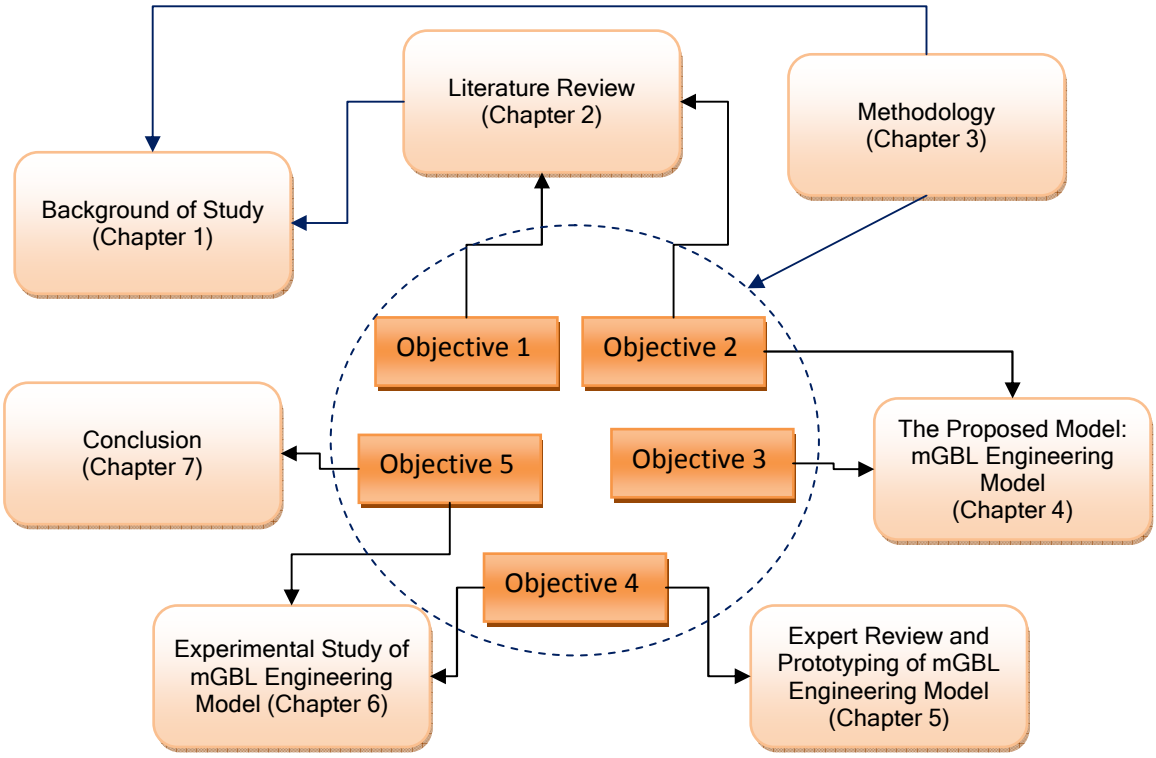


Figure 1.4: Thesis structure based on research objectives

Chapter 3 which comes next, describes the research methodology that underpins this thesis, and provides an overview of the range of research activities used in this study. The chapter discusses the rationale for the range of methods and techniques employed towards achieving the research objectives. Then, Chapter 4 describes the main contribution of this study which proposes a mGBL engineering model. Three phases and twelve components of the model are presented, and a few suggested activities for each component are discussed.

Chapter 5 first discusses the expert review. Then, a prototype development that was undertaken by implementing the proposed model is described. The chapter goes on to describe a strategy to evaluate mGBL using the proposed adapted heuristics evaluation strategy. Four sets of components for the evaluation are presented, with one focusing on the learning content. The other evaluation approaches of mGBL engineering model are described in Chapter 6: Experimental Study of mGBL Engineering Model. This chapter begins by describing the pre-selection review process and the results. In the final section of this chapter, the evaluation of the proposed model through experimental study with the instrument developed is elaborated. The results of the experimental study are then presented.

Finally, Chapter 7 provides some concluding remarks of the thesis by discussing the findings of the study, particularly considering the implications of the mGBL engineering model. This chapter also provides research limitations, summarizes the contribution to knowledge arising from the study, and considers future directions of the study.

CHAPTER 2

Literature Review

2.1 Introduction

This chapter describes the theories and literatures related to this study such as game-based learning, theories of play, theories of learning, learning approaches, and instructional design model. The main focus of this chapter is on the review of the existing literature on development methodologies of mobile game, game-based learning models, and instructional design models. The review discloses the needs for a more comprehensive development methodology on mGBL.

2.2 Game Definition

The common definition of game is an activity that is undertaken for enjoyment. Many researchers have come out with various definitions over game with their own preferences. In this study the term game refers to any digital game.

Prensky (2001) defines game as an organized play that provides the players with enjoyment and pleasure. While, Dempsey et al. (1996) define a game as a set of activities involving players (one or more) which has goals, constraints, payoffs, consequences, rule-guided, and competition aspect. A game makes players to be immersed in the imaginary world of the game (Fabricatore, 2000), and engaged in an artificial conflict, defined by rules, and resulted in a quantifiable outcome (Salen & Zimmerman, 2003). In addition, while playing games, the players can be

motivated via challenges, fantasy and curiosity (Randel et al., 1992). In order to achieve the game goals, the players need to make decisions to manage the game resources (Costikyan, 1994).

Despite the various game definitions, Juul (2003) has analyzed a selection of important game definitions which constitute to six points. A game has i) rules, and ii) outcomes, iii) in which each outcome has different values that motivate, iv) players to achieve outcomes, v) and attached themselves to the outcomes, vi) and always the consequences of the activity are optional and negotiable.

To summarize all definitions, a game is played for enjoyment which has rules, goals, game world, and interactivity. A player needs to make decision based on rules and interacts within the game world in order to achieve the game goals. The characteristics are used throughout this study to represent the sort of the game being studied.

2.3 Game-Based Learning (GBL)

GBL can be defined as a mixture of educational content and computer games (Prensky, 2001). The hybrid incorporation between education and game entertainment make the educational context more interesting to the players. In comparison between game and GBL, Pohl et al. (2008) state that game has no external goal but is played because of fun. In contrast, GBL always has external goal that is to learn something. In addition, Dondlinger (2007) describes that GBL has an added characteristic which is the learning content.

Thus, it can be said that a GBL utilizes the game characteristics in order to allow a player to learn something. The overall GBL characteristics will provide motivation, engagement, learning environment, and feedback to the player.

2.3.1 The Widespread Use and Trends of GBL

The recent generations of students have access to technologies not only computers, but also devices such as digital music and video players, mobile phones, video games, and others. These gadgets can be utilized as learning tools. Van-Eck (2006) found three factors that result in widespread public interest in GBL as learning tools.

i) The first factor is the increasing number of ongoing research on GBL.
ii) The second factor is the growing "Net Generation," or "digital natives," who have become disengaged and not interested with conventional learning instructions. This is because they entail various kinds of information, favour inductive reasoning, need interactions with content frequently and quickly, and have exceptional visual literacy skills (Oblinger & Oblinger, 2005; Prensky, 2005). All these reasons are all matched well with GBL characteristics.
iii) The third factor is the increased popularity of games around the world in various available formats such as computer games, console games, hand-held games, and mobile games.

GBL has become more popular in recent years, and in fact it is recommended that teacher who wants to adapt their learning environment to meet the students' needs, should implement digital games as learning tools (Prensky, 2001). The games can be utilized in a variety of subjects and ways.

2.3.2 Categories of GBL

In examining GBL, there are several approaches to categorize GBL by their differences. These include the differences in game format, platform, devices, content, learning goals, and so forth. The most common means of differentiating GBL is categorizing them by genre.

The vast majority of discussions on categories of GBL focus on game genres. Quinn (2005) explains that genres can be beneficial in understanding differences in games, their types of engagement, and providing templates for game design and development. In relation, Dempsey et al. (1996) organize the GBL by genre: simulation, puzzle, adventure, experimental, motivational, modeling, and others. In contrast, Griffiths (1996, 1999) states that GBL can be broken down into nine categories; sports (e.g. football), racers (e.g. car racing), adventures (fantasy games), puzzlers (e.g. jigsaw puzzle), platformers (e.g. Mario Brothers), platform blasters (similar to platformer but focuses more on action and shooting), beat 'em ups (e.g. Street Fighters), shoot 'em ups (e.g. shooting games), and weird games (other types that do not fit into these categories).

Later, Prensky (2001) also identifies similar game genres, which can overlap: puzzle, simulation, action, strategy, adventure, fighting, role-playing, and sports. Then, Quinn (2005) lists the following game genres: action, fighting, driving or flying, sports, 3D shooter, card or board, strategy, fantasy role playing, adventure, multiplayer, massively multiplayer online role-playing game (MMORPG), and combinations of genres. Bergeron (2006) further lists standard GBL genre: action, adventure, arcade (retro), combat (fighting), driving, first-person shooter, military shooter, multiplayer, puzzle, real-time simulation, role playing game, shooter, simulation, sneaker, sports, strategy, third-person shooter, trivia, and turn-based. However, Kirriemuir and McFarlane (2004) note that every year games come out which do not fit into these genres. Apperley (2006) argues against the current use of genres to classify games. He argues instead for categorizing games by focusing on the type of interaction of the game.

Some other researchers argue that for educational games, it would be more sensible to focus on the learning approaches or outcomes of the game rather than

the game genres. Therefore, the next sub-section previews the characteristics of GBL that have been discussed by a few researchers.

2.3.3 Characteristics of GBL

A few researchers have discussed the characteristics of GBL with their own justifications. Pivec and Dziabenko (2004) suggest eight common main characteristics of GBL which are i) rules, ii) clear and predefined objective, iii) competitive elements, iv) action and instantaneous feedback, and v) challenge. They also put forward the learning opportunities by means of games using the constructivist characteristics such as vi) interaction, vii) coping with problems, and viii) understanding of the whole.

Later, Deubel (2006) proposes that there are a few essential characteristics required for effective GBL such as i) the high level of learning and engagement factors; ii) rules; iii) goals; iv) outcomes of the games are clear; v) provide immediate feedback; and vi) interactive role of students. In addition, Linek (2007) also provides three important aspects of GBL; these are i) storyline and game play within the game, ii) cognitive elements and learning tasks that players want to address to, and iii) motivation of the players. She noted that these three aspects are not separated but rather connected to provide an enjoyable learning platform by using the motivational potential of games. On the other hand, Gee (2005) discusses the GBL characteristics by providing the principles of learning to be embedded in GBL. These principles are clustered into three: empowerment of the learner, problem solving, and process of understanding as outlined in Table 2.1.

Table 2.1: Characteristics of GBL (Gee, 2005)

Cluster	Principles	Description
Empowered learners	Co-design	Learners feel like active agents (producers) and not just passive recipients (consumers). Players should feel that they have their own actions and decisions in the game.
	Customize	Different learners have different learning styles. Learners should be able to choose their own learning style, and try other new styles.
	Identity	Learners adopt a new identity that they value and in which they become heavily invested. Learners can adopt and practice their chosen identity or character and engage in the game for fantasies, desires, and pleasures.
	Manipulation and Distributed knowledge	Learners feel expanded and empowered when they can manipulate powerful tools in intricate ways that extend their area of effectiveness. Player should be able to manipulate the game objects which become tools for carrying out the player's goals.
Problem solving	Well-order problems	The problems learners face early should be well designed to lead them to hypotheses that are successful for the later solution of the next problem. Early problems are designed to lead players to proceed when they face harder problems later on in the game.
	Pleasantly frustrating	Learning works best when new challenges are pleasantly frustrating but within, their range of competence. The games adjust challenges and give feedback in such a way that different players feel the game is challenging but doable.
	Cycles of expertise	Good pacing in learning is constituted through cycles of extended practice, tests of mastery of that practice, then a new challenge, and the new extended practice.
	Information on demand and just-in-time	Learners use information best when it is given 'just-in-time' (when they can put it to use) and 'on demand' (when they need it). Players do not need to read a manual to start, but as a reference. After played a while, the player knows what to do for further playing.
	Fish tanks	When confronted with complex problems, letting the learner see some of the basic variables and how they interact can be a good way into confronting more complex versions of the system later on. In the game, players can use tutorials or play first level or two then they can easily understand the game as a whole system.
	Sandboxes	If learners are put into a situation that feels like the real thing, but with risks and dangers greatly mitigated, they can learn well and still feel a sense of authenticity and accomplishment. Designer cannot expect new players to learn if they feel too much pressure, understand too little, and feel like failures.
	Skills as strategies	Learners learn and practice skills best when they see a set of related skills as a strategy to accomplish goals they want to accomplish.
Understanding	System thinking	Any learning experience is enhanced when we understand how it fits into a larger meaningful whole. This will help players see and understand how each of the elements in the game fit into the overall system of the game and its genre (type).
	Meaning as action image	Most learners learn through experiences they have had and imaginative reconstructions of experience. Games make the meanings of words and concepts clear through experiences the player has and activities the player carries out.

Another key characteristic discussed by researchers is engagement, which can be seen as an important GBL characteristic as determined by Malone (1981). He states that the three key features that create an engaging GBL are challenge, fantasy, and curiosity. Additionally, Jones (1998) argues that the following features are essential to the design of engaging GBL:

i) Task possibly completed.
ii) Task has clear goals.
iii) Task gives instantaneous feedback.
iv) Player has an ability to focus on task.
v) Deep but effortless involvement.
vi) Player has a sense of control over actions.
vii) Concern for self disappears during flow, but sense of self is stronger after flow activity.
viii) Sense of duration of time is altered.

The suggestions of engagement in GBL by Malone (1981), Prensky (2001), and Deubel (2006), Linek (2007) further provides the key features of an engaging GBL, and a group of 12 elements that make GBL engaging has been identified and is exhibited in Table 2.2.

Table 2.2: Elements of engaging in GBL as described by Prensky (2001)

Characteristics of game	**How characteristics contribute to players engagement**
• Fun	• Enjoyment and pleasure
• Play	• Intense and passionate involvement
• Rules	• Structure
• Goals	• Motivation
• Interaction	• Doing
• Outcomes and feedback	• Learning
• Adaptive	• Flow
• Winning	• Ego gratification
• Conflict/ competition/ challenge & opposition	• Adrenaline
• Problem solving	• Sparks creativity
• Interaction	• Social groups
• Representation and a story	• Emotion

All of these GBL characteristics are the core elements that useful in the design and development of GBL for learning environment. The learning environment can be in various platforms and that include mobile learning. GBL that is implemented in mobile learning environment is called as mGBL. The next section describes more about mGBL.

2.4 mGBL

mGBL refers to GBL that utilizes mobile technologies such as mobile phones, PDAs, and other handheld devices for playing platform. Mohamudally (2006) describes that the concerning issues of mGBL are mobility and restrictions on mobile technologies. He further states that the mGBL concepts are grounded in pedagogical theory and are adjusted to the technical capabilities of current standards of mobile phones.

mGBL applications are developed for a broad variety of learning contexts such as role play and multiplayer games (Sanneblad & Holmquist, 2003; Lonsdale et al., 2004; McAlister & Xie, 2005; Mohamudally, 2006). Some mGBL applications focus on collaboration (Sanneblad & Holmquist, 2004; Sanchez et al., 2006); while others are mainly played individually (Krenn et al., 2008; Mitchel et al., 2006).

Mitchel et al. (2006) for example, have proposed the three year pan-European funded project, which prototyped mGBL in three sectors: i) e-health, ii) e-commerce, and iii) career guidance. The project was based on research findings conducted by Mitchell (2003) and Mitchell and Savill-Smith (2004). In addition, other examples of mGBL projects are listed in Table 2.3.

Table 2.3: Example of mGBL Projects

Bellotti et al. (2003)	An ELIOS group at the University of Genoa has introduced Venice Game (VeGame). The game offers a kind of 'electronic treasure hunt' through the narrow streets of Venice. As visitors make their way along a designated 3km track, they are presented with a series of quizzes and riddles on Venetian art and history.
Attewell (2005)	A text messaging quiz game that provides the user learning on how to drive a car, by testing theory based questions. Using text messaging for mobile learning is least popular because the cost of gaming increases with each text message sent to the game server.
Schwabe and Goth (2005)	The mobile game is a prototype of an orientation game in a university setting. Their study revealed a number of design issues including the accuracy of current outdoor and indoor positioning systems, and the game requires near real-time response time. The evaluation of the effects shows that features such as 'map-navigation' and 'hunting and hiding' lead to excitement and fun.
Bogost (2006)	A mobile game named Emergency 112 teaches first aid techniques for medical emergencies. The player takes the role of a good Samaritan who finds pedestrians in trouble then must check the victim's condition and choose an appropriate diagnosis and treatment.
Ardito et al. (2007)	The mobile game supports students to learn history at an archaeological site. The approach uses game-play by helping players to acquire historical notions and making archaeological visits more effective and exciting.
Kam et al. (2007)	English language learning in mobile game has been introduced which gives more accessibility to children in out-of-school settings. The player is required to travel to Kanpur by train to meet a business associate at 4 PM on September 24, 2006. The avatar must not be late, so as not to create a poor impression. Along the way, he will encounter a few situations that require English conversations. Multiple-choice options are provided in the game for possible responses that he can select.
Maniar and Bennett (2007)	The mobile game called C-Shock that reduces culture shock by teaching the player about the specific culture in question. The game is targeted at helping international students cope with 'culture shock' and university life in Britain.
Afzainizam (2008)	The mobile game developed by Afzainizam is 'Think Fast'. It is an educational game that challenges players to solve math questions. The quicker the players answer, they are rewarded with more points. Player should answer the questions correctly within time limit to feed the creature named 'Chopas'. If the answers are wrong, the player will feed another creature named 'Chokoz' who will grow and eat up 'Chopas' and the game will be over.
Miloš et al. (2009)	The mobile game is an adventure game genre where it is more narrative and oriented to problem-solving skills. In this system, knowledge is integrated into adventure game, received in controlled manner during interaction with non playing characters (NPCs). It is a 2D game that requires the player to solve specific quests by moving through the game environment, communicating to NPCs and solving problems.
Mingoville (2010)	The Mingoville Company has launched Kids' English Sudoku game in 2010 for the mobile phone. It only runs on newer mobile phones. It is a great way of practicing English vocabulary and listening skills for kids. In the game, children have to find the right word by listening to the words and pick the one missing in the grid. The game combines text, sounds and images for more fun English learning with different levels.

Bakopoulos and Tsekeridou (2010)	A 3D educational mobile game called 'MobiSpell' is designed and implemented with the aim to teach hard-to-spell words to young children. The educational game features a fighter plane style environment in which spelling is accomplished by shooting down letters. Incentives and motivation such as points and medals encourage learning and motivate children to develop skills.
Botella et al. (2011)	The game which is developed for the treatment of cockroach phobia uses a mobile phone as the application device. Results from the study showed that the use of the mobile game reduced player level of fear and avoidance before a augmented reality session exposure treatment was applied. This study has high interest in clinical psychology for the treatment of specific phobias.

The overall findings of these projects show that mGBL has potentials in promoting and encouraging learning in mobile environment. In addition, these projects also demonstrate the characteristics of mGBL that become part of the characteristics of mobile game. The next sub-section explains the characteristics of mobile game.

2.4.1 Characteristics of Mobile Game

The interesting mobile game feature is their wide reach because mobile phones are the most commonly carried-along personal devices. In contrast to console games that are targeted to youngsters and teenagers, mobile games are more accessible to everyone (Yuan, 2003). Mobile games also shift the paradigm of console games due to the hugely different target user, lifestyle, and distribution strategies.

Yuan has explained that mobile game should be designed by following these characteristics:

i) **Easy to learn.**

Mobile games cannot have steep learning curves since they are targeted for all types of users because they will not spend hours reading the game operation manuals. Therefore, it is important to keep the game simple.

ii) **Rich social interactions**.

Mobile games quickly become uninteresting when the player discovers the game pattern or has exhausted all the play activities. To solve this, the mobile

game (especially subscription-based) can be played with other players to increase the intelligence and randomness of the game play.

iii) **Interruptible**.

Mobile phone users often have little free time available between tasks (e.g., while waiting for a bus or taxi). The same mobile device is also used for games, messaging, picture taking, and data access. Therefore, a good mobile game should allow users to switch smoothly between tasks and provide entertainment values for short time periods.

iv) **Subscription based**.

Mobile game revenue depends on their large distribution. It is indeed expensive to design and develop each game from scratch. Thus it is significant to offer different titles from the same game engine along similar basic storylines. Subscription-based mobile games are the best way to generate sustainable revenues.

v) **Take advantage of mobile innovations**.

Good mobile games should take advantage of the enhanced mobile technologies and services such as Global Positioning System (GPS) extensions and Short Message Service (SMS)/ Multimedia Message Service (MMS) messaging.

vi) **Non-explicit content**.

Since all range of ages and gender play mobile games and often in public or work settings, explicit violent or sexual content must be avoided.

Although these are the characteristics of mobile games, they are also ought to be applicable in mGBL since mobile game uses the same platform, which is a mobile platform. Next, the salient features of mGBL are described.

2.4.2 Characteristics of mGBL

In addition to the characteristics mentioned in section 2.4.1, mGBL has some added features. As suggested by Trifonova (2003), specifically for mGBL, using the concept of mobile learning should have the characteristics in the following list for effective learning:

i) **Short, not more than 5-10 minutes long module.**

The players should be able to use their short waiting time for learning, like doing quizzes, reading small pieces of data, or using forums or chat.

ii) **Simple, funny, and added value functionality.**

The limitation properties of mobile devices make it complicated to use complex and multimedia content. Players should be able to use the learning system without having to read any user manual.

iii) **Area/domain specific content, delivered just in time or place.**

The mobility capability should be able to guide and support students and teachers in new learning situations whenever and wherever it is necessary. The dependency of the content can be relative to location context (i.e. based on learner location), temporal context (i.e. based on time), behavioural context (i.e. based on learner behaviour) and interest specific context (i.e. based on leaner's preferences).

Mitchel (2006) further adapted the characteristics defined by Trifonova (2003) and suggested that mGBL should have the following characteristics:

i) Self-explaining.

Learning applications should be self-explaining and support a playful way of learning.

ii) Small units of learning contents.

The learning contents should split into small units which require only a reduced span of attention so that game play and learning can take place during pauses.

iii) **Available any time.**

The learning contents should be available any time, and the games should be integrated in the situational and local context of the learner.

Apart from that, Krenn et al. (2008) also summarize these criteria of mGBL that players comment from their assessments:

i) **Design elements and functionality of the user interface.**

The critical issues are font size and readability, the distribution of text and supporting pictures over the screen. These elements need to be carefully designed to meet user's expectation.

ii) **Story line and appropriateness of system feedback to the user.**

The mGBL should provide the expected feedback and good responses in coherent way.

iii) **Interplay of game software and device capabilities.**

Loading mode of the game should not be too long because a player will mainly get irritated and the response time of user interface should be synchronized.

Earlier, Thomas et al. (2003) present five principles that have been identified as being principally appropriate to the development of mGBL. The principles are:

i) **Adaptation.**

mGBL should be adaptive for supporting learner preferences in different access pathways. It also allows the learner to search relevant information while playing and feeling immersed in the game.

ii) **Challenge and mastery.**

Players have different skill levels to play games. Hence, mGBL should be designed to accommodate the various of learner skills while still keeping them challenged. To achieve this, a series of play testing on both skilled and unskilled players can be done, and based on the result; games can be made easier or harder.

iii) **Goals.**

mGBL goals need to be presented early, clearly stated, and should be meaningful, obvious, and easily generated.

iv) **Community and collaboration.**

Games in mobile devices offer community and collaboration practices. Through mobile platform, cooperative learning environments are suggested because they are found to promote positive interdependence amongst learners.

v) **Context.**

mGBL needs to include the learner's environment into the game play experience. In mobility context, the users' contexts, such as location, people, and objects around them are more dynamic.

The principles and characteristics of mGBL presented in this section provide a conceptual overview of what could become a good practice to the development of mGBL. The next section discusses another key mGBL element that needs to be an integral part of the mGBL development process, which are learning theories.

2.5 Learning Theories in mGBL

Learning theory was introduced to explain how people obtain knowledge, skills, and attitudes and implementing the learning theory in educational programme to improve the learning process (Newby et al., 2006). Today in the technology era, educational tools aligned with learning theories are used in educational programme to support the learning process. When tools are associated with learning, it is unfeasible to ignore the learning theories. Therefore, the dominant learning theories that shape the learning landscape through mGBL are discussed in this section. There are various different theories of learning. These available theories are useful to consider their applications in learning environment. Some theories focus on ways to describe and control observations, behaviours, and events of learning. Others attempt to describe the frameworks of learning such as the nature

of attention, the way memories are formed, and the way learners process and give meaning to knowledge. Learning theories are likely to fall into several main paradigms, including behaviourism, cognitivism, and constructivism.

2.5.1 Behaviourism

Kang (2004) describes that behaviourism theory started in the early of the 20th century and the proponents are Bandura, Watson, Skinner, and Pavlov. It is a paradigm that assumes all learners are passive and responding to environmental stimulus (Skinner, 1938; Kettanurak et al., 2001). The learner starts with knowing nothing and then shaping appropriate behaviour through reinforcements (positive or negative). Both positive and negative reinforcements increase the probability that the antecedent behaviour will happen again. On the contrary, punishment decreases the likelihood that the antecedent behaviour will happen again. Hence, this theory describes that learning happens when a correct response is demonstrated.

The strength of this theory can be observed when the learners are focused on a clear goal. With the clear goal, they can respond automatically to the cue of that goal. The cue acts as a signal to the learners for performing the intended behavior with reward availability (Seifert, 2011). Therefore, cues are important to the learners in assisting them to give correct responses and enhancing learning by improving their attention, comprehension, and retention (Weinstein & Underwood, 1985). In classrooms, cues are sometimes provided by the educator or established routines in the class. As an example, asking on a student to answer can be a cue, where if the student answers correctly at that moment, then the student may be reinforced with praise or acknowledgement. However if that cue does not occur where the student is not called on, then the answer may not be rewarded.

In general, two types of cue commonly practiced by educators are verbal and non-verbal cues (Landin, 1994). A verbal cue consists of a word, phrase, or sentence that describes a particular aspect of a concept or skill. Verbal cue is widely used because it is a common way to communicate, and more information may be expressed verbally (Hirumi, 2002). On the other hand, non-verbal cue such as visual and kinesthetic cues are helpful to all learners for the variety of learning and appropriate when visual cues have limited value.

In a conventional learning environment, this theory is applied where the concentration is on the lower level of skill or knowledge, and the responses given by students after learning has been conducted (Driscoll, 2002). This theory can be applied successfully when the learning environment supports the good and immediate responses (Kettanurak et al., 2001). On the other hand, the weakness point of the theory occurs when the learners may discover themselves in a situation where the correct response does not occur, the learners cannot give respond.

In relation to mGBL, this theory can be applied by concentrating on the specific learning objectives and instructions of the mGBL, giving excellent controls to the player while playing, and providing good feedbacks from the mGBL itself as explained by Newby et al. (2006).

2.5.2 Cognitivism

The revolution of cognitivism has replaced the behaviourism in the 1960s as the leading paradigm because it can solve the weakness of behaviourism (Kang, 2004). The focus of cognitivism is on the inner mental activities of the human mind because it is precious and necessary for understanding how people learn (Kettanurak et al., 2001). Mental activities such as thinking, knowing, memory, and problem-solving are focused in this theory which creates the knowledge. Kang (2004) further describes that the cognitive process is the main focus for learning

resources. It is different than the behaviourism by stressing that learning is a change of knowledge state and not only the change of behaviour.

Cognitive theory was influenced from the development of computer technology and used a computer as a model of how human thinks (Driscoll, 2002; Newby et al., 2006) which refers to information processing. Broadly, cognitive theory which is based from Bruner (1960) suggests that learning should follow the individual cognitive development. The different types of cognitive level are introduced from the curriculum model which will help the learner revisits, extends, and deepens their knowledge, understanding, and skills (Bruner, 1960).

The strength of this theory is that learners are trained to do a task in similar way to allow consistency. This will make the learners solve a problem using their own possible solution. However, the weakness occurs when the learners are able to accomplish a task, but not through the best suited way to the learners.

To relate this theory with mGBL development, a few aspects can be considered such as providing organized learning contents, offering learning levels from easy to hard, incorporating appropriately helpful screen design, and supplying different game resources. These characteristics will make the mGBL meaningful to players.

2.5.3 Constructivism

In constructivism, learning is seen as an active process of constructing knowledge rather than acquiring it (Kettanurak et al., 2001). Knowledge is created based on learner experiences and interactions. Learners actively construct or create their own understanding by assembling knowledge from different sources appropriate to the problem at hand (Newby et al., 2006). Therefore, the new information is gathered by linking to prior knowledge and experiences.

Constructive theory is the main contributor toward the successful learning process in 1990s (Kang, 2004). This theory focuses on the learners rather than instructors. Individual learner is unique and has own capability of learning. He is encouraged to show his skills and potential useful for him in learning environment. Vygotsky's social development theory is one of the foundations for constructivism (Kettanurak et al., 2001, Newby et al., 2006). The social development theory stresses the interaction of interpersonal (social), cultural-historical, and individual factors are the keys to human development (Kettanurak et al., 2001).

The advantage of this theory is obvious when the learner is able to understand various realities, and then he is able to deal better with real life situations. If a learner can solve problems, he may apply his existing knowledge better to other situations (Schuman, 1996). On the other hand, in a situation where agreement is essential, different thinking and action of different people may cause problems especially when the situation needs only the right and exact decision (Schuman, 1996).

This theory impacts mGBL development in terms of providing good game play such as different game levels, complex learning content, and non-linear game environment. These characteristics allow players to explore the learning content in the mGBL while playing.

To summarize, the behaviourism learning theory led to the introduction of the cognitive learning paradigm. Soon, however, theorists realized that, other factors should also be considered and this led to the constructive approach being explored. Actually, constructivism is based upon behaviourism and cognitivism in the sense that it accepts multiple perspectives (Schuman, 1996). Table 2.4 summarizes the three dominant learning paradigms.

Table 2.4: Summary of Learning Theories

Aspects	Learning Theories		
	Behaviourism	**Cognitivism**	**Constructivism**
Proponents	Bandura, Pavlov, Skinner, & Thorndike	George Miller & Gagne	Dewey, Piaget, Bruner, & Vygotsky
Philosophy	• Learning occurs when new behaviours or changes in behaviours are acquired as the result of an individual's response to stimuli. • The influence of the external environment contributes to the shaping of the individual's behaviour.	• Learning is a change in knowledge stored in memory. • Process of selecting information • (Attention), translating information (Encoding), and recalling that information when appropriate (Retrieval).	• Learning is the process where individuals construct new ideas or concepts based on prior knowledge and/or experience. • Individuals construct knowledge by working to solve realistic problems, usually in collaboration with others.

Further description on the implication of learning theories to the study is described in the next section.

2.5.4 Implications of Learning Theories to the Study

Developing instructional tools requires specific elements which include learning theories and instructional design model. The designers are required to embed the learning theories into the design and adopt the instructional design model during the development of instructional tools.

Table 2.5 summarizes the characteristics of mGBL which are based on the three paradigms. It explains that the characteristics in the learning theories can be absorbed into the mGBL. In behaviourism stance, it stresses the reinforcement and control to the learner by providing good feedback from the system. In cognitivism perspective, the system should facilitate the support of transferring, remembering, and recalling knowledge in learner's memory. From constructivism approach, the

learner should be given opportunities to explore and acquire knowledge that they want.

Table 2.5: Learning theories for mGBL characteristics

Aspects	Learning Theories		
	Behaviourism	**Cognitivism**	**Constructivism**
Characteristics for mGBL	• State objectives and break them down into steps. • Provide hints or cues that guide players to the desired behaviour. • Use consequences to reinforce the desired behaviour. • Provide good system feedback and response.	• Organize new information. • Link new information to the existing knowledge. • Use techniques to guide and support learners' attention, encoding, and retrieval process. • Provide good screen design and navigation. • Supply variety of game resources for options. • Provide adventure storylines.	• Pose good problems - realistically complex and personally meaningful. • Create group learning activities. • Model and guide the knowledge construction process. • Offer various game levels • Offer great game play and challenges
Advantages (Egenfeldt-Nielson, 2006)	• Behaviourism provides the concept of repetition and reward. • The player practices in a game through repetition while receiving rewards after each proper response.	• Cognitivism attempts to build intrinsic motivation by integrating learning and game experience. • Player engages in a discovery process through a game experience that integrates learning and play akin to the limitations and potentials of the human mind.	• Constructivism provides game challenges that offer player to solve problem in the game environment. • The challenges can be solved through player's experiences in previous game level/ level.

Another important implication of learning theories to mGBL is the learning model. The learning model that suits mGBL approach is the experiential learning theory as described in the next section.

2.5.5 Experiential Learning Theory

Experiential learning theory is based on constructivism paradigm. Experiential learning has been proposed by Kolb (1984) and referred from works of Dewey, Piaget, and Lewin (Nielsen-Englyst, 2003).

It is an activity oriented approach that depends on the learner's active participation in the learning process (Kolb, 1984; Kiili, 2005). Learner involves in an activity then needs to reflect and evaluate the activity by determining the usefulness of the activity. Through this activity, leaner gains experience that provides preparation for future situations. In the experience, learner extracts and learns meaningful, relevant, and essential knowledge and skills that can be transferred and used in daily activities (Gentry & McGinnis, 2007). Figure 2.1 shows the sequences in the experiential learning which consist of five stages that start with experience stage followed by share, process, generalize, and finally apply stage. These sequential stages are derived from three main concepts: do, reflect, and apply.

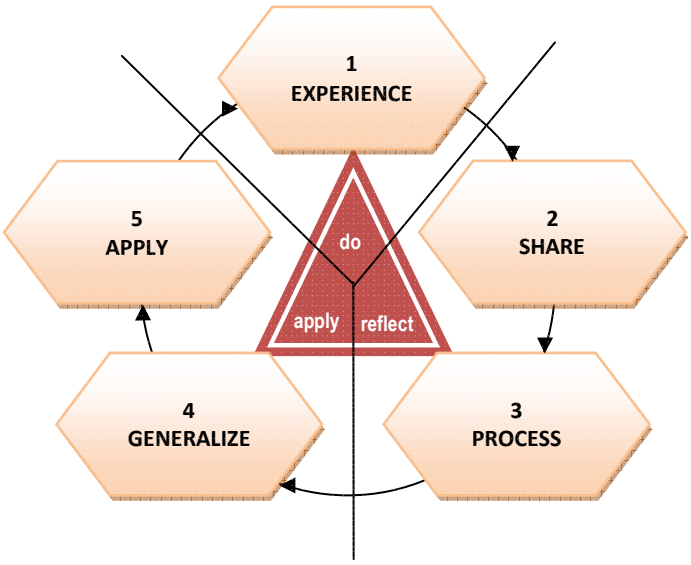


Figure 2.1: Experiential learning stages (Kolb, 1984)

Learning acquired by learners through the five stages in the experiential learning is called as an experience process. Each stage needs to be followed to create a total learning experience. The steps are as follow:

i) **Experience**

This is an early stage in the cycle in which the activities are conducted for the learning process.

ii) **Share**

After learners have experienced an activity they can share or give what they have observed and how they perceived about the experience.

iii) **Process**

This is the essential step in the experiential learning cycle where learners process the experience in a meaningful way for future situations.

iv) **Generalize**

In this stage, learners make connection between their experiences to similar or different situations in the real world.

v) **Apply**

In this final stage, the learners apply what they have gained into the actual situations in which they are involved in the real world.

The experiential learning theory is found to be suitable to use as a learning model for mGBL. This is based on several reasons, particularly the theory:

i) Is applied in accordance with the game because the players will be doing activities (challenges) to seek knowledge through the concept of exploration in a game environment.

ii) Makes the learning process exciting, challenging, and relevant thus applicable to other situations in daily activities.

iii) Provides opportunities for the players to take on challenges and step out of their comfort zones in a game environment.

iv) Builds transferable experiences and skills gained in the game that are valuable in real life situations.

v) Provides player's with concrete experiences that can simulate (in a game) to the real situations.

Therefore, the learning model of mGBL that is adapted from experiential learning theory is produced and is illustrated in Figure 2.2. The flow of the mGBL learning

model is begin when learner starts to play in the mGBL environment. Then he starts to solve tasks or challenges based on the learning objectives and content. After that, he gains knowledge and experience from it, and later he looks at the experience gained and begins to analyze and reflect the knowledge and the outcomes. Based on the experience gained, the learner makes connections between these experiences with the current situation. Finally, he will practice and apply knowledge acquired previously in the real world.

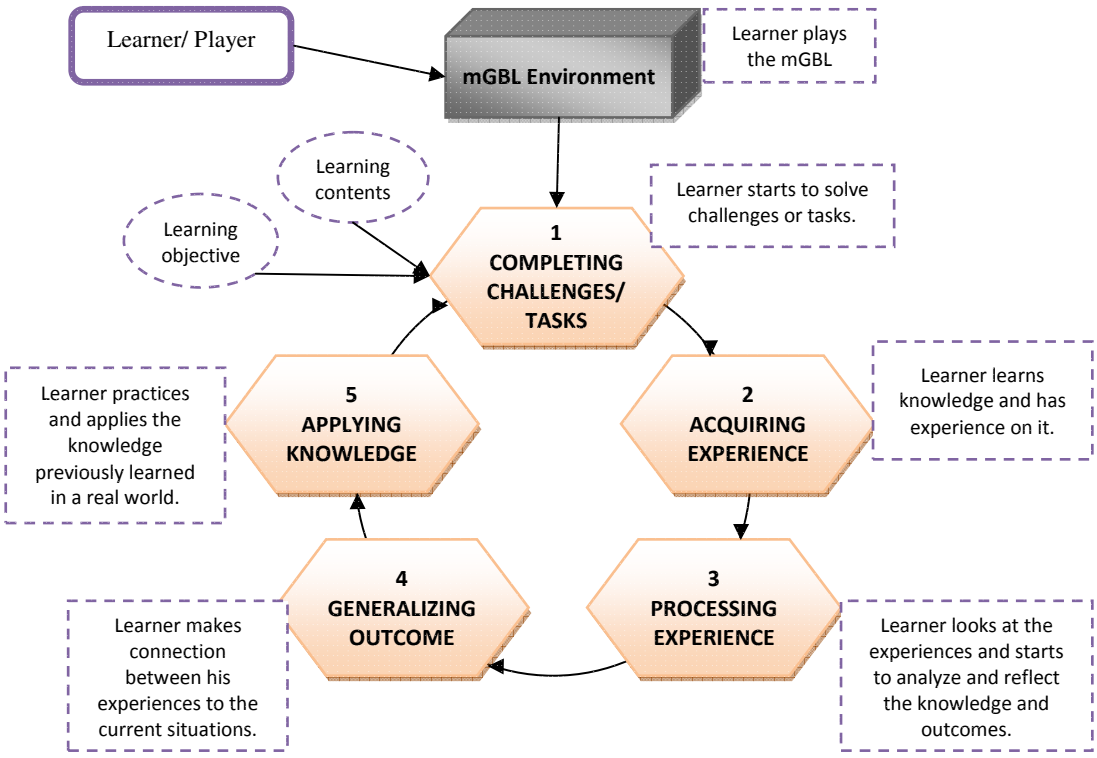


Figure 2.2: Learning model of mGBL using the experiential learning theory (Kolb, 1984)

In addition to learning theories and learning model, other aspects that are considered relevant to mGBL development are learning approaches as described in the next section.

2.6 Learning Approaches

Various learning approaches have been discussed in available literatures and these approaches underlie from the three basic paradigms discussed in the previous section; behaviour, cognitive and constructive. Multiple Intelligence theory (Gardner 1983; 1993; 2000), Nine Events of Instructions (Gagne, 1985; Gagne et al., 1992), and problem-based learning are seen to be more of interest to this study and have been applied to many learning environments (Becker, 2006b). These theories are discussed in relation to the mGBL in this section.

2.6.1 Multiple Intelligences

Gardner (1983, 1993, 2000) pioneered the Multiple Intelligences theory to account a broader range of human ability. Generally, this theory provides nine potential pathways to learning. It is believed that individuals will naturally learn best under one or more of their intelligences. Therefore, the learning systems should be most effective if different intelligences are incorporated into the learning environment.

In general, the theory of Multiple Intelligences gives impact to the learning in three aspects (Gardner, 2000): (i) curriculum is suggested to incorporate these intelligences such as arts, self-awareness, communication, and physical education; (ii) instructional methods should appeal to all the intelligences, such as role playing, musical performance, cooperative learning, reflection, visualization, and storytelling; and (iii) assessment of learning should measure and consider the multiple forms of intelligence.

The nine intelligences are as follows: i) linguistic intelligence (the ability to master languages- spoken and written), ii) logical-mathematical intelligence (the capacity to analyze problems logically and scientifically), iii) interpersonal intelligence (the ability to understand and relate to other people), iv) intrapersonal intelligence (the

capacity for understanding oneself), v) spatial intelligence (the ability to know and react to the space), vi) bodily-kinesthetic intelligence (the capacity for moving around using own body), vii) musical intelligence (skill in the performance, composition, and appreciation of music), viii) naturalist (think through nature and natural forms), and ix) existential (sensitivity to complex issues surrounding our existence, and developed skills in pondering deep questions). Each of the intelligences can be considered in combination as mGBL content. Chapter 4 details these examples.

Examples of works using the Multiple Intelligence theory are conducted by Cai, Liu, and Liang (2010), and Mingzhang et al. (2007). Cai, Liu, and Liang (2010) proposed a design model for education game to teach Chinese as a foreign language. The design model applied the Multiple Intelligence theory, using a gaming concept in the learning environment. The successful development of the game not only allows players to complete various tasks in the virtual situations to achieve the educational purpose of learning Chinese language and culture, but also provides some references for the future development of similar games.

Similarly, Mingzhang et al. (2007) also utilized Multiple Intelligence theory in designing a role-playing game for learning. Their work has analyzed the education superiority of role playing game-learning, and discussed its design flow from the perspective of multi-dimensional intelligence theory. The combination of the design flow, characteristics of role-playing game, and education game environment make the project usable in promoting the use of Multiple Intelligence.

Although not all intelligences can be applied in a mGBL at a time, at least few are applicable. In fact, mGBL can make players so engaged by addressing these types of intelligences, where each player has equal opportunity to take advantage of his/her own particular strengths (Becker, 2006b).

2.6.2 Nine Events of Instructions

Gagne (1985) has published a book that identifies the mental conditions for learning. In consequences, Gagne et al. (1992) created a nine-step process called the nine events of instruction, which correlates to and addresses the conditions of learning. The Nine Events of Instructions are useful for instructional designer to develop an effective learning system. These events include: i) gain attention, ii) inform learners of objectives, iii) stimulate recall of prior learning, iv) present the content, v) provide "learning guidance", vi) elicit performance (practice), vii) provide feedback, viii) assess performance, and ix) enhance retention and transfer. Chapter 4 shows brief descriptions of the Nine Events of Instructions which can be associated with mGBL.

In conjunction, a project conducted by Matsuda (2008) utilized the Nine Events of Instructions. He proposed a training system to improve teachers' professional competence through mathematical thinking and problem solving processes. The system provides a platform for the execution of several game boards, which were designed to achieve different objectives for different conditions of teaching.

Another example is an augmented reality game used in mobile learning which was proposed by Fotouhi-Ghazvini et al. (2009). The game adds a real sense of learning to mobile games by providing models of the real world settings for learners. By using the paradigm of Nine Events of Instructions, educators can effectively incorporate the proposed games into their learning environment. The project was successful because the learning objectives are integrated into the game rules, story, and different levels of the proposed game.

2.6.3 Problem-Based Learning

Problem-based learning (PBL) originates from medical education and now it has been widely used in various disciplines at a variety of educational levels. PBL is a learning approach in which students are dealt with a problem and challenged to find the solution (Barrows, 1996). The advantages of PBL include, it emphasizes on solving complex problems in rich contexts and promotes the higher-order thinking skills (Savery & Duffy, 1995). It also requires students to take active, task-oriented, and self-directed approaches into their learning activities. Further, PBL encourages students to involve in team work and practice their communication skills. More importantly, it gives students the problem-solving skills, critical, analytical, and creative thinking skills, as well as individual research skills (Wood, 2003).

According to Barrows (1996), PBL approach caters for student-centred learning and is related to constructive approach. He also provides the characteristics of PBL which include: (i) learning is student-centred; (ii) focus of learning through authentic problems; (iii) new information is obtained through self-directed learning; (iv) learning occurs in small groups; and (iv) teachers are facilitators. In addition, two fundamental principles underlying PBL are: (i) PBL is directly related to constructivist ideas of teaching and learning (Pearson, 2006), and (ii) PBL is promoting learning through social process.

To implement PBL in learning environment, Merrill (2002) states that PBL is based upon resolving problems that are encountered in everyday life. As Merrill explains, in the PBL practice, students will be guided by the instructor at the early stages, and later, as students gain expertise and become more confident, this guidance is gradually faded. PBL seems to be more effective if students are first introduced to simpler problems, and then gradually to more complex problems, in the mean time other learning elements are gradually added to make them more realistic (Merrill, 2002).

In relating PBL approach to mGBL design and development, few aspects are analyzed based on mGBL characteristics and features. The analysis (Figure 2.3) indicates that there are few aspects of PBL environments that may be utilized to enrich mGBL elements:

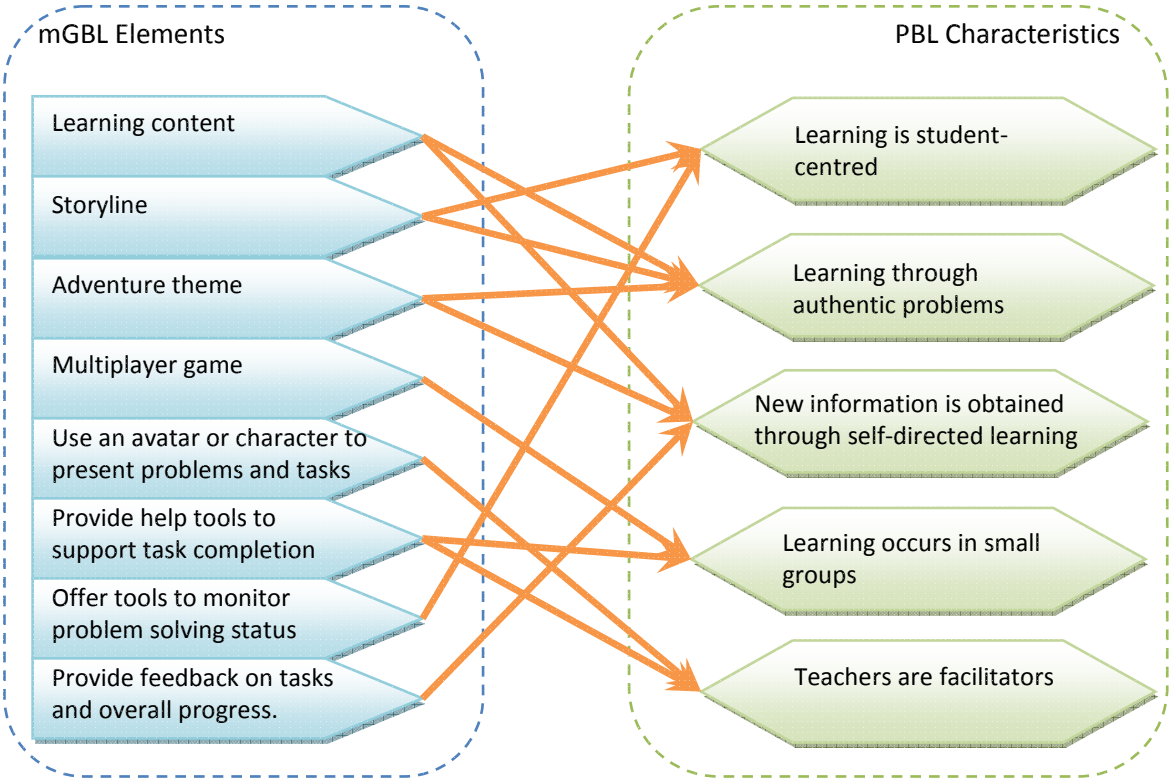


Figure 2.3: mGBL elements mapped with PBL characteristics

Another theory that should be considered in mGBL is appreciative inquiry theory which is described in the next section.

2.7 Appreciative Inquiry Theory

Appreciative Inquiry (AI) has been developed by David Cooperrider in the 1980s. In general, this theory makes people notice the truth and the kindness by carrying out research activities and towards the discovery of what works rather than what does not work (Cooperrider, 1990; Cooperrider et al., 2003). AI comes from two words: appreciate, which is to value or to recognize with gratitude, and inquiry, which is defined as to seek or to understand through asking questions.

AI can be implemented in various fields to seek and understand what is needed including teaching and learning environments. This theory is also closely related to software development as it provides four phases. Each phase is given a name beginning with 'D' and the model is known as 4-D model (Figure 2.4):

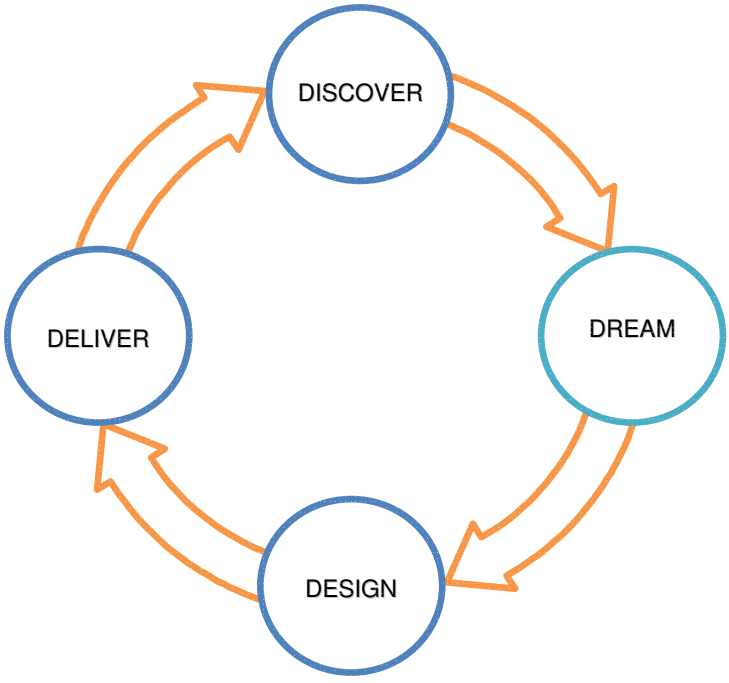


Figure 2.4: Appreciative inquiry stages of 4-D model (Cooperrider et al., 2003)

The following briefly outlines the four phases of the model:

2.7.1 Discover

This stage leads opportunities to discover the positive issues and people attitudes in the environments that will bring significant values into life. Therefore each and everyone will start to appreciate themselves and their colleagues. In relating to game development, discover stage will put activities that find out and notice new potentials and possibilities of team member's skills, game requirements, and project planning.

2.7.2 Dream

The dream stage encourages people to imagine and co-create the future. They are encouraged to envision organization for better achievement and what can be done next. Creativity is needed at this stage where the rest of the team members will work on further. For game development perspective, in dream stage, designers can dream on how they want their own games to be. All ideas are sketched or noted down and dreams on papers. Designers are encouraged to be bold and risk-taking in their imaginations.

2.7.3 Design

In design stage, the main objective is to deliver the dream as imagined at the earlier stage. This can be done in small groups of people to explore particular design elements which are then shared with the large group and further refined. As for design stage in game development, designers start to develop game based on the dreams and desires they had generated earlier. During this stage, the real development of the game is conducted using particular tools such as Flash.

2.7.4 Destiny/ Deliver

The final phase is to deliver the dream and the new design. The term 'deliver' can be interchangeably with the term 'Destiny'. Whichever term is used, the final phase consists of experimentation and improvisation. In game development, the destiny stage is where the final product is completed. The product should go through a systematic testing procedure to make sure it is playable and contains no error before it is delivered to the market.

AI theory is seen closely related to mGBL development phases based on the 4-D stages: discover, dream, design, and deliver. Figure 2.5 indicates the AI 4-D stages that are related to mGBL development phases.

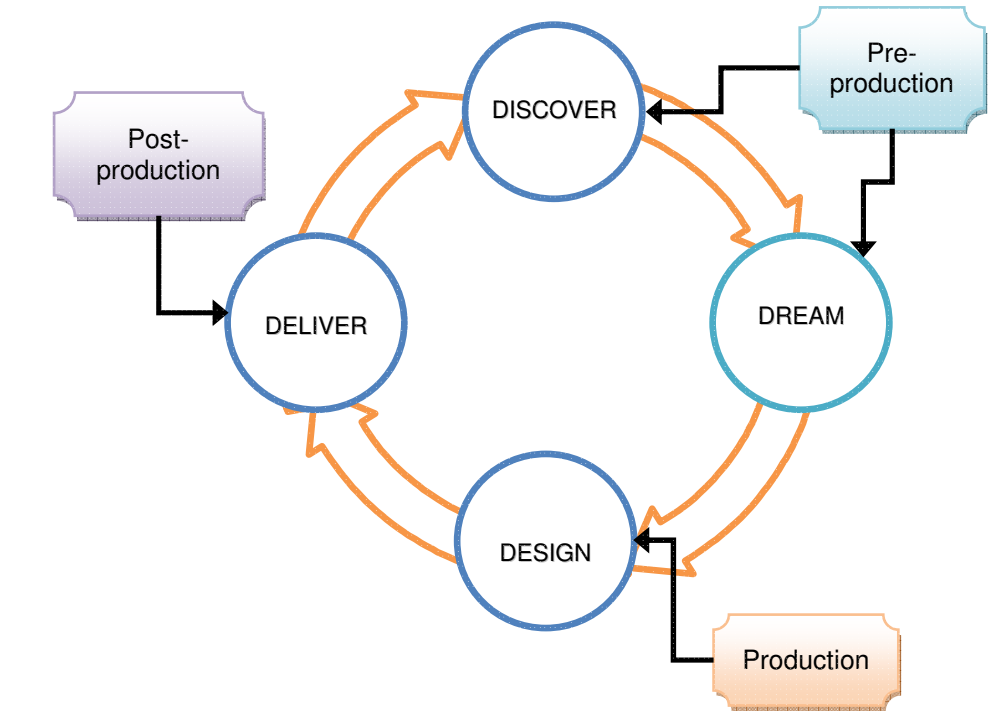


Figure 2.5: AI stages interrelated to mGBL development phases

2.8 Game Theory

The field of game theory was first introduced in 1944 by von Neumann and Morgenstern in their book titled “Theory of Games and Economic Behaviour” (Auman, 1987). Since then, this theory was developed extensively and has been widely recognized as an important tool in many fields (Auman, 1987).

Game theory cannot be interpreted into a single field but is used in social sciences, political sciences, computer sciences, economics, biology, engineering, philosophy, and many others (Aumann, 1987). The game theory attempts to provide a situation related to strategic decision in which people makes right decisions to succeed. The situation in the game theory is a competition while people are players (Ross, 2009).

The players are assumed rational who have the ability to (i) assess outcomes; (ii) calculate paths to outcomes; and (iii) choose actions that yield their most-preferred outcomes (Ross, 2009). In addition, each game player heads an option of possible strategies (two or more). Further, a strategy is described as a predetermined ‘programme of play’ that allows the players to take actions in response to every possible tactic other players might use.

To summarize, in the context of mGBL, a few terms that the game theory contributes directly to the mGBL include:

i) Player is the learner that plays mGBL application.
ii) Outcome is the mGBL goal (or learning objective) that the player needs to achieve.
iii) Choice is the option that the player can choose within the game environment towards achieving the game goal. It can also be described as a game strategy.
iv) Programme of play is the game rules that the player needs to follow through.

2.9 Theory of Play

Play is an activity that people participate in to explore and interact with the environment (Verenikina et al., 2003). In a game, the activity is considered as a major component which contributes to the enjoyment and fun. In children's context, Verenikina et al. (2003) define play as an activity that is enjoyable and spontaneous; yet supports their psychological development. The activities in play are fundamentally motivated because usually players have certain internal desires, curiosities and interests to engage in play.

The most important aspect is the benefits of play. Through play, a number of skills especially among children can be developed. The benefits of play below are summarized based on Moyles (1989; 2005) and Singer et al. (2006) as follows:

i) **Fine and gross motor skills**.

   Through physical challenges, help players to develop their physical and motor skills.

ii) **Sensory knowledge**.

   Players can practice their senses including sight, hearing, taste, touch, and exploration of space.

iii) **Exploration of different roles**.

   Players act differently in different situations in their play environments.

iv) **Development of social skills**.

   The skills such as cooperation, sharing, turn-taking, conflict resolution, and leadership can be developed.

v) **Development of cognitive skills**.

   Cognitive skills are important and players can develop the skills through playing creative and abstract thinking, exercising imagination, solving problems, socializing cognition, and mastering new concepts.

vi) **Development of language skills**.

Play can also improve players' communication skills, vocabulary, storytelling and literacy.

vii) **Affective or emotional development**.

In affective domain, some skills players could be potentially developing include self-confidence, self-esteem, anxiety reduction, and self-expression. Other important feelings are enjoyment, fun, relaxation, and tension reduction.

Besides, play also provides a medium for learning. Besides the above-mentioned benefits, the learning method through play gives the opportunities to practice, choose, imitate, imagine, gain confidence, and persevere (Moyles, 1989; 2005). In addition Singer et al. (2006) state that through play, the benefits of learning are offered by:

i) providing a meaningful context for children to learn concepts and skills;
ii) making learning fun and enjoyable;
iii) encouraging children to explore and discover together and on their own;
iv) allowing children to extend what they are learning;
v) encouraging children to experiment and take risks;
vi) providing opportunities for collaborative learning with adults and peers; and
vii) allowing for the practice of skills.

The benefits are listed in the above paragraph supported by the theoretical perspectives of play. There are various theories of play and the most remarkable would be Piaget, Vygotsky, and Bateson. The theories of play are identified effecting to children's wellbeing and advance their cognitive, social, and emotional development (Verenikina, 2003). Amongst theories of play related to this study are outlined in Table 2.6 as reviewed by Verenikina (2003). She has reviewed the theoretical approaches to child's play and also outlined the characteristics of play essential for the development of young children in relation to computer games.

Johnson et al. (2005) state that knowing the theories about play is important so that appropriate responses to children's play behavior could be respectively shaped.

Table 2.6: Theories of Play (Verenikina, 2003)

Theories	Descriptions
Psychoanalytic Theory (Freud, 1968; Freud, 1959; Erikson, 1963)	• This theory states that play will reduce anxiety to the children by giving them a sense of control over their world. The control is an acceptable way to express the forbidden impulses. • In interacting in a game world, players are allowed to have a sense of control over the game events that they could not control in their real lives, such as traumatic experiences and conflicts.
Cognitive Theory (Piaget, 1962)	• Through cognitive theory, play will foster children's mind development. Learning through play allows for the learning in an informal and relaxed environment. • Piaget states that play could provide assimilation and accommodate of knowledge without any attempt to adapt into the outer reality. • In a game world, players can fantasize through the game play and rules towards achieving the game goal.
Communication and Meta Communication (Bateson, 1976)	• This theory stresses about the shared understandings that are developed between children as they play together. • Meta communication is seen to be essential to the development of shared understandings about the focus of play and strategies to communicate the understandings. It lays the foundations for development of children's self-reflection in communication and the awareness of its rules and strategies. • For multiplayer game, players can challenge among themselves using their own strategies.
Socio-cultural Theory (Vygotsky, 1977; 1978)	• Vygotsky suggests that play promotes abstract thought in symbolic ways. It separates meaning from objects and actions. • Play gives children the opportunity towards the social roles and society rules. • In game world, it allows players to engage in their game play, both in cognitive and socio-emotional development.

Based on Table 2.6, Piaget, Erikson, and Vygotsky agree that children always use play for self teaching. The children play through situations either in realistic or fantasy. Therefore, some features of these theories give good values in the development of mGBL especially in terms of game play, storyline, and learning content. For example, a mGBL could have a fantasy storyline, casual or informal game play, and interesting learning content that really suit the target users.

In conclusion, based on the description of benefits of play to learning, using game for learning indeed has great opportunities to be put into practice in the learning environment.

2.10 Game Design and Instructional Design

When considering games used for learning, it is necessary to examine both game design (GD) and ID. Salen and Zimmerman (2003) define GD as a process of creating a game that would be encountered by a player in a meaningful play. They describe that meaningful play appears from the interaction between players with the game, and from the environment in which the game is played. On the other hand, Reiser and Dempsey (2007) describe the ID as a systematic process that is employed in developing educational and training programmes in a consistent and reliable manner.

Over the years, many accepted and well-tested ID models have been proposed (Bagdonis & Salisbury, 1994; Andrews & Goodson, 1995; Reigeluth, 1999; 2008). Essentially, ID models outline the overall procedures by presenting specific guidelines for each step and management of the process. Reiser and Dempsey (2007) also state that in order to have an effective instructional design process, the interdependent, synergistic, dynamic, and cybernetic characteristics are needed in ID. In general, ID includes the following steps: analysis, design, development, implementation, and evaluation (Reiser & Dempsey, 2007). Unfortunately, none of the models are directly applicable for game although they are also viewed as instructional materials (Becker, 2006b).

GD has been evolving as a discipline for several decades and there are plenty of books and resources available on how to design games (Rollings & Adams, 2003; Crawford, 2003; Bates, 2004; Saulter, 2007) and mobile games (Dholkawala, 2005; McGuire, 2006; Dynamic Ventures Inc., 2007; Janousek, 2007). These resources could inspire game developers to produce games in the market. Generally, the steps in GD are grouped in three phases, namely: pre-production, production, and post-

production. All activities in GD and ID are considered similar towards developing a product to be delivered to the target users.

In comparison between both approaches, ID is a complex task supported by several decades of ID disciplinary development. The principles can be followed and be as ID, yet designing good instruction actually takes more than educational criteria. In addition, ID has proceeded in a more structured manner of an academic discipline. On the other hand, GD has been developed largely by practitioners in the game industry. GD is enlightened based on experiences (and some theories) among game designers and developers in which most game designers approach their tasks from the perspective of the player experience (Crawford, 2003) which is more closely aligned with the entertainment industry. In contrast, instructional designers approach their task from the perspective of the contents that need to be delivered (Gagné, 1992) in the learning environment. The major difference between both approaches lies in their respective aims. In particular, ID focuses on the outcomes or objectives, while game design focuses on game play or engagement. In fact, the goal of successful GD is the creation of meaningful play, while the goal of successful ID is the creation of meaningful learning experiences (Salen & Zimmerman, 2003).

In Rules of Play, Salen and Zimmerman (2003) suggest three cognitive schemas for understanding games, namely rules, play, and culture. Rules constitute to essential logic and focus on the intrinsic mathematical structure of games. Play refers to human experience and activity within the game and emphasizes the player's interaction with the game or other player. Meanwhile, culture provides a larger social context supported by the game activity and highlights the cultural context into which any game is embedded. They also point out that these schemas can be applied to any kind of design. Whereas ID, to differentiate with a game, constitutes of learning content, learning processes, and learning cultures. Learning content refers to the target knowledge or skill for student to master. The learning processes

are formed from the learner experience and activity options within the learning environment. Learning cultures are the large social context supported by the learning program.

In a summary, even though both GD and ID are greatly complex tasks with different technical approaches, the design of instructional games (game-based learning) requires both. A GBL should incorporate instructional materials and learning contents. Additionally, if it is a mobile game, then mobile issues need to be considered too. However, to date, a structured methodology for this purpose is highly scarce.

2.11 Instructional Design Models

ID models provide procedural frameworks for the systematic development of learning instruction. Gagne et al. (1992) define ID model as an approach to organize resources and methods to create effective learning system. It is helpful for designers to design and develop instructional materials in a manageable manner. Thus, ID models are seen as prescriptive in the sense that they provide guidelines or steps for outlining the designs, as well as specifying how end-products instruction should be. Conceptually, ID models draw ideas a lot from software engineering. In that sense, they are useful and applicable for problem solving and developing learning software in the context of learning environment.

Generally, ID models incorporate essential elements of ID process including analysis, design, development, implementation, and evaluation (Reiser & Dempsey, 2007). Various ID models have been proposed and this study focuses on the models that are slightly related to GBL development; namely ADDIE model, Dick and Carey model, ARCS Model, ASSURE model, and Morrison, Ross and Kemp model.

2.11.1 ADDIE model

ADDIE model portrays all stages or phases that are considered as iterative processes. It begins with identifying instructional goals and ends with summative evaluation. ADDIE model is well-known and applicable across in many areas (education, business, government) and levels of users (novice, intermediate, expert). It also suggests that student-oriented instructional approach is utilized to design meaningful software to students (Seel & Glasgow, 1998). ADDIE model is defined as a standard model for developing learning materials (Peterson, 2003; Bottouri, 2003). The five phases in ADDIE model (Figure 2.6) are discussed in the following:

i) Analysis

First, in analysis phase, the most important thing to do is to analyze all requirements that designers should identify such as the learning problem, learning goals and objectives, audience's requirements, existing knowledge, and other relevant requirements. This phase also considers the learning environment, limitations, the delivery options, and the timeline for the project.

ii) Design

Next, the designer determines how the content should be delivered. The activities involved in this phase are designing storyboards and developing prototypes, also considering the look and feel, graphic design, user interface, and learning content.

iii) Development

The outcomes of the previous two phases are utilized in this phase. The actual creation or production of the content and learning materials are conducted in development phase.

iv) Implementation

During implementation, the product is put into action. Working manual for guiding the learner and teacher is developed. All materials are then delivered or distributed to the target learners.

v) Evaluation

After delivery, the effectiveness of the training materials is evaluated through formative and summative evaluations. Formative evaluation is conducted at every phase of the ADDIE process while summative evaluation is performed at the end of the process. This will provide users with opportunities to give feedback. After that the revisions are made as necessary for further enhancement.

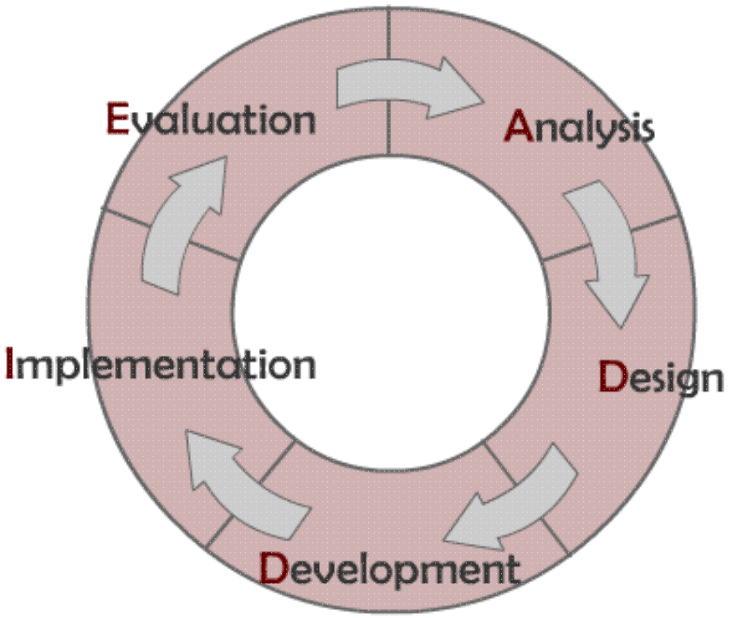


Figure 2.6: ADDIE model

2.11.2 Dick and Carey instructional design model

Dick and Carey (1996) propose a systems approach model for designing an instruction. The Dick and Carey Design Model is argued as one of the best known models (Bottouri, 2003), and its strategy in designing instruction is similar to software engineering. This model provides guidelines to instructional designers especially novices for developing instructional systems.

Figure 2.7 illustrated the model with 10 steps as discussed in the following:

i) **Identify the Instructional Goals**.

First step in this model is to identify the desirable goal of instruction. The goal would be the outcome that leaner will be able to do at the end of instruction.

ii) **Conduct Instructional Analysis**.

The purpose of this analysis is to find out the skills involved in reaching the goal that has been identified. These include mental and behaviour skills.

iii) **Identify Entry Behaviours and Learner Characteristics**.

At this step, the aim is to determine the minimum skills that the learners should bring to the learning tassk. The learners' characteristics are intellectual skills, abilities of verbal comprehension and spatial orientation, and their traits of personality.

iv) **Write Performance Objectives**.

Through this step, the main goals are divided into specific and detailed objectives. The objectives will guide the designer or instructor to the process of assessment development.

v) **Develop Assessment Instruments**.

The assessment materials will be developed in order to diagnose an individual possession of the necessary prerequisites for learning new skills. This is also helpful in evaluating the instructional system itself.

vi) **Develop Instructional Strategy**.

This step is conducted in order to define the instructional activities using the instructional strategy. All the activities should be aligned with the specific objectives.

vii) **Develop and Select Instructional Materials**.

The media will be selected at this stage and all media are intended to convey events of instruction. This step includes media selection, strategy development, and production.

viii) **Develop and Construct Formative Evaluation of Instruction**.

This step will present information for altering and improving instructional materials. The aim is to improve the instruction for effective learning and possible for many students.

ix) **Design and Conduct Summative Evaluation**.

In order to know the student performance, summative evaluation is conducted. This step aims to know the effectiveness of the system as a whole.

x) **Revise Instruction**.

The final step is to revise the instruction in order to ensure that any mistake or ineffective activities during the previous instruction are corrected.

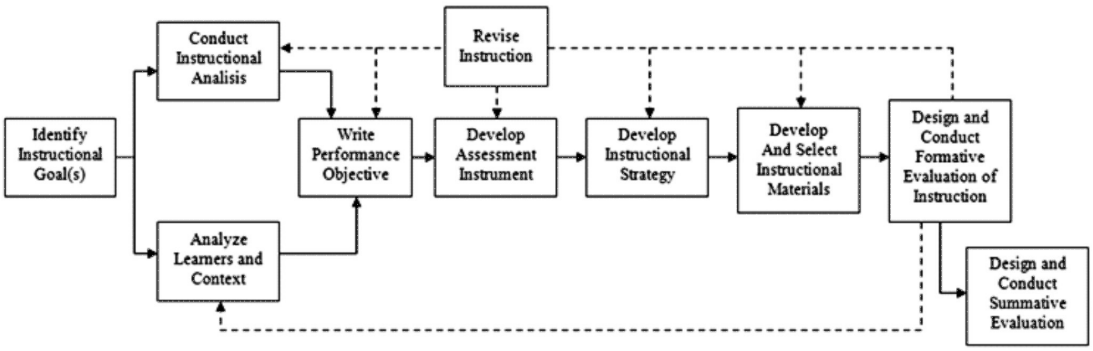


Figure 2.7: Dick and Carey Design Model (Dick & Carey, 1996)

2.11.3 Keller's ARCS Model of Motivation

Keller (1993) synthesized existing research on psychological motivation and he has proposed four criteria that must be met for a learner to be motivated to learn. He states that the criteria: attention, relevance, confidence, and satisfaction (ARCS) are the conditions that motivate people to learn. Moreover, Keller also suggests that the ARCS conditions occur as an integrated and sequential process and the key aspect to motivate learners is to engage them in the learning environment. The ARCS model is an instructional design model that incorporates within Gagne's nine events of instruction as depicted in Figure 2.8.

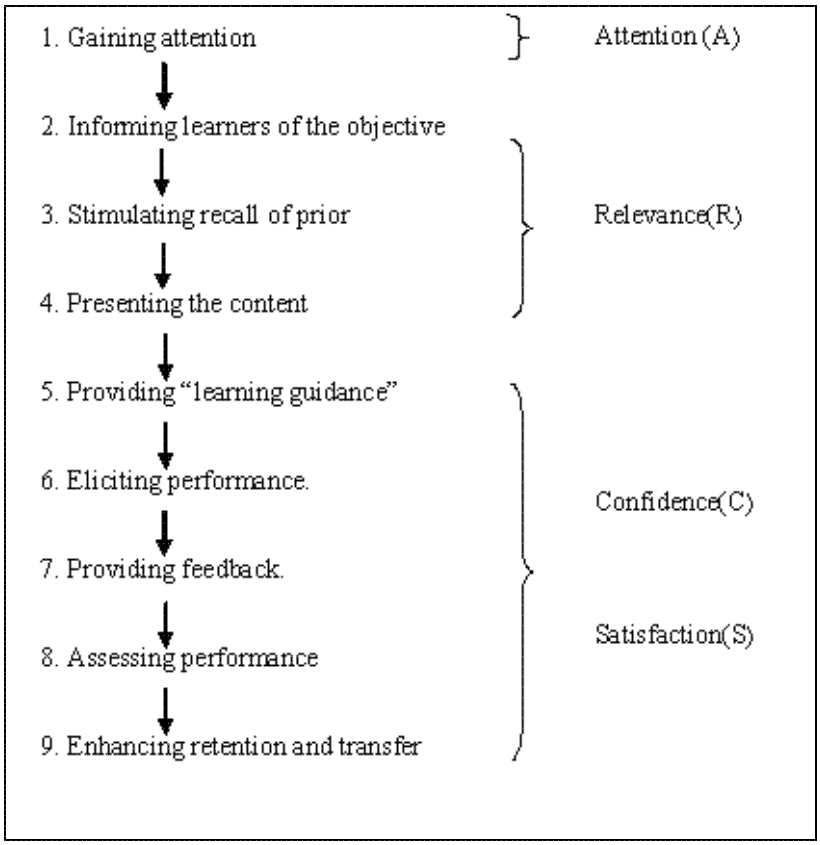


Figure 2.8: ARCS model with Gagne's events of instruction (Keller, 1993)

Each component in Figure 2.8 is described below:

i) Attention

The main important aspect is gaining and keeping the learner's attention, which also corresponds with the first step in Gagne's model. The strategies to gain attention include sensory stimuli, inquiry arousal, and variability (variance in techniques and use of media).

ii) **Relevance**

Having successfully gained the learner's attention, it is important to provide them with the appropriate relevancies by stating the benefits. If they feel that the learning activities are relevant to the objectives and benefit to them, they will gain motivation to continue with the learning programme.

iii) **Confidence**

Besides attention and relevance, the students should feel confident to succeed in the programme. This aspect is necessary so that students feel that they should put a good faith effort into the learning programme. If they are unable to accomplish the objectives or that take too much time or effort, their motivation will decrease.

iv) **Satisfaction**

Lastly, learners will sustain in motivation if they feel comfortable with the results. They feel that they should acquire some types of satisfaction or reward from the learning experience, which can be in the form of entertainment or a sense of achievement. For example, a high score in a game and a passing grade in a test might be rewarded with a completion certificate.

2.11.4 ASSURE Model

Heinich and Molenda (1993) have proposed an instructional design model called ASSURE; an acronym for the description of a set of tasks for the selection and use of educational technology. The ASSURE model as depicted in Figure 2.9 also incorporates Robert Gagne's events of instruction to ensure effective use of media in instruction.

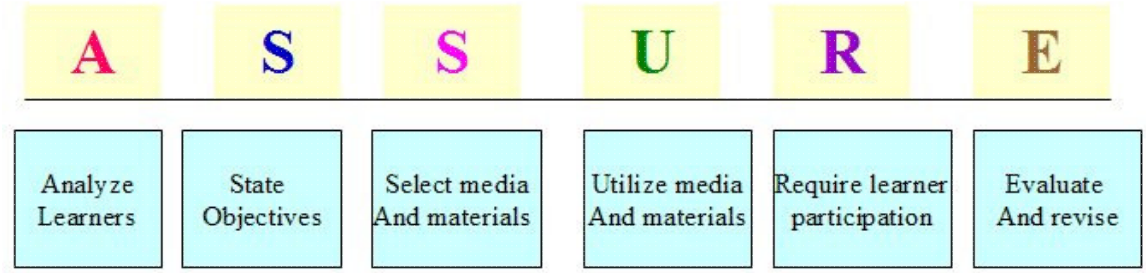


Figure 2.9: ASSURE model (Heinich & Molenda, 1993)

The model is helpful for designing courses using different kinds of media. It allows for the possibility of incorporating other resources and technologies into the course materials. The processes in ASSURE are:

i) **Analyze Learners**.

This first step is to identify factors that may affect the students' learning behaviour. Such factors are styles of learning, precondition knowledge or skills, emotional, and cultural or economic issues.

ii) **Stating learning outcomes**.

Learning outcome should be measurable and stated the expectation of what learners will obtain. This ensures that the learning outcomes help them to determine what instructional techniques or methods to use.

iii) **Selecting or producing appropriate media**.

At this step, it is important to choose the right technology or more realistically instructional media and technologies to be used in learning environment. The key is to match the learner requirements with the selected media that have the characteristics required to present the knowledge, skills, or attitudes to them.

iv) **Utilize media and materials**.

When media and technologies have been selected or produced, the next important step is the preparation of the learning environment. All facilities should be possibly in a good condition.

v) **Require learner participation**.

In ASSURE model, learners' participation, engagement, and knowledge construction should be encouraged.

vi) **Evaluation and revision**.

Evaluation step is essential when implementing learning technologies of all kinds. This step will make sure that learning is taking place as expected, and if not the material should be revised and corrected.

2.11.5 Morrison, Ross, and Kemp Model

This model has nine small ovals representing the 9 basic steps in the systematic design process (Morrison, Ross, & Kemp, 2004):

i) Identify instructional problems, and specify goals for designing an instructional program.
ii) Examine learner characteristics that should receive attention during planning.
iii) Identify subject content, and analyze task components related to the stated goals and purposes.
iv) State instructional objectives for the learner.
v) Sequence content within each instructional unit for logical learning.
vi) Design instructional strategies so that each learner can master the objectives.
vii) Plan the instructional message and delivery.
viii) Develop evaluation instruments to assess objectives.
ix) Select resources to support instruction and learning activities.

The two ovals which surround these 9 basic procedures suggest that the activities are the boundaries for the whole project and that they are continuously running. In the first oval the revision/formative evaluation activities are undertaken at each stage of the development process, and if undertaken carefully, it can assist in making the learning materials be very effective by the end of the project. The second oval deals with a number of aspects, including planning activities, project management, arranging necessary services to support both the project and the instruction once it is implemented, and any summative evaluation as required. Figure 2.10 depicts the model.

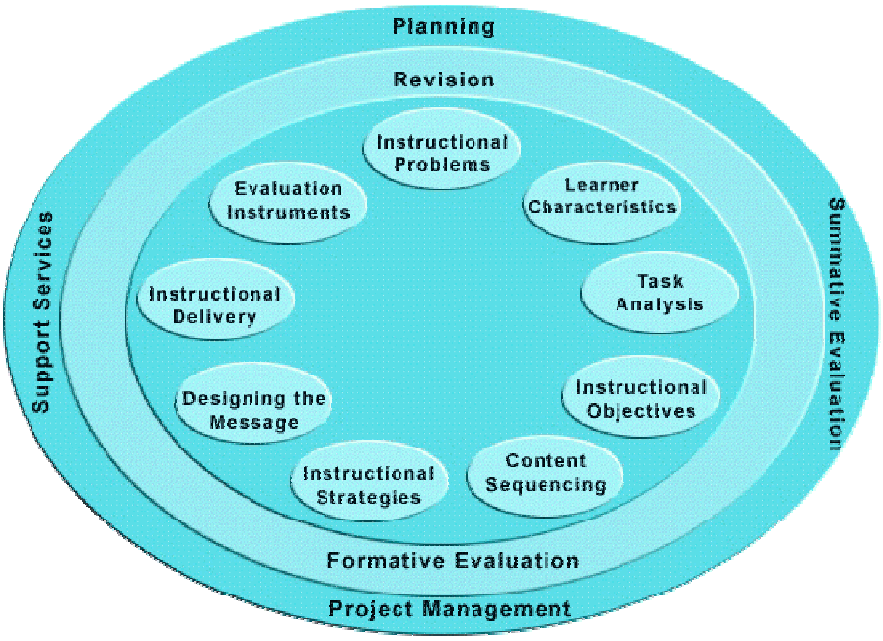


Figure 2.10: Morrisonson, Ross and Kemp Model (Morrison, Ross & Kemp, 2004)

2.11.6 Implications of ID Models to the Study

Since mGBL involves learning elements, then the ID models that must be considered describe what processes should be used to plan and prepare for the instruction. Designers will be able to apply the ID models in creating effective instruction. Hence, this study elaborates and describes five ID models (ADDIE model, Dick & Carey model, ARCS model, ASSURE model, and Morrison, Ross and Kemp model) because they are possibly related to game design. All the models share three major activities: analysis, strategy development, and evaluation. In analysis, requirements are gathered and analyzed. While in strategy development, the activities are focused on the development of learning object. Lastly in evaluation, evaluation of the developed learning object is evaluated.

The three major activities (analysis, strategy development, and evaluation) in ID models can relate to game design phases. The mapping between the ID model and

GD model is easily seen in Figure 2.11. Therefore, this study considers on both aspects of design; ID model and GD model, to be implemented in developing the proposed mGBL engineering model.

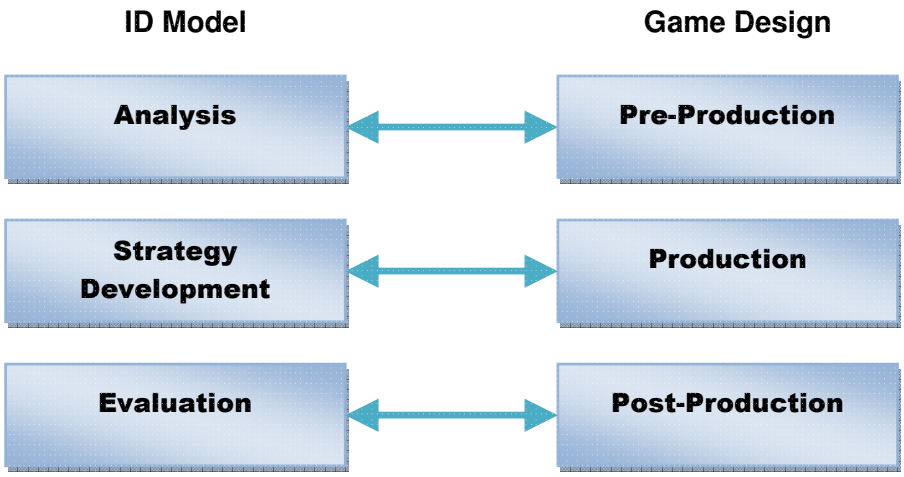


Figure 2.11: Phases alignment in Instructional Design model and Game Design

2.12 Game Design Models and Development Methodologies

Game design and development methodology include processes and components that help and guide the designers and developers to develop games. This is similar to system development methodology. Avison and Fitzgerald (1995) define methodology as:

> *"a set of phases which guide the developers in their choice of techniques that might be appropriate at each stage of the project".*

Ealier, Palvia and Nosek (1993) instead defined methodology as:

> *"a methodology is an organized and systematic approach to system life cycle or its parts. It will specify the individual tasks and their sequences".*

Recently, Vaishnavi and Kuechler (2007), define development methodology as a set of steps or guidelines used to perform a task. In regards to game, according to Rollings and Adams (2003), “game design is the process of (i) imagining a game, (ii) defining the way it works, (iii) describing the elements that make up the game (conceptual, functional, artistic, and others), and (iv) transmitting that information to the team that will build the game”.

In this study, GD model is also considered as development model or methodology. Therefore, based on these definitions, two sets of review have been conducted on (i) GBL design models, and (ii) mobile game development methodologies. Both reviews are discussed in the remainder of this section.

Various GD models have been introduced with specific respective phases. The GBL design models reviewed include: Input-Process-Outcome Game Model (Garris et al., 2002), Experiential Gaming Model (Kiili, 2005), Integrated Model for Educational Game Design (Paras & Bizzocchi, 2005), The Fuzzified Instructional Design Development of Game-like Environments (FIDGE) Model (Akilli & Cagiltay, 2006), Four Dimensional Framework (de Freitas & Oliver, 2006), Adaptive Digital GBL Framework (Tan et al., 2007), Games for Activating Thematic Engagement (GATE) (Watson, 2007), The Digital Game Involvement Model (Calleja, 2007), Framework for Designing GBL for Children (Noor Azli et al., 2008), and GBL Model for History Courseware Design (Nor Azan et al., 2009). These were selected to represent GBL design models for the past 8 years (i.e. 2002-2009).

2.12.1 Input-Process-Outcome Game Model

Garris et al. (2002) propose an input-process-output model for learning from game. The model elaborates the key features of instructional game based on three components: input, process, and output. The input component consists of instructional content and game characteristics while the process component

involves the game cycle. The game cycle can be described as user behaviour, system feedback, and user judgment. In the output component, the learning outcome is achieved. The model also stresses the debriefing process between the game cycle and the achievement of the learning outcomes. It provides a link between game and the real world which actually connects game experience and learning. The model incorporates the instructional content with the characteristics of games. Then, these features trigger a game cycle that includes user judgments such as enjoyment, user behaviours such as greater persistence, and further system feedback. This game cycle results in recurring and self-motivated game play to the player. Finally, this engages the player in game play and leads to the achievement of learning objectives or outcomes. The model is illustrated in Figure 2.12.

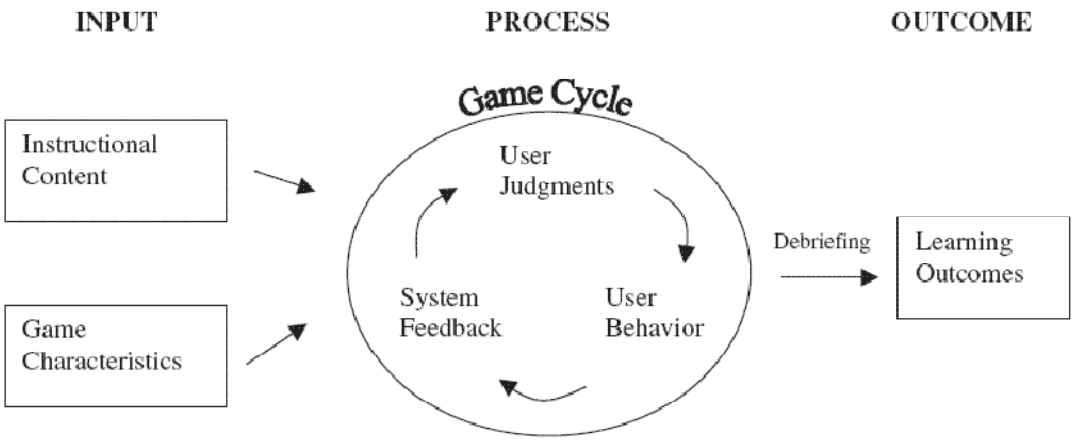


Figure 2.12: Input-Process-Outcome Game Model (Garris et al., 2002)

The model adopts the input-process-output framework and the main component is the game cycle that is triggered by the game features and instructional contents. The game cycle can be viewed as iterative, involving repeated judgment-behaviour-feedback loops. Through game cycle, it provokes interest, enjoyment, involvement, and confidence to players in the game context. In addition, the game cycle is where the player learns the instructional content.

In summary, this model offers an input-process-output model of instructional games, but the model does not provide any detail steps for developing GBL. The model also describes that the learning outcomes occur outside of the game cycle during the debriefing. This can be argued because players learn many things during the game play, but not only after it is over. For example, players could learn from the game activities and interactions within the game which include valuable contains. Moreover, players must increase their skills and strategic knowledge within the game itself to finish the game until the end (Kearney & Pivec, 2007).

2.12.2 Experiential Gaming Model

The experiential gaming model was proposed by Kiili (2005) consisting of gaming cycle and a design cycle. It can be utilized to design and study both educational games and general games. The design cycle describes the main phases of GD. While the gaming cycle presents a description of the gaming and learning process in games. It also provides for the game designers with the most important factors that influence the gaming experience and learning with games. As depicted in Figure 2.13, the phases include idea generation, active experimentation, reflective observation, schemata construction, and pre-inventive idea generation. Although this model provides the GD phases, it is not very comprehensive to provide guidelines to the game designer to develop educational game.

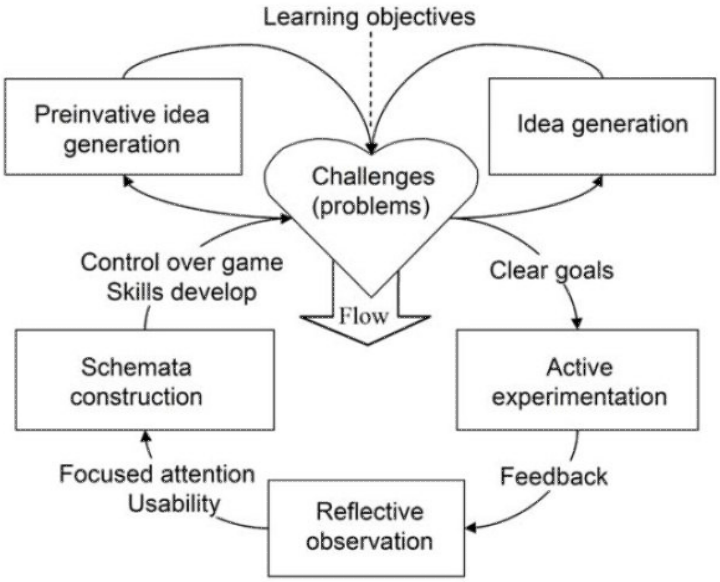


Figure 2.13: Integrated Experiential Gaming Model (Kiili, 2005)

The model utilizes the flow theory proposed by Csikszentmihalyi (1975) and emphasizes the flow antecedents in educational game design which are challenges, clear goals, feedback, sense of control, playability, usability, focused attention, and frame story. The aim of designing the educational games is to enhance the experiencing flow among players because the flow theory has positive impacts on learning, exploratory behaviour, and the attitudes of players (Prensky, 2001; Skadberg & Kimmel, 2004). A comparative analyses and limitations of this model are further summarized in Table 2.7 (page 91-92).

2.12.3 Integrated Model for Educational Game Design

Paras and Bizzocchi (2005) suggest an integrated model for educational game design. This model stresses on the integration of components to be considered during the game design process. The suggested components are game play, flow, motivation and learning environment, endogenous fantasy, immersion, and reflection. They describe that games cultivate play, which then creates a state of flow. When players have experienced the flow, their motivation increased and this

supports the learning process. Figure 2.14 depicts the components integrated in the proposed model.

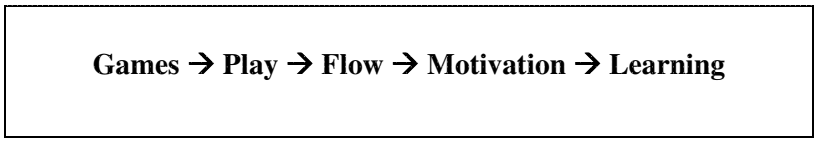


Figure 2.14: Integrated Model for Educational Game Design (Paras & Bizzocchi, 2005)

The key component that is emphasized in this model is reflection because it is the essential part of the learning process. Whereas in the state of flow, players rarely reflect on the learning that is taking place. In summary, the model describes how games can perform as effective learning environments by integrating reflection into the process of play, producing a unique learning experience that is intrinsically motivating. The model also proposes that the challenge for educational game designers is to develop the environments where the dynamics of learning are fully integrated with the dynamics of game play. Table 2.7 (page 91-92) further details the comparative analysis and limitations of this model.

2.12.4 The Fuzzified Instructional Design Development of Game-like Environments (FIDGE) Model

The FIDGE model is suggested by Akilli and Cagiltay (2006) for developing the game-like learning environments. The model consists of five phases, which are pre-analysis, analysis, design, development, and evaluation. They claim that the phases are dynamic and based on fuzzy logic concept which provides the non-linear processes. There are two principles underliying this model, the principle related to the design team and the principle related to the instructional design process.

The pre-analysis phase provides a starting point for the instructional designers to determine the target group, subject, goals, and game characteristics. These

activities are tentatively established and could be easily changed when the analysis phase is conducted. In the next phase, needs, learners, context, content, cost, and risk are analyzed before the design takes place. Further, in design-development phase, a few tasks are conducted based on the analysis phase. The real development of the game-like environment is conducted in this phase. Lastly, in the evaluation phase, formative evaluation, summative evaluation, and synthesis are carried out. All these phases are illustrated in Figure 2.15.

In short, this model can be utilized for developing educational games both for novice and expert game designers. However, it seems similar to the traditional rapid prototyping model and does not really define the educational aspect to be embedded in the game design component. Furthermore, the fuzzy logic concept that is said to be applied is not clearly discussed.

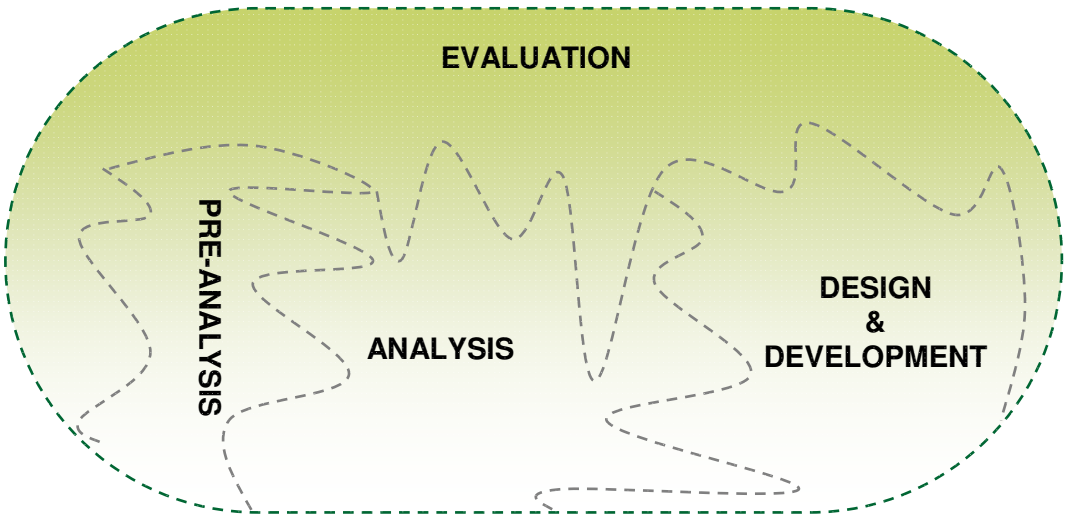


Figure 2.15: The Fuzzified Instructional Design Development of Game-like Environments (FIDGE) Model (Akilli & Cagiltay, 2006)

2.12.5 Four Dimensional Framework

The four-dimensional framework is composed of four generic dimensions: (i) context, (ii) learner aspect, (iii) mode of representation, and (iv) pedagogic approach. The framework is proposed by de Freitas and Oliver (2006) and built upon previous works of Mayes and de Freitas (2004; 2006). These four dimensions may be used effectively by educational game designers to be considered to support effective learning outcomes (see Figure 2.16).

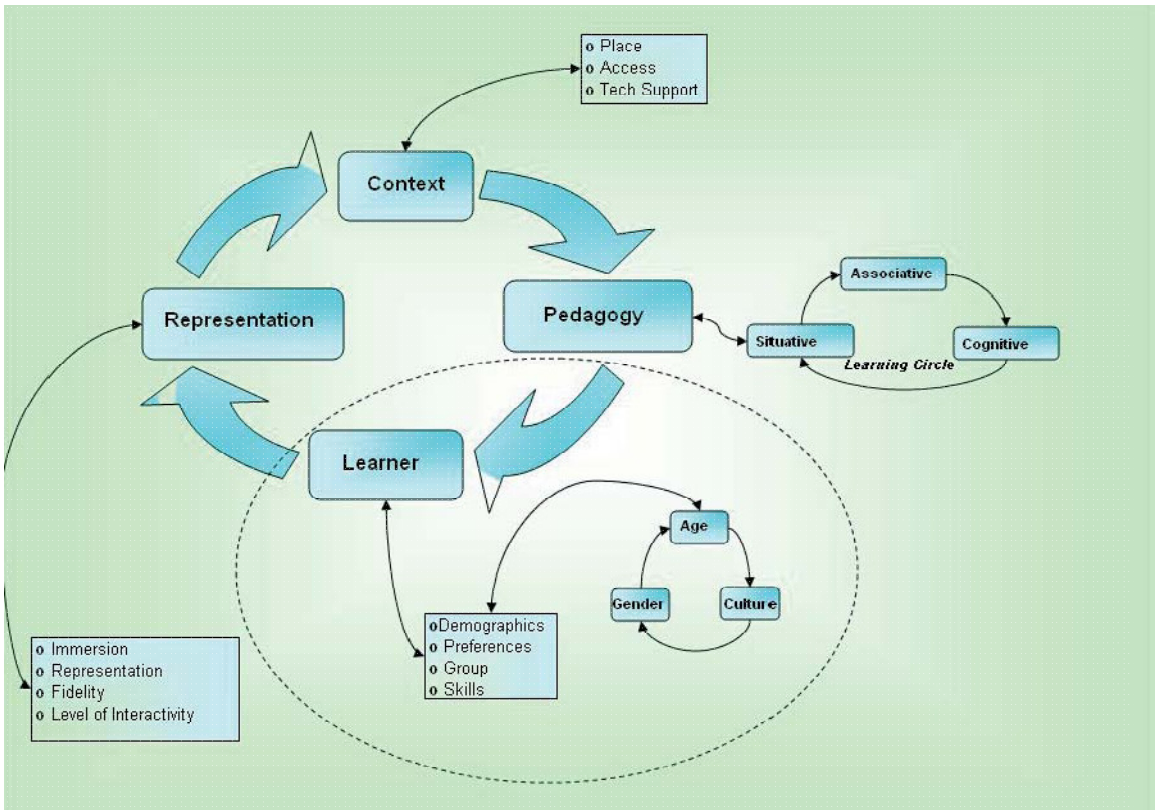


Figure 2.16: Four Dimensional Framework (de Freitas & Oliver, 2006)

Context as the first dimension refers to how the game is utilized. The contextual factors consist of the place of the game is used, the technical support is provided, and the access for game play environment. Second dimension is related to the learner aspects such as age, gender, culture, demographics, preferences, group, and skills. It provides appropriate considerations to support learning outcomes and activities.

The representation of the game refers to the level of immersion and fidelity, interactivity, and narrative of the game that bear upon the effective learning. This dimension is commonly related to the game itself. In addition, pedagogic model is particularly essential for using games in learning environment. There are three learning perspectives that come into play promptly at different points as learning progresses. Such perspectives are associative, cognitive, and situative modes of learning. The benefits of the framework are seen in its flexibility, ease of use, and ability to help game designers to develop game contents for learning. However the framework does not suggest any sequential order of development activities among the four dimensions.

2.12.6 Adaptive Digital GBL Framework

Tan et al. (2007) proposed an adaptive digital GBL framework by adapting four frameworks which are the Design Framework for Edutainment Environment (Embi, 2005), Adopted Interaction Cycle for Games (Barendregt & Bekker, 2004), The Engaging Multimedia Design Model for Children (Said, 2004), and Game Object Model (Amory & Seagram, 2003). The adapted framework defines important features and characteristics of best practices to be considered in designing GBL. The features are divided into two perspectives: learner and game design.

First, the learner perspective includes psychological needs, cognitive development, and learner's behaviour. Understanding the psychological needs of learner are important because if the needs are accomplished, learners might have interest in continuously playing the GBL. Second, through cognitive development, it is essential for game designers to design suitable games for the learners and this will enhance the learning process in terms of cognitive thinking. Third, based on the principles of behavioural learning, appropriate design which facilitates the learning behaviour of learners could be outlined to offer enhanced learning environments.

On the other hand, the game design perspective consists of multimodal, task, and feedback. The multimodal aspect consists of the modality and interaction factor of developing a game. It incorporates elements of multimedia, design of interface, and narrative. Second aspect is the tasks in the game that help learners to absorb the learning contents which might come in different levels of difficulty. Feedback refers to responses that learners receive from the game in direct or indirect information. The feedback can be in different types such as rewards, penalties, and other information.

In conclusion, the components suggested in this framework could assist learners in enhancing motivations and satisfaction through game playing and could assist game designers in developing GBL. However, this framework only suggests the components to be considered in developing the GBL development and does not provide any "how-to" guideline for developing GBL.

2.12.7 Games for Activating Thematic Engagement

Games for Activating Thematic Engagement (GATE) is a design model that focuses on engagement (Watson, 2007). The purpose of GATE is to utilize video games for students' engagement in learning content and to encourage them to further explore within the learning contents. The engagement gives a motivating, interesting, and entertaining learning environment through the use of video games.

Additionally, the GATE model specifies a design process as a guideline for the design and development of educational video game; in fact it is also suitable for adapting the available commercial games for instruction. This model provides some values that are applicable for designing instructional game.

The values are listed as follow:

i) Instruction should be interesting, enjoyable, entertaining, and engaging.
ii) Instruction should encourage creativity, critical and divergent thinking, and experimentation.
iii) Instruction should be tailored to meet specific students' needs and goals, while still requiring students to meet minimum and broad requirements.
iv) Instruction should encourage collaboration and debate.
v) Instruction should promote meta-cognition and self-awareness.
vi) Instruction should not be limited by the available technology or media, but should be adaptable to various learning resources and environments.
vii) Instruction should result in understanding, measured through learner performances.

The GATE model suggests activities for designing instructional games, which include: developing a context, establishing problem space or world of experience; supporting implementation structure; preparing learners to benefit from game and implementing the game, and providing feedback to learner. Although GATE model provides the activities to design and develop instructional game, the activities and phases are not well explained.

2.12.8 The Digital Game Involvement Model

The Digital Game Involvement Model (Calleja, 2007) comprises six frames of involvement which are structured into two temporal phases: macro-involvement and micro-involvement. The macro phase cares at motivational attractors to games that influence sustained engagement through the long-term aspects of each of the six frames. While, the micro phase of the model focuses on the involvement of the game-play from time to time during play.

The six frames as seen in Figure 2.17 are related to each other; and will not apply equally to every game; some will clearly be more relevant to certain games than the others. The frames and phases outlined in the model aim at providing concepts of the digital game involvement salient aspects.

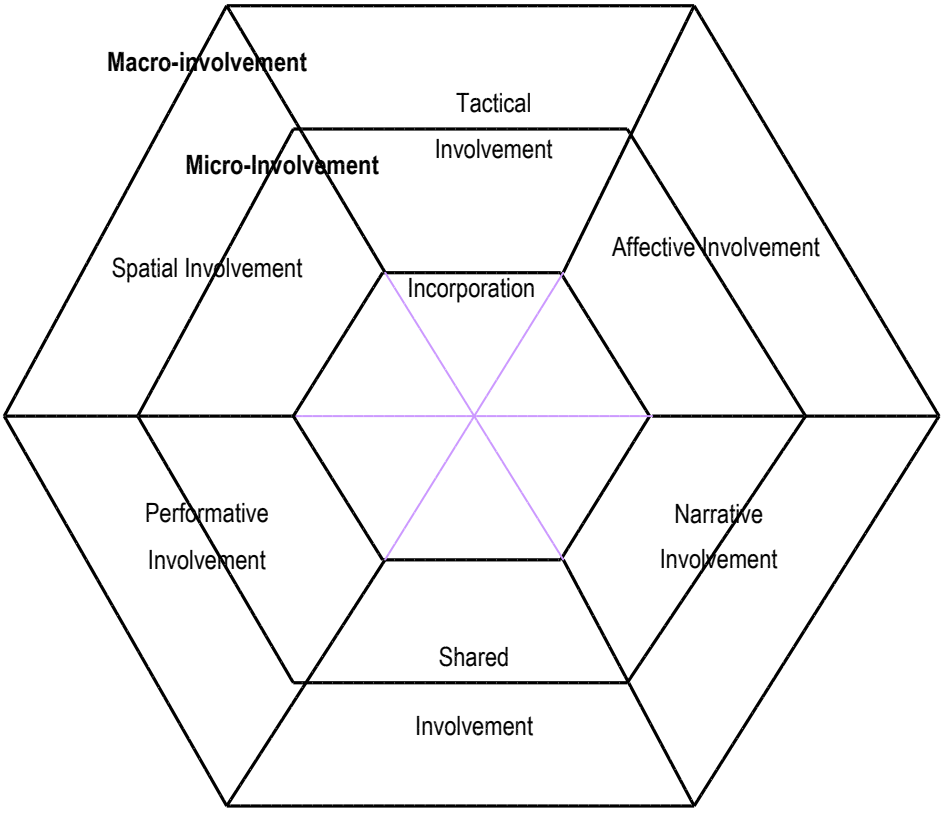


Figure 2.17: The Digital Game Involvement Model (Calleja, 2007)

In Figure 2.17, tactical involvement corresponds to the engagement with all forms of decision making made within the context of the game. Performative involvement relates to all modes of game control, ranging from learning controls to the fluency of game movement. Affective involvement describes the player's mood and emotional states, such as excitement and fun that suit the player's needs. Shared involvement enables the players to control their agent (avatar or character) within the game environment and anchors the players firmly to the environment both spatially and socially. Narrative involvement presents the narrative elements in a

game such as the game-world's history and background, or in a simple word is the storyline. Spatial involvement is connected to locating oneself within a game area which is not only the visible screen but also mental maps that enable players to explore and exploit the game-space for strategic purposes. Incorporation replaces the metaphor of immersion which makes the game world present to the player while simultaneously placing a representation of the player within it through the avatar.

In a nutshell, this model only presents the involvement aspects in game but does not illustrate any specific design activities for developing GBL.

2.12.9 Framework for Designing GBL for Children (Noor Azli et al., 2008)

Noor Azli et al., (2008) have proposed a framework for designing digital GBL that had been modified from Experiential Gaming Model (Kiili, 2005). The proposed framework presents additional components which are related to each other. These new components are theory of play, lesson, story and narrative, engagement, motivation, and challenges.

The framework shows the relationship between educational game engagement and motivation to clear goals, rules, appropriate feedback, good usability/playability, focused attention, potential control and a perception of challenges that are matched to the person's skills. As seen in Figure 2.18 the challenges are based on educational objectives, theory of play, and the story. The core task is to sustain the motivation and engagement of the player by providing appropriate challenges and good playability. Similar with the Experiential Gaming Model, this framework does not provide clear procedural activities in developing GBL. It only focuses on the components that should be considered for designing GBL.

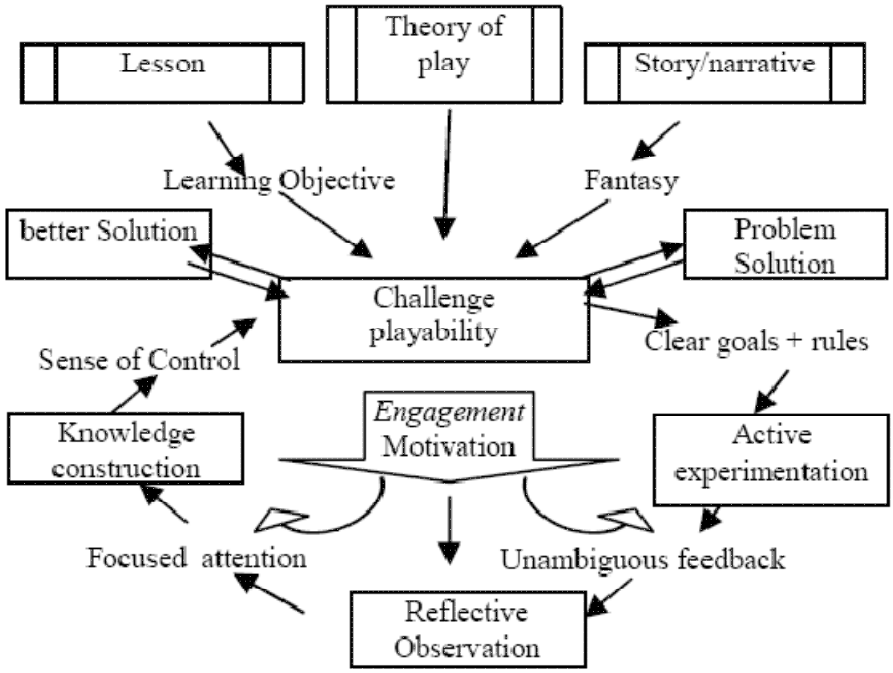


Figure 2.18: Framework for Designing GBL for Children (Noor Azli et al., 2008)

2.12.10 Digital GBL Model for History Educational Games Design

Nor Azan et al. (2009) propose a Digital Game Based Learning (DGBL) model specifically for history educational game design. The model comprises of components that can be separated into two: pedagogy and digital games components. The elements for the pedagogy component are: learning goal setting, learning theory setting, educational psychology, country curriculum needs, patriotism and moral value, and memorization and forgetting theory. While in the digital game component, the elements include game story's background, rules, immersive, enjoyment, feedback, multimedia technology, challenges and competition, and reward.

All elements in the pedagogy component focus on the learning context, method and the history subject content towards achieving the learning objective. On the other hand, the elements in digital game component suggest the features in a DGBL that need to be considered when designing game activities.

Figure 2.19 illustrates the model. It shows the design components which blend the instructional and game component but it does not specify the phases and activities that should be followed to design and develop DGBL.

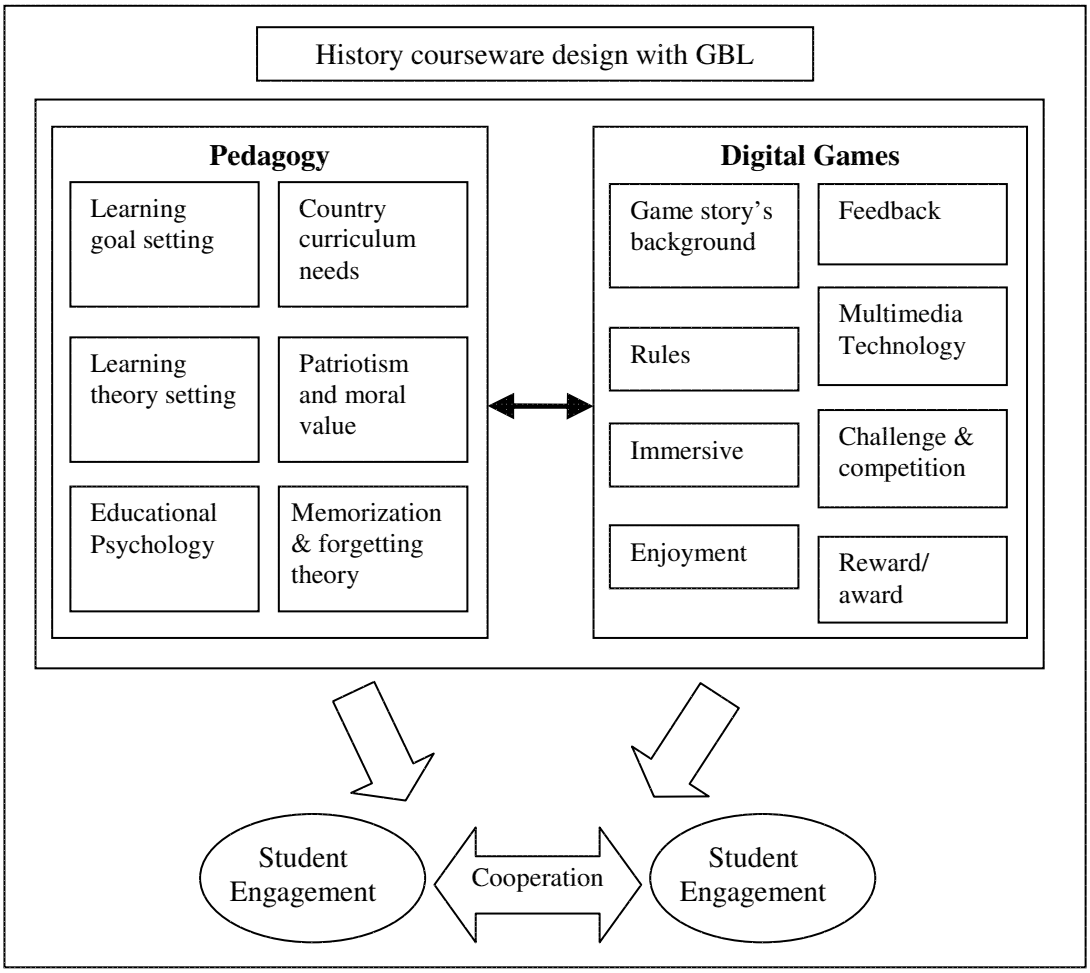


Figure 2.19: Proposed components in DGBL Model for History educational games design (Nor Azan et al., 2009)

2.12.11 Comparative Analysis of GBL Design Models

A comparative analysis over all the ten design models described in section 2.12 has been carried out. Based on the comparative analysis, the similarities and limitations of each model were tabled and exhibited in Table 2.7.

Table 2.7: Comparative Analysis of GBL Design Models

Models/Frameworks	Model Descriptions	Limitations
Input-Process-Outcome Game Model (Garris et al., 2002).	• The model adopts the input-process-output framework. • The main component is the iterative game cycle that is triggered by game features and instructional content. • Through game cycle, it can lead to the player interest, enjoyment, involvement, and confidence in the game context.	This model only provides components to be considered during designing GBL, but not the specific processes to develop GBL.
Experiential Gaming Model (Kiili, 2005)	• The model utilizes the flow theory and emphasizes the flow antecedents in GBL design which are challenges, clear goals, feedback, sense of control, playability, usability, attention, and frame story. • The model consists of a gaming cycle and a design cycle.	Although this model provides the GD phases, it is not very comprehensive to provide guideline to the game designers to develop GBL.
Integrated Model for Educational Game Design (Paras & Bizzocchi, 2005)	• This model stresses out the integration of components to be considered during the game design process. • The suggested components are game play, flow, motivation and learning environment, endogenous fantasy, immersion, and reflection. • They describe that games foster play, which then produces a state of flow and this supports the learning process.	This model only provides components to be considered during designing GBL, but not the specific processes to develop GBL.
The (Fuzzified Instructional Design Development of Game-like Environments) FIDGE Model (Akilli & Cagiltay, 2006)	• The model consists of five phases, which are pre-analysis, analysis, design, development, and evaluation. • The phases are dynamic and based on fuzzy logic concept which provides the non-linear processes. • Two principles underlie this model, the principle related to the design team and the principle related to the instructional design process.	It seems similar to the traditional rapid prototyping model and does not clearly define the educational aspects to be embedded in the game design component.

de Freitas & Oliver, (2006)- Four Dimensional Framework	• This framework is set out based on four generic principles: context, mode of representation, pedagogic approach, and learner aspect.	Although the framework is flexible and able to help game designers to develop game content for learning, it does not facilitate game designers in understanding the flow between the four dimensions.
Adaptive Digital GBL Framework (Tan et al., 2007)	• The framework defines key features and characteristics of best practices to be considered in designing GBL. • The features are divided into two perspectives: learner and game design.	This framework only suggests the components to be considered when developing GBL and does not provide the step-by-step guidelines in developing GBL.
Games for Activating Thematic Engagement (GATE) (Watson, 2007)	• The purpose of GATE is to utilize video games for students' engagement in learning content and to encourage them further exploring within that content. • The engagement gives a motivating, interesting, and entertaining learning environment through the use of video games.	Although GATE provides the activities to design and develop instructional game, the activities and phases are not well explained.
The Digital Game Involvement Model (Calleja, 2007)	• It comprises six frames of involvement which are structured into two temporal phases: macro-involvement and micro-involvement. • The six frames of involvement are spatial, tactical, affective, narrative, shared, and performative.	This model only presents the involvement aspects in game but does not illustrate the specific design activities to develop GBL.
Framework for Designing GBL for Children (Noor Azli et al., 2008);	• The framework was modified from Experiential Gaming Model (Kiili, 2005). • It presents additional components which are theory of play, lesson, story and narrative, engagement, motivation, and challenges.	Similar with the Experiential Gaming Model, this framework does not provide clear procedure in developing GBL. It only focuses on the component that should be considered for designing GBL.
GBL Model for History Courseware Design (Nor Azan et al., 2009);	• The model comprises of components that can be separated into two: pedagogy and digital games component. • In pedagogy component, the elements introduced are: learning goal setting, learning theory setting, educational psychology, country curriculum needs, patriotism and moral value, and memorization and forgetting theory. • In the digital game components, the elements are game story's background, rules, immersive, enjoyment, feedback, multimedia technology, challenge and competition, and reward/ award.	This model shows the design components which blend the instructional and game component but does not specify the phases and activities to be followed in designing and developing GBL.

When the existing GBL design models were examined, some were found to be more complicated than the others, but overall the value of the GBL design model for motivating students to learn should not be denied. Some models convey on the content to be included in the game and some focus on the steps to design the game. It is also worth mentioning that almost all of the reviewed models have been adopted to design or develop games. Table 2.8 summarizes such cases.

Table 2.8: Examples of Studies Adopting the Reviewed Models

Models/Frameworks	Authors	Descriptions
Input-Process-Outcome Game Model (Garris et al., 2002).	Lynch and Tunstall (2007)	The authors successfully developed an innovative e-learning simulation tool for an undergraduate course by adopting the Input-Process-Outcome Game Model. A conceptual framework for ensuring quality in creative education projects was also outlined in their study for the future development of e-learning and adaptive game projects.
Experiential Gaming Model (Kiili, 2005)	Hämäläinen et al. (2006)	The study designed a 3-D collaboration virtual game environment. The game intended to make learning more effective by promoting student's interaction. The development model was referred to the Experiential Gaming Model. The eScape game was used for empirical experimentation, which encourages learners to solve problems collaboratively. The results revealed that the game persuaded student teams to enter into collaboration.
Integrated Model for Educational Game Design (Paras & Bizzocchi, 2005)	Yang et al. (2008)	A GBL system, called PILE (physical interactive learning environment) was developed which utilized video capture virtual reality technologies and was applied in educational setting. The learning content is about English learning materials of the third grade of elementary school. An experiment of using the PILE system was conducted for examining English learning achievement, motivation, and attitude of students. Positive learning motivations and attitudes on English learning were found in the study.
The (Fuzzified Instructional Design Development of Game-like Environments) FIDGE Model (Akilli & Cagiltay, 2006)	Dielmann and Meaux (2011)	The study presented a conceptual framework for understanding the factors that affect the outcome of individuals with Attention Deficit Hyperactivity Disorder (ADHD). The study also demonstrated how instructional design models can be used to guide the design and implementation of educational games as instructional tools for the population. The FIDGE model and Gagné's Nine Events of Instruction were utilized to understand the unique technological needs of the ADHD learners.

de Freitas & Oliver, (2006)- Four Dimensional Framework	Pappa and Pannese (2010)	The study developed an engaging game and presented the methodology adopted in the case of the e-VITA project that applies GBL (Four Dimensional Framework) to promote knowledge sharing and transfer. The study analyzed the e-VITA framework, which is central to the project's iterative development approach. The findings showed that the e-VITA prototype game was successfully developed and evaluated.
Adaptive Digital GBL Framework (Tan et al., 2007)	Yang et al. (2010)	The study used the GBL concept (from Digital GBL Framework) as the basis to construct a system model to provide a more relaxing environment to the dental students. The theories and practical skills in the dental casting course were selected for creating the educational gaming content. In the findings, the study successfully established a learning environment for dental casting through gaming that included the operation in dental lost-wax casting and the study of fundamental knowledge in dental casting.
Games for Activating Thematic Engagement (GATE) (Watson, 2007)	Huizenga et al. (2009)	A mobile game called Frequency 1550 was developed by The Waag Society to help students in acquiring historical knowledge of medieval Amsterdam. The study investigated in terms of student engagement in the game, historical knowledge, and motivation for History. A quasi-experimental design was used to compare the results. The findings showed that those students, who played the game, were engaged and gained significantly more knowledge than those pupils who received regular project-based instruction.
The Digital Game Involvement Model (Calleja, 2007)	Sicart (2010)	The study introduced ethical game play as a relevant concept for understanding the moral possibilities of GBL design. Ethical game play is the experiential outcome of a player taking choices based on the moral evaluation of a given dilemma. The study proposed that these types of experience should be designed as problems for players.
GBL Model for History Courseware Design (Nor Azan et al., 2009);	Huang and Zhang (2010)	Based on analysis of the relation between the teaching and digital games, the study designed a game-based geographical information system (GIS) learning model and discussed its key technologies. The GIS-learning game model has the essence characteristics including scalability and independence, which will be practical application in the teaching.

However, none of the reviewed models provides any specific guide for developing GBL in mobile platform. Therefore in the next section, the development methodologies for mobile game are discussed.

2.13 Mobile Game Development Methodologies

To date, only a handful of mobile game development methodologies are being practiced in mobile game industry, namely: Best Practice for Mobile Game Development (Dholkawala, 2005), Scrum Methodology (McGuire, 2006), Game Development Methodology (Dynamic Ventures, 2007), Game Life Cycle (Janousek, 2007), and Design-Protect-Build-Test-Market-Sell (Edwards & Coulton (2006). The descriptions of each methodology are described as follows:

2.13.1 Best Practice for Mobile Game Development

Dholkawala (2005) in her article has proposed a general guideline to develop mobile game. This guideline suggests steps in developing mobile game in general from developing game concept until the trimming process of the mobile game. Figure 2.20 shows the five main steps in developing mobile game.

In the first phase, the storyboarding process is concentrated on, which caters the development of the game concept, game play and storyline. At this stage, all works are geared towards capturing player's imagination when experiencing the game. After the game idea is initialized, the entire concept is then implemented. Developers should consider the main functionalities of the game such as game interactivity and logical functions. The most important activity at this phase is the platform compatibility check so that the game is made available for the player to play the game on different devices.

The next phase is a script optimization. Optimizing the script is very important in order to make the game runs smoothly and performs well. One of the major issues

should be alerted is when the memory of the devices is full. Hence, the scripts for the game should be optimized in corresponding to all functionalities in the game. Another important phase is ensuring the graphics and sounds are trimmed and optimized which reflect not only on the file size but also the game performance. However, embedding sound in mobile game is harder compared to incorporating sound in computer games.

In the last phase, testing is required in order to find and fix errors and bugs. This activity should be conducted many times to ensure the game can run on the target platform and device.

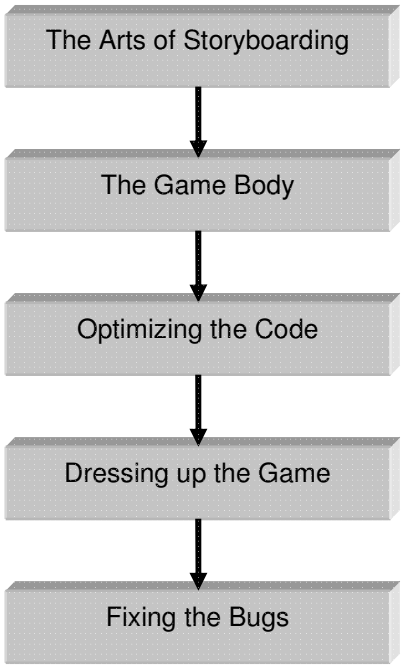


Figure 2.20: Best Practice for Mobile Game Development (Dholkawala, 2005)

2.13.2 Scrum Methodology

The Scrum methodology is proposed by McGuire (2006) which is based on Agile Methodology. The iterative process is the main concern in this methodology. One of the main principles is that project teams are restructured into smaller teams that work together on particular activities of a project. The methodology can be broken down into small activity cycles called Sprints. Each Sprint starts by conducting a meeting involving the entire team to build objectives and then they will self-organize into small Scrum teams. The Scrum teams are multi-disciplinary, where artists, designers, and programmers work together collectively.

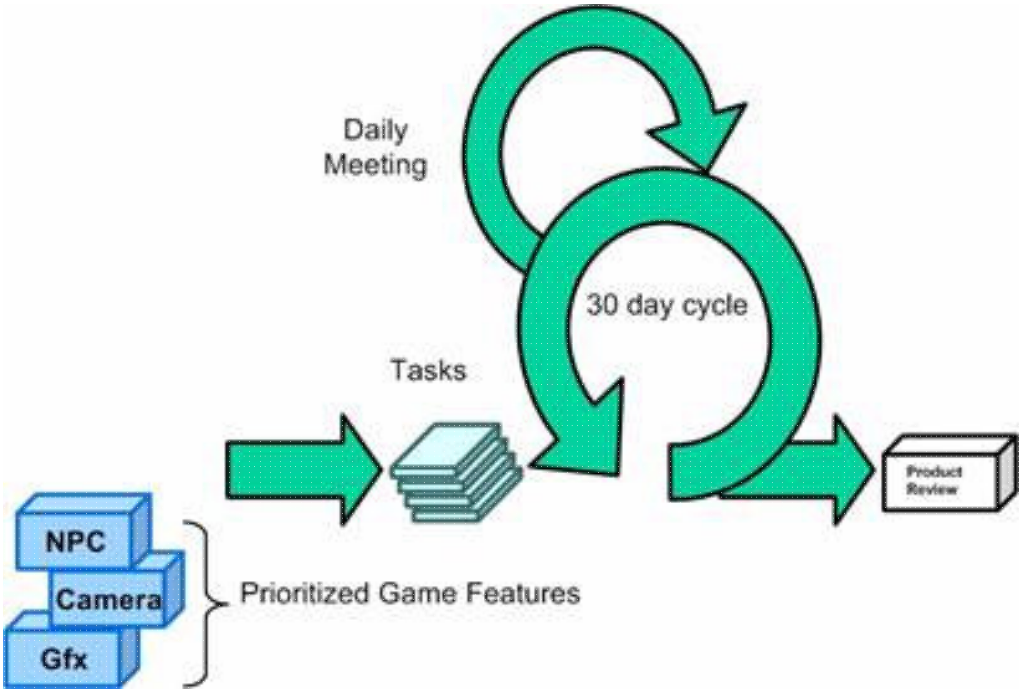


Figure 2.21: Scrum methodology (McGuire, 2006)

Figure 2.21 shows the Scrum methodology where game features are divided into specific tasks by programmers, artists, and designers. Afterwards, they work on these features for a certain time; perform their tasks and involve in daily meeting. Finally, at the end of each iteration cycle, a product review is conducted. The main

advantage of the Scrum methodology is that the publishers and project leaders are able to identify the team's performance for every iteration.

2.13.3 Game Development Methodology

Dynamic Ventures, Inc. (2007) has expertise in developing software applications for mobile devices such as client data applications, mobile games, and task management system. They utilize the latest software development and software programming tools and technologies. The company follows the iterative process which helps in reducing development time and delivering the product faster.

The methodology provides guideline to develop general mobile game. The feedbacks and inputs are fully focused in this methodology and it can be gathered from the client, stakeholders, and developers. The methodology consists of iterative processes which are also based on agile methodology. It has been verified and has successfully released several software into the market.

The activities or milestones in the methodology help the developer to identify needs and address the most important development issues. Referring to Figure 2.22, the methodology starts with developing an idea, a game concept or a description of short problem. Then, the process continues by gradually developing the game in a sequence of milestones to develop working prototypes.

At each milestone, the developer improves and refines the game based on feedbacks and inputs from clients, stakeholders, and developers along with the testing results and diagnostics code. The company claims that this approach provides better end products that adapt to changing specifications and meet the overall expectations.

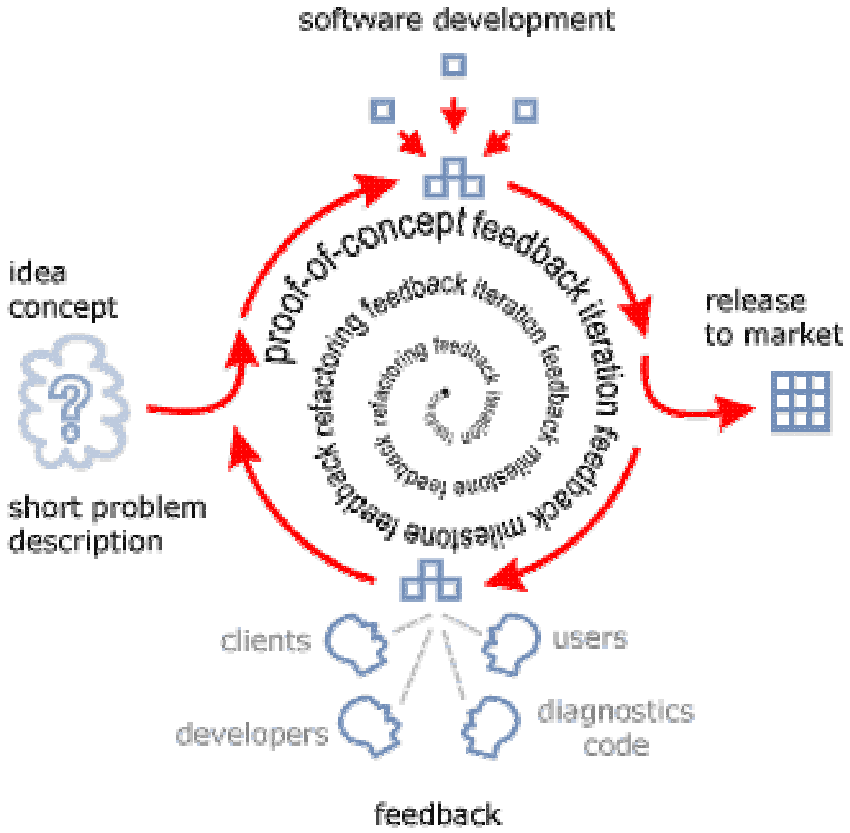


Figure 2.22: Game development methodology (Dynamic Ventures, Inc., 2007)

2.13.4 Game Life Cycle

Janousek (2007) proposed a method for developing mobile games which is based on the Flash Lite Game Life Cycle. This methodology focuses on developing mobile game using Flash Lite Platform because he claimed that the platform offers one of the best environments for rapid mobile game development for casual type contents. The method consists of six sequences as depicted in Figure 2.23.

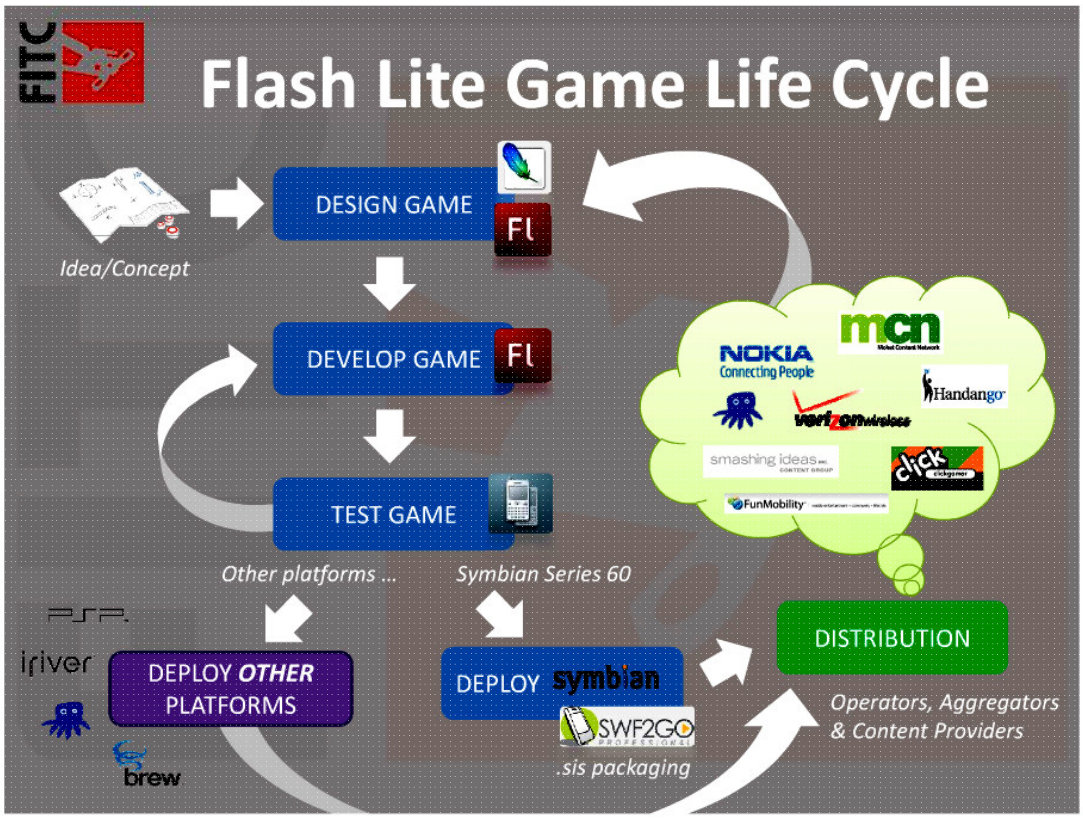


Figure 2.23: Game development life cycle (Janousek, 2007)

Similar with all the above-mentioned methods, the first phase is to generate the game idea or concept. From concept, the game is designed based on the idea and requirements needed for that particular game. In the next phase, the game is developed using the tools and software which have been identified in the earlier stage. After that, the game is tested in order to make sure the game is working smoothly. All errors and bugs occur in this stage will be refined and enhanced before the game is deployed on different platforms and devices. Finally, the game is ready to be distributed to the publisher, content providers, or operators.

2.13.5 Design-Protect-Build-Test-Market-Sell

Edwards and Coulton (2006) proposed an approach that underlies from the "Design-Build-Test" philosophy (Repening et al., 2005) for developing a mobile game. The approach becomes "Design-Protect-Build-Test-Market-Sell" by adding three new stages which are protect, market, and sell. The authors claim that this approach contains a non-linear process. The design, built, and test phases are still iterative but with added input from marketing issues that encompass the whole process. Figure 2.24 shows the proposed approach.

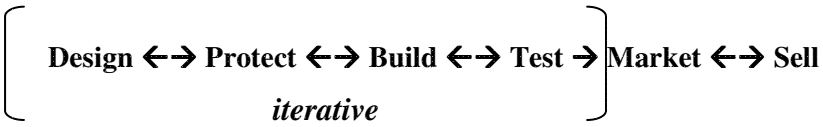


Figure 2.24: Design-Protect-Build-Test-Market-Sell (Edwards & Coulton, 2006)

The proposed approach is similar to the other game development methodologies that are based on design, built, and testing. However this approach concentrates on the commercial issues of the game development such as protecting intellectual property (IP); mobile application marketing, and selling issues. The design process involves planning and designing a marketing concept. The process involves the creation of novel and valuable IP and such IP must be protected in a number of ways, such as IP rights and trademark. The process continues with the development of the mobile game which is based on the design concept previously completed. Testing process often starts at the early development stage and bugs or errors will be corrected and enhanced.

In addition, this approach suggests that the game developers develop an understanding of the business processes such as accounting, finance, marketing, and sales. A business plan is expected to be produced which includes marketing information, development costs, support costs, and potential sales and revenue.

2.13.6 Comparative Analysis of the Mobile Game Development Methodologies

The focus of the mentioned methodologies may be different, in which some try to address many aspects in the development process, while some others try to further detail one or two of the processes. This section describes the comparative study carried out to compare and explore the available development methodologies proposed by several researchers or developers in terms of the steps to be performed when using the methodologies and their limitations (if any). Table 2.9 summarizes of the main steps of the mGame development methodologies.

Table 2.9: Comparison of steps involve in mobile game development methodologies

Authors	Dholkawala (2005)	McGuire (2006)	Dynamic Ventures (2007)	Janousek (2007)	(Edwards & Coulton (2006)
Steps and activities	a. Storyboarding b. Game body/ design c. Code optimization d. Dressing up the game e. Fixing the bugs/ testing	a. Preparation & Planning b. Prioritize features c. Features assigned d. Development e. Meeting for feedback f. Game review/ testing g. Adjustment h. Game Release	a. Idea & concept b. Problem description c. Software development d. Feedback e. Diagnostic code f. Iteration g. Release to market	a. Idea/ concept b. Design game c. Develop game d. Test game e. Deploy f. Distribution	a. Design b. Protect c. Build d. Test e. Market f. Sell

On top of that, Table 2.10 exhibits brief descriptions and disadvantages of each methodology.

Table 2.10: Comparisons of Mobile Game Development Methodologies

Methodologies	Descriptions	Limitations
Best Practice for Mobile Game Development (Dholkawala, 2005)	• This methodology suggests steps in developing mobile game in general from developing game concept until the trimming process.	• This guideline is for general use for developing mobile game. • Is not suitable for mGBL as no ID model is considered. • It is specifically using Flash technology. • This methodology does not include theory of game and theory of play.
Scrum Methodology (McGuire, 2006)	• The methodology is based on Agile Methodology. • The iterative process is the main concern for this methodology. • It focuses on the tasks given to each individual of the development team.	• This methodology is for general use for developing mobile game. • Is not suitable for mGBL as no ID model is considered. • This methodology does not include theory of game and theory of play.
Game Development Methodology (Dynamic Ventures, Inc., 2007)	• The methodology provides guideline to develop general mobile game. • It focuses on the feedback and input from the client, stakeholders and developers. • It is an iterative process.	• This methodology is for general use for developing mobile game. • Is not suitable for mGBL as no ID model is considered. • This methodology does not include theory of game and theory of play.
Game Life Cycle (Janousek, 2007)	• The methodology is based on the game life cycle.	• This methodology is for general use for developing mobile game. • Is not suitable for mGBL as no ID model is considered. • It is specifically for developing game using Flash technology. • This methodology does not include theory of game and theory of play.
Design-Protect-Build-Test-Market-Sell (Edwards & Coulton, 2006)	• This approach is similar to a general guide of developing software. • It focuses on creation of protected IP, and understanding of business processes and strategies.	• This methodology is for general use for developing mobile game. • Is not suitable for mGBL as no ID model is considered. • This methodology does not include theory of game and theory of play.

2.13.7 Implications of Comparative Analysis to the Study

The literatures suggest that the engineering model of mGBL should be a combination of two models; game development and instructional design (ID) model. So, it would be irrational to overlook the ID model or learning theories in an attempt to create any technology for learning purposes (Becker, 2006b). The analyses in Table 2.9 and Table 2.10 explain that all of the reviewed development methodologies provide general guidelines to develop mobile games. In summary, all the methodologies explicitly emphasize about the testing activities. Meanwhile, only one methodology includes deployment phase. Planning, conception of idea, and storyboarding, are some common steps shared by all methodologies.

In addition, not a single methodology incorporates any ID model or learning theory for content creation. Also, game or play theories are not incorporated at all in their metodologies. Hence, it ought to be noted that this is the research gap that should be the focus of this study.

2.14 Summary

Games are known as a good platform to motivate people to play, interact, communicate and as well as learn. Many researches have proven the potential use of game in learning environment. In addition, game and learning can be successfully developed and implemented in learning environment by combining both GD and ID approaches. From the literatures, game for learning should be designed and developed by considering various issues such as learning theories, theory of play, mobile platform and technologies for mobile games, game design, instructional design and others. In a nutshell, a number of ID models, GBL design models, and mobile game development methodologies have been reviewed. This finally results in the identification of the focus of study. Figure 2.24 depicts the overall overview of the literature that has been reviewed throughout this research.

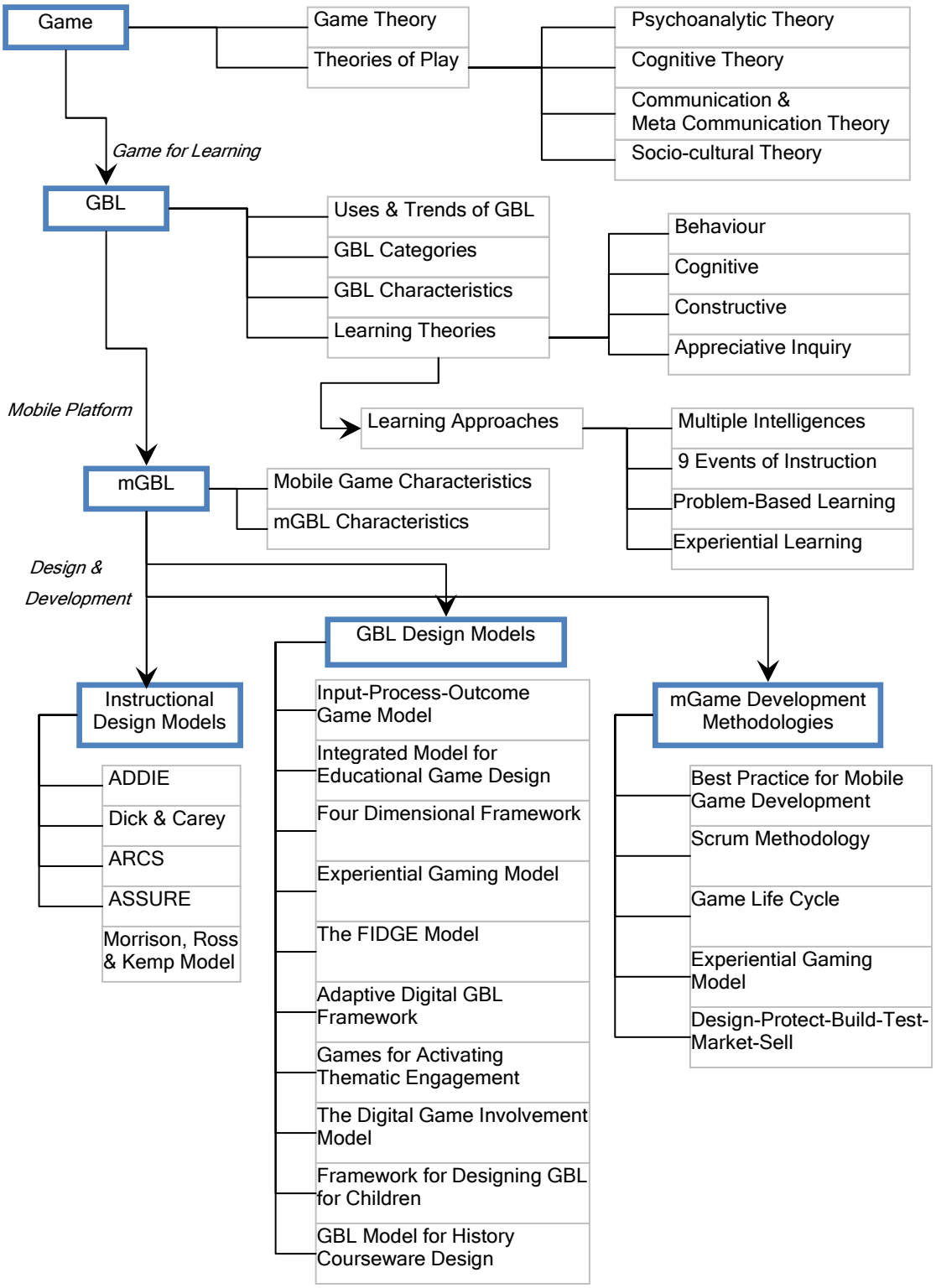


Figure 2.24: Overview of the literature study

CHAPTER 3

Methodology

3.1 Introduction

This chapter describes the research design and methodological approach of the study. In particular, this chapter discusses the overall research processes and the methods used to achieve the objectives of this study. The methodological approach is adopted from the well-known design research approach in information system. Each phase in the methodology is elaborated and the strategies to be applied for accomplishing the objectives of this study are also described in this section.

3.2 Design Research

The selection of appropriate research methodology is based on the main aim of this study to develop a mGBL engineering model. When considering a suitable methodology to be adopted, the methodology should guide this study towards achieving the target aims. A design research paradigm is seen to be highly compatible with this study, as it caters well to produce the expected outcome of this study which is an engineering model. In recent years, design-based research has become popular as the methodology in various fields such as Human Computer Interaction (HCI) (Carroll, 2000; Druin, 2002), educational research (Collins et al., 2004; Barab & Squire, 2004), instructional design and technology (Richey et al., 2004; Reigeluth, 2008), and information system (Vaishnavi & Kuechler, 2007; Purao, 2002).

In HCI, the design research is already utilized by several researchers. For example, Carroll (2000) advocates a design research that should achieve two complementary goals: (i) to understand the world in the process of gathering design requirements, and (ii) to improve the world through the process of design. The HCI requirements are the user needs and the research in HCI would improve the issues that fulfil the user's needs. The outcome would be an artefact that is interpreted as a HCI theory. The theory is validated through the subsequent evaluation of the design. This evaluation of the strengths and weaknesses of a specific design may then be generalized to a wider design genre in HCI.

In educational research, design-based approaches are often referred to as design experiments, iterative design, or design research (Collins et al., 2004). In these methods, the researcher conducts a series of educational experiments. These experiments are run at a small scale, to allow elaboration of interpretation. This interpretation then feeds into the next round of design. Thus, in the next iteration, the design is further refined and at the same time the interpretation is validated. The products of the design process in educational research could be tools, practices, and methods which are often seen as transient and discarded between iterations (Collins et al., 2004). In particular, the design research in ID and technology is also known as design experiment (Brown, 1992; Collins, 1992) that focuses on identifying potential improvements for an ID theory.

In information system, design research has been broadly and fundamentally used for solving problems (Hevner et al., 2004). It attempts to create innovations that define ideas, practices, technical capabilities, and products. The outcomes or artefacts of the design research are generally defined as (i) constructs (vocabulary and symbols), (ii) models (abstractions and representations), (iii) methods (algorithms and practices), and (iv) instantiations (implemented and prototype

systems) (Hevner et al., 2004; Vaishnavi & Kuechler, 2007). The two main phases in information system are build and evaluate. Both phases are continually conducted for refinement until the final design artefact is produced.

In addition, Hevner et al. (2004) have proposed seven guidelines to assist researchers to understand the requirements for effective design science research. The guidelines can be used based on researchers' creative skills and judgment how to apply the guidelines in their works. Table 3.1 summarizes the guidelines for design science research.

Table 3.1: Design science research guidelines (Hevner et al., 2004)

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions for important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Therefore, as discussed in the examples in previous paragraphs, this study is relevant to be conducted by adopting the design research approach, and what follows is the rationale of selecting the approach.

3.3 Rationale of Using the Design Research

Design research seems appropriate for this study, as it caters well for phases and provides research outcomes that are relevant to the expectation. Aspects being considered for choosing this approach include:

i) The design research caters for research problem pertaining to artefact design issues.
ii) The context and domain of the study suit the design research, as it is partly under the field of educational technology.
iii) The expected outcome of this study is an engineering model which is a type of design artefact (model or method).
iv) The design research is a dynamic process that can be included in various relevant specific activities such as evaluation strategy (Section 3.7) that will be conducted in this study.
v) Each specific guideline in the design research (Table 3.1) is relevant and practical to be utilized in this study.

Hence, although this study concerns with mobile game development, design research approach is adopted to produce artefacts in the form of mGBL and engineering model.

3.4 Phases in Methodology

A prominent design science research methodology (Vaishnavi & Kuechler, 2007) is adopted for accomplishing the research objectives. The methodology is the most accepted approach taken by researchers, where the primary focus is on the finished artefacts such as models, methods, or prototypes (Purao, 2002). The research methodology can be divided into five phases; (i) awareness of problem, (ii) suggestion, (iii) development, (iv) evaluation, and (v) conclusion. Figure 3.1

illustrates the activities that have been conducted in this study. The overall process is mainly focused on developing an engineering model of mGBL.

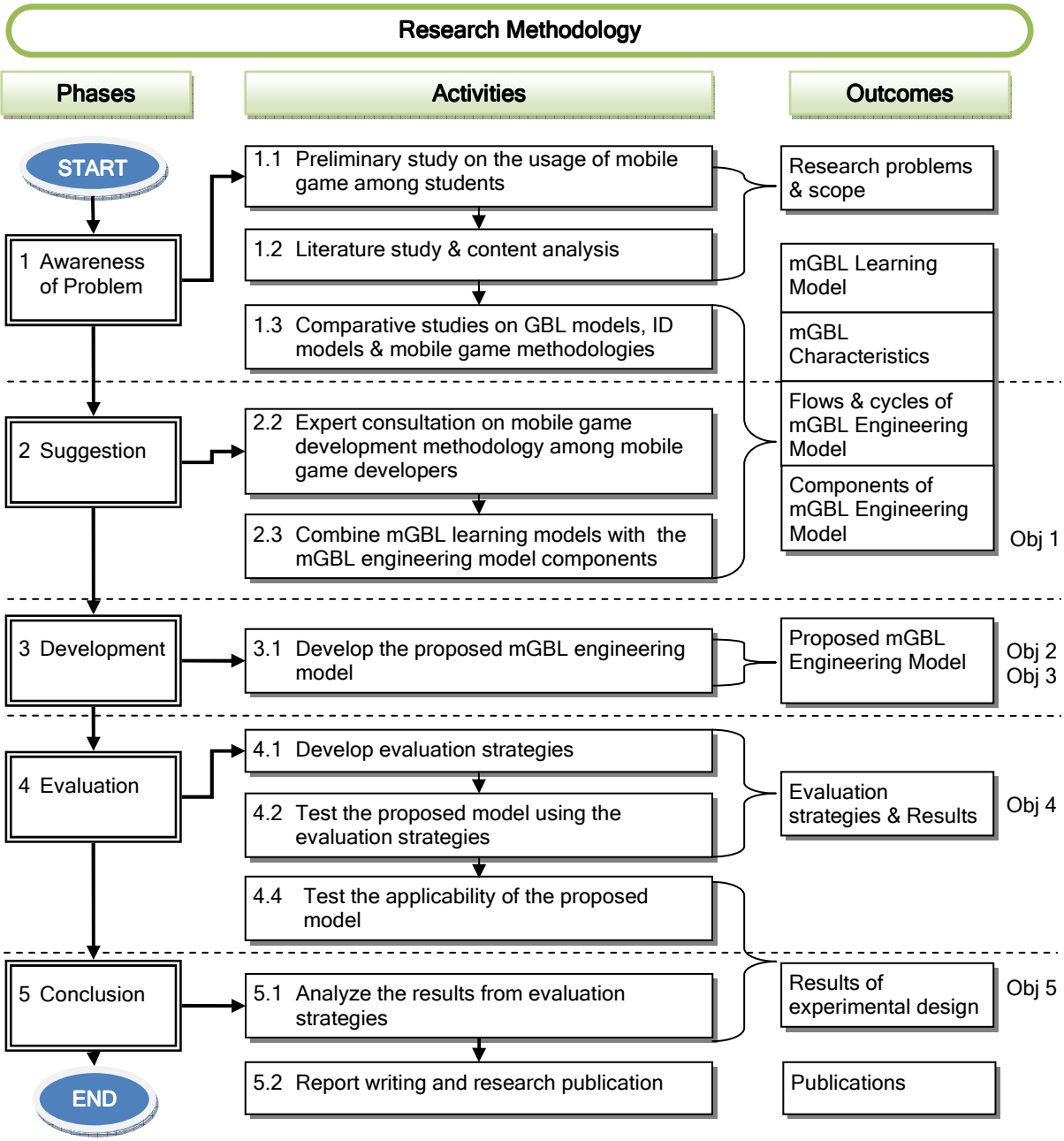


Figure 3.1: Research Phases

3.5 Phase 1: Awareness of Problem

In the first phase (Figure 3.2), the problem to be solved is defined through literature study and content analysis. The problem statement was established based on these activities and from few aspects that motivate the study. Apart from that, a preliminary study and three comparative studies were also conducted in order to find out the key issues of developing mGBL application. Consequently, these studies lead to the construction of the research questions, objectives, and scopes as previously discussed in Chapter 1.

3.5.1 Literature Review and Content Analysis

Content analysis is a process of obtaining sufficient knowledge about the intended study; in which the contents can be acquired from many sources of information including text, video, audio, and other forms of elements (Preece et al., 2002). In this study, the aim of content analysis was to determine the key issues of developing mGBL including model components, phases, activities, and other related issues. Figure 3.2 visualizes the theories reviewed which include game concept, GBL concepts and characteristics, mGBL concept and characteristics, appreciative inquiry theory, learning theories and approaches, and play and game theories. These existing theories are used as a basis to determine the key issues and components in developing mGBL. The literature and content analysis are discussed in Chapter 2.

3.5.2 Comparative Studies

Three comparative studies have been conducted in this phase: which analyzed and compared (a) ID models, (b) mGame development methodologies, and (c) GBL design models. The objective of these comparative studies was to compare and explore the available development methodologies and models proposed by several researchers and developers in terms of the phase and steps to be performed. The analyses were based on brief descriptions and limitations of the methodologies.

These studies also resulted in determining the main components of the mGBL engineering model. The results of these comparative studies are discussed in Chapter 2.

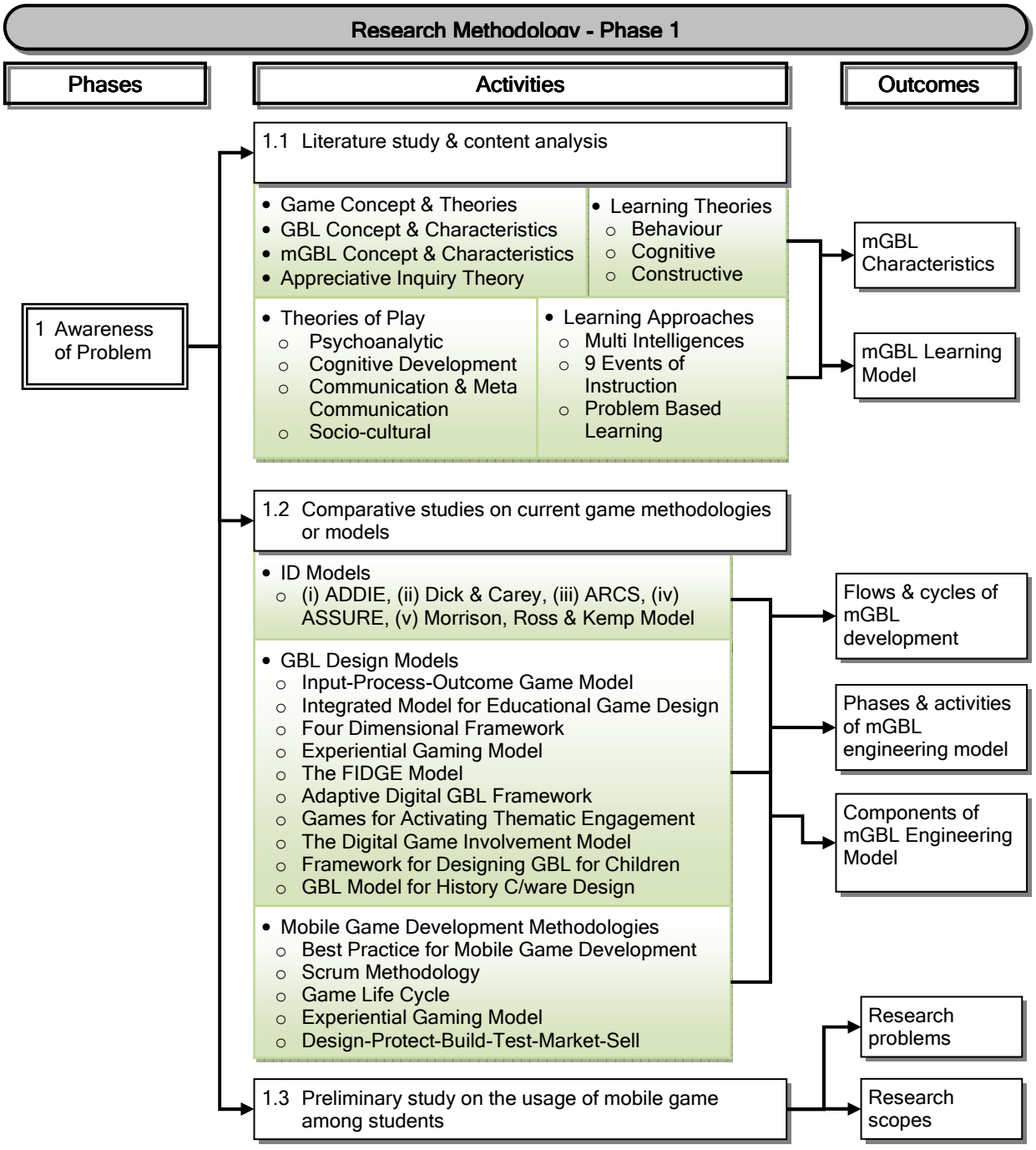


Figure 3.2: Phase 1- Awareness of Problem

3.5.3 Preliminary Study- a Survey

In the process of developing the research aims, an initial study was conducted. The analyses of the study support the formulation of problems and the main aim of this research. The study was a survey on student preferences over mobile learning. The main objective was to find out the specific target audiences for mGBL and their preferences in learning, either using mobile phone or other game devices. Basic statistical method was used to assess the students' responses which were based on descriptive technique. Two months (between August and September 2008) were allocated for data collection period. The findings and discussion for this study are discussed in Chapter 1.

3.6 Phase 2 & 3: Suggestion and Development

In the second phase (Figure 3.3) of this research, the outcomes of literature study, content analysis and preliminary studies were used to compare and document the components of the proposed model. In addition, studies on the flow and cycle of the methodologies were also conducted to determine appropriate solutions for the proposed model. Then, some phases and steps of mobile game methodology were identified and further incorporated with the purposed components of the model in the third phase. This combination was then converted into the proposed mGBL engineering model.

3.6.1 Study on the Flows and Cycles of mGBL Development

The main objective of this activity is to identify flows and cycles of the proposed model. The main activities were reviewing the literatures by comparing existing models (including ID models, GBL design models, and mobile game development methodologies) and conducting expert consultation. The findings were then integrated in the proposed model (as discussed further in Chapter 4).

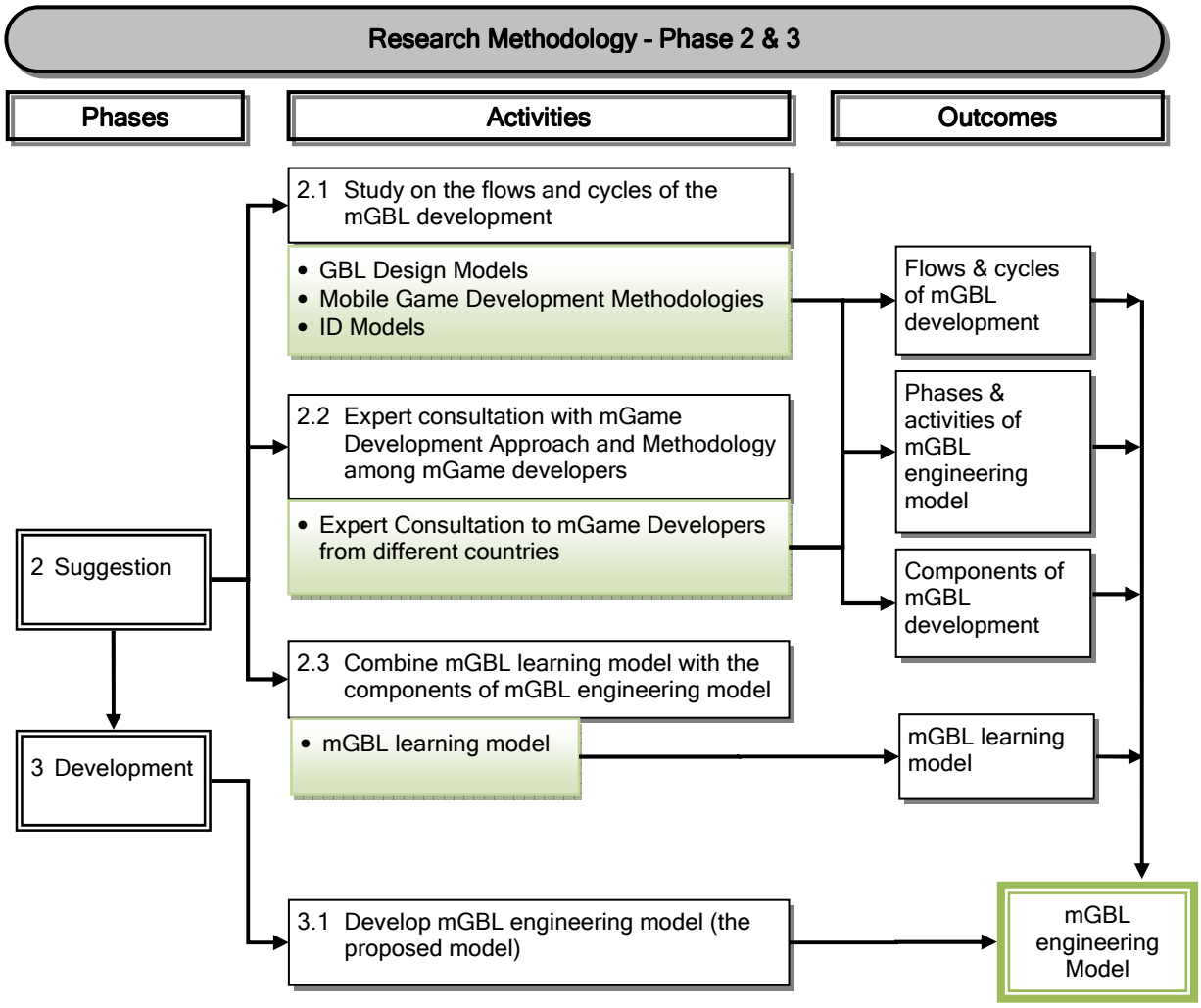


Figure 3.3: Phase 2 & 3 – Suggestion and Development

3.6.2 Expert Consultation

Expert consultations were conducted in order to provide empirical evidence from game industries (mobile game developers) that follow their own mobile game development methodology. The main purpose of this activity is to identify components, phases and steps involved in developing mobile game which are currently practiced by mobile game developers. The findings are discussed further in Chapter 4.

3.6.3 Combine mGBL Learning Model with the mGBL Engineering Model

At this stage, all components gathered that are related to mGBL development were compiled and integrated into the mGBL engineering model. The combination includes model components, learning model, phases, activities, and flows. In the next development phase, the final proposed model was developed.

3.6.4 mGBL Engineering Model Development

The development of the proposed model was based on activities conducted in previous phases. The key issues of developing mGBL that have been identified in previous phases and all proposed phases, components, activities of mGBL engineering model were integrated to form the proposed model. The model development process was iterative based on the evaluation conducted. Detailed descriptions on the proposed model are described in Chapter 4.

3.7 Phase 4: Evaluation

Vaishnavi and Kuechler (2007) suggest different types of approaches to evaluate and validate research outcome, namely: demonstration, experimentation, simulation, using metrics, benchmarking, logical reasoning, and mathematical proofs. These approaches vary in terms of their appropriateness and the strength. In addition, Hevner et al. (2004) suggest the methods to be used for evaluating of the research outcome which are summarized in Table 3.2. They also mentioned that the selection of evaluation methods must be matched appropriately with the research outcome.

Table 3.2: Design evaluation methods and techniques (Hevner et al., 2004)

Methods	Examples of Techniques
Observational	• Case Study – Study artefact in depth in business environment. • Field Study – Monitor use of artefact in multiple projects.
Analytical	• Static Analysis – Examine structure of artefact for static qualities (e.g., complexity). • Architecture Analysis – Study the fitness of artefact into technical IS architecture. • Optimization – Demonstrate inherent optimal properties of artefact or provide optimality bounds on artefact behaviour. • Dynamic Analysis – Study artefact in use for dynamic qualities (e.g., performance).
Experimental	• Controlled Experiment – Study artefact in controlled environment for qualities. • Simulation – Execute artefact with artificial data.
Testing	• Functional (Black Box) Testing – Execute artefact interfaces to discover failures and identify defects. • Structural (White Box) Testing – Perform coverage testing of some metric (e.g., execution paths) in the artefact implementation.
Descriptive	• Informed Argument – Use information from the knowledge base (e.g., relevant research) to build a convincing argument for the artefact's utility. • Scenarios – Construct detailed scenarios around the artefact to demonstrate its utility.

For this study, the experimental method was appropriate for the evaluation. Apart from the experimental method, two other evaluation methods as utilized by Sherwood and Rout (1998) were adopted; (i) expert review, and (ii) demonstration by developing a prototype of the mGBL application. The combination of these three evaluation methods (see Figure 3.4) ensures that the final implementation of the mGBL engineering model represents an approach to the development of mGBL that have proven benefits in terms of certain criteria (as described next).

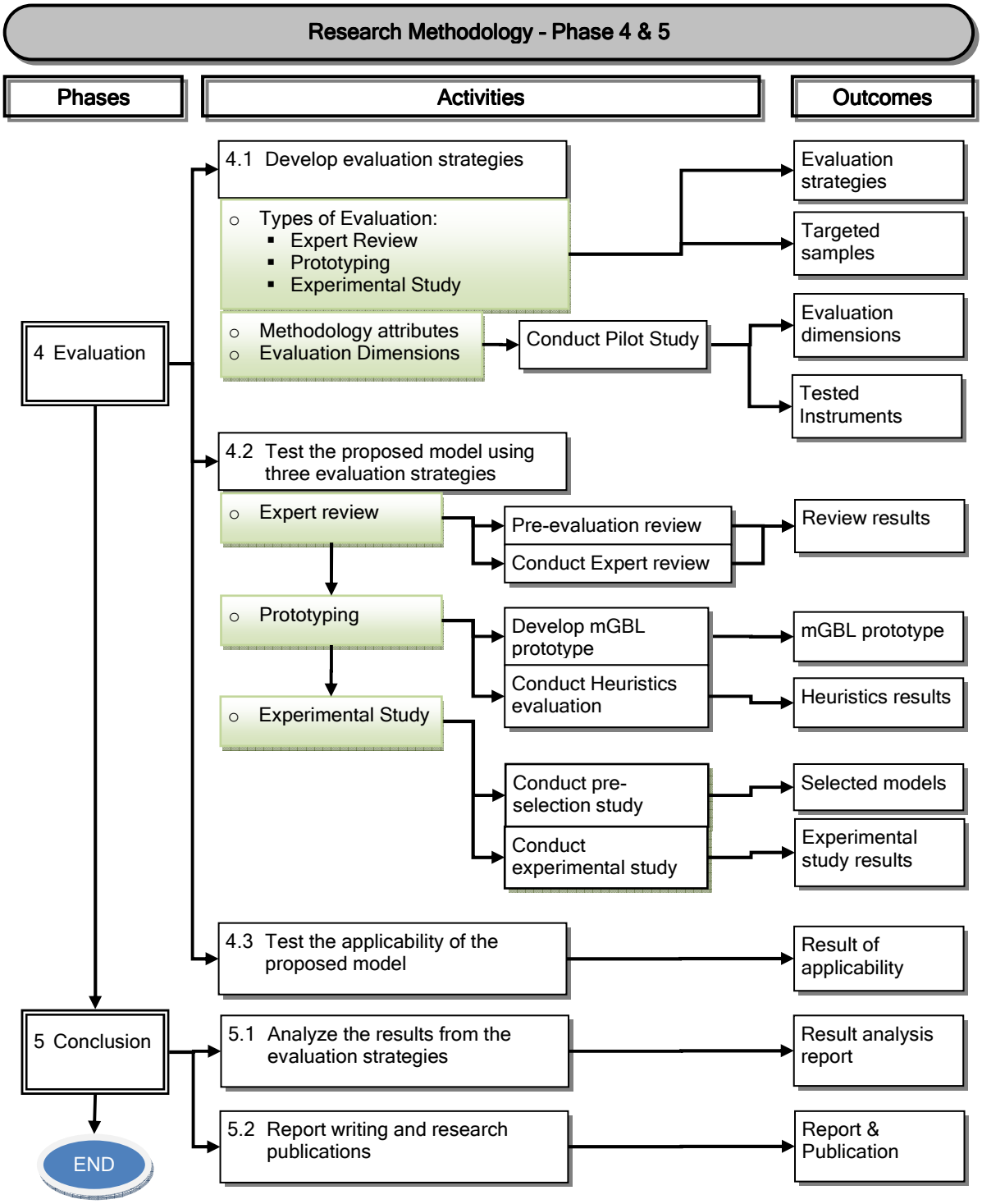


Figure 3.4: Phase 4 & 5 – Evaluation & Conclusion

3.7.1 Pre- Evaluation and Expert Review

In system development, expert review is recognized as a significant way to improve the quality of the developed software and as a complement for testing of other products (Wiegers, 2002). Therefore, this study adopted it in the evaluation of the proposed model. In the expert review processes, two activities were conducted: (1) pre-evaluation review, and (2) the actual expert review. Both activities were formed in particular to evaluate the proposed model.

The pre-evaluation review acted as the initial evaluation of the proposed model which was conducted with seven academicians who have experiences in multimedia or software engineering domains. While, the expert review process was conducted with mobile game developers from the mobile game industries and academic experts. Three developers and one academic expert participated as the review committee. Schneiderman (1998) suggests that having between three to five experts participating in an expert review is sufficient. The procedures for the expert review were arranged using the following manner: (a) setting up the review form based on the selected evaluation attributes; (b) conducting the review; and (c) analyzing the results. Detail descriptions and results of the pre-evaluation and expert review session are discussed in Chapter 5.

3.7.2 Prototype Development and Heuristics Evaluation

The evaluation stage was also conducted through mGBL prototype development. Prototyping is widely acknowledged by software developers for early development testing. Costagliola et al. (2001) reveal that prototyping will help the developer to figure out the requirements to develop the expected end product (in this case the mGBL). The development of mGBL prototype followed the phases which are proposed by the mGBL engineering model. A local game development company took part in the prototyping stage. In the end, the prototype was examined using heuristics evaluation to examine whether the proposed model is applicable for

assisting in developing mGBL application. This study decided that as an assumption, if the prototype can be developed and is playable, then the model is applicable to the development of mGBL application. Further details on the development of the mGBL prototype and results of the heuristics evaluation are described in Chapter 5.

3.7.3 Pre-Selection Study on the Preferred Models for mGBL Development

The study was conducted involving 77 undergraduate students undertaking Game Application Development course at Universiti Utara Malaysia that are to represent samples of potential game developers. The objective of the survey was to know the preferred choice of development methodologies for mGBL development. It was assumed that once the preferred choices are known, then it will better reflect the choices of potential game developers. Therefore, the most preferred control models for experimental study were considered. The 15 methodologies and models as described in Chapter 2 were grouped into three categories (each with five models) namely; mobile game development methodologies, ID models, and GBL design models. Finally, the chosen models were used for the experimental study by comparing with the mGBL engineering model. In Chapter 6, detailed descriptions and results of the pre-selection study are explained.

3.7.4 Experimental Study

The third part of the evaluation stage is an experimental study. As discussed by Luna-Reyes and Andersen (2002), the experimental study can be performed on a real project to measure the practicality aspect, and therefore this can assist for validating the proposed model. In particular, this study focuses on the eight dimensions that could be concerned with the evaluation of the proposed model. Basically, the experiment intended to compare a group of students who implemented the proposed model (one experiment group) with students who implemented other preferred models (three control groups). The experimental study was conducted according to suggestions of Bordens and Abbott (2008) that

the experimental study should be designed based on the available resources and the study purposes.

The experimental study was conducted by assigning a project to student in four groups which consist of one experimental group and three controlled groups. They could be represented samples of potential game developers. The students were asked to develop an mGBL application for their project assessment. In general, the procedures of the experimental study were arranged in the following steps:

i) conducting a pre-selection study on the preferred models for mGBL development,
ii) selecting the students and dividing into four groups,
iii) running the experiment by giving different models including the proposed model to each group,
iv) collecting the data based on the evaluation dimensions that should be measured,
v) analyzing the data using ANOVA and multiple comparisons.

Detailed descriptions and results of the experimental study are described in Chapter 6.

3.7.5 Instruments Developed for this Study

Instruments utilized were developed for the following phases:

i) Expert Consultation (Appendix A)
ii) Pre-Evaluation Review (Appendix B)
iii) Pre-Selection Study on the Preferred mGBL Development Models (Appendix C)
iv) Expert Review and Experimental Study (Appendix D)
v) Heuristics Evaluation Strategy (Appendix E)

3.7.5.1 Instrument for Expert Consultation

The main objective of this activity is to get advices from the experts regarding the phases, activities, flow, and related issues regarding the development of mobile game for learning. An online form was produced and this activity was conducted for two months between August and September in 2008. The instrument used was a questionnaire with 12 questions which include demographic profile, and close and open-ended type questions in regards to the objective of this activity (refer to Appendix A).

3.7.5.2 Instrument for Pre-Evaluation Review

A pre-evaluation review is an activity to seek views of peers. The pre-evaluation review of the proposed model was conducted to gain comments and suggestions for improvement. It was also to ensure that the mGBL engineering model represents a systematic and clear approach upon the development of mGBL. The activity was similar to peer review technique which is recognized as a significant way to improve the quality of the developed product and also as a complementary testing (Wiegers, 2002). The pre-evaluation review is the initial evaluation of the proposed model. Seven academicians who have experiences in multimedia or software engineering domain involved in the review. The instrument (refer to Appendix B) was developed to get initial feedbacks and comments about the proposed model using the following dimensions (Veryard, 1985; Platts, 1990; Lang & Barry, 2000; Riemenschneider, 2002; Yu & Cysneiros, 2002; Ciconte, 2003; Hecksel, 2004; Bonner, 2008; Kerzner, 2006):

i) **Visibility**

   The model is visible to the game developers, so that the developers can judge the relevance and completeness of the game development.

ii) **Clarity**

   The model as a whole is workable and the phases in the model are easily followed and steps or activities included in the model are easy to apply.

iii) Effectiveness

The model is perceived to increase productivity, effectiveness and quality of mGBL development.

iv) Flexibility

The model provides flexible development process with minimal planning and the model should be flexible and adaptable for future use.

3.7.5.3 Instrument for Pre-Selection Study on the Preferred mGBL Development Models

The purpose of this study was to determine the preferred choice of the mGBL methodology and model from the views of potential developers. The 15 methodologies and models as described in Chapter 2 were grouped into three categories, namely; mobile game methodologies, ID models, and GBL models. Each category consists of five models.

An explanation session was arranged to the 77 respondents in order to describe the 15 methodologies and models for a better understanding. Then, the students were asked to rank (from 1 to 5) the models based on their preferred choice. The instrument used is provided in Appendix C.

3.7.5.4 Instrument for Expert Review and Experimental Study

In evaluating the proposed model, some evaluation dimensions were studied which can be used for assessing the model. A number of evaluation dimensions have been proposed by researchers to evaluate models and methodologies which were extracted from different fields such as general software development, multimedia applications, and project management. These are from Veryard (1985), Platts (1990), Henderson-Sellers (1995), Lang and Barry (2001), Riemenschneider (2002), Yu and Cysneiros (2002), Ciconte (2003), Hecksel (2004), Bonner (2008), and Kerzner (2006). These dimensions were compared and composed as exhibited in Table 3.3.

From the comparison table, this study selected a list of dimensions for evaluating mGBL engineering model. The conditions for determining the dimensions were based on the most cited as described in the literatures. Therefore, the evaluation dimensions for mGBL engineering model were customized based on these dimensions.

Table 3.3: Comparison of evaluation dimensions from 10 studies

No.	Dimensions	A	B	C	D	E	F	G	H	I	J	Total
1	Compatibility/ Adaptability	✓	✓		✓	✓	✓			✓	✓	7
2	Availability/ Visibility	✓			✓			✓	✓		✓	5
3	Complexity/ Comprehensive	✓		✓	✓	✓	✓			✓		6
4	Relative Advantage/ Performance/ Effectiveness	✓			✓	✓			✓	✓		5
5	Evolutionary Development/ Broadness/ Inclusiveness	✓			✓				✓	✓		4
6	Flexibility/ Scalability	✓							✓	✓	✓	4
7	Reliability/ Accuracy	✓						✓	✓			3
8	Ease of Use/ Serviceability/ Straightforward/ Understandability/ Clarity	✓	✓		✓	✓	✓		✓			6
9	Usability/ usefulness	✓	✓			✓			✓			4
10	Security/ reduce risk & errors							✓	✓			2
11	Maintainability/ Manageability/ project management/ speed of development	✓		✓	✓		✓	✓	✓		✓	7
12	Well supported/ tools/ guidelines	✓		✓			✓					3
13	Intention to use					✓						1
14	Social Factor					✓						1
15	Validation/ Verification/ Test/ Metrics			✓			✓					2
16	Description on Deliverables/ Notation			✓								1

Legend: ✓- means the study includes the particular dimension

Notes:

A - Veryard (1985)
B - Platts (1990)
C - Henderson-Sellers (1995)
D - Lang & Barry (2001)
E - Riemenschneider (2002)
F - Cysneiros (2002)
G - Ciconte(2003)
H - Hecksel (2004)
I - Bonner (2008)
J- Kerzner (2006)

Eight dimensions are proposed and some of the dimensions that share similar connotation are stated as a single dimension. For instance, “compatibility/ adaptability” is stated as compatibility and “availability/ visibility” becomes visibility. The choices of the term selected are based on the most appropriate to

describe the dimensions that are under evaluation. Table 3.4 defines the chosen dimension for evaluating the mGBL engineering model.

Table 3.4: Construct Descriptions for mGBL Engineering Model

Dimensions	Descriptions
1. Visibility	• The model is **visible** to the game developers, so that the developers can judge the relevance and completeness of the game development.
2. Complexity	• **Complexity** is the degree to which a model is perceived as difficult to use. The more complex the model, the more difficult to use. • **Learning** about the model should be easy, clear and understandable.
3. Compatibility	• **Compatibility** refers to the degree to which a model is perceived as being consistent with the existing values, needs, and past experiences of game developers.
4. Flexibility	• The model provides **flexible** development process with minimal planning. The model is also **adaptive** and **responsive** to changing user needs. The model should be **flexible** and **adaptable** for future use.
5. Clarity	• The model as a whole is **workable**. The phases in the model are **easily followed** and steps or activities included in the model are **easy to apply**. • The model also provides **specific guide** upon the development of mGBL.
6. Effectiveness	• The model is perceived as being better than other model. By using the model, it will increase the **productivity, effectiveness, and quality** of mGBL development.
7. Manageability	• The processes and activities in the model to **be capable** of being **managed or controlled**. In general, the model also provides **project management**.
8. Evolutionary	• The model provides the **dynamic process** which evolves through continuous feedback from users. • The model is capable to incremental change, to cope with **new ideas** or **technological** opportunities. • The model provides developers to **communicate and collaborate** with **users** continuously to incorporate their evolving requirements.

A set of evaluation form with items was developed based on the 8 dimensions (as described in Table 3.4). The 10-point semantic scale was formed for each item with 1 is the lowest score and 10 is the highest. Each score represents the level of agreement for each item (Figure 3.5). The sample of this evaluation form is presented in Appendix D.

Strongly Disagree Strongly Agree

1 2 3 4 5 6 7 8 9 10

Figure 3.5: 10-point semantic scale

Pilot Study

A pilot study was conducted to the instrument as part of this research. It was considered useful in order to investigate the wellness and feasibility of the instrument (Teijlingen & Hundley, 2001). Obviously, once piloted the instrument would be appropriate for the main research data collection. The pilot study was conducted involving a group of undergraduate Multimedia students as respondents. Before data were collected, they were given an explanation about the mGBL engineering model as the chosen model for developing mGBL application. 46 students completed the questionnaire and this number is adequate to obtain reliable result in response to Sekaran (2003) who suggests employing at least 30 datasets for obtaining reliable result in statistical tests. Reliability test of the instrument was conducted and produced the results as described in next paragraph.

Reliability of a instrument reflects the consistency and stability of the instrument. The value of Cronbach's alpha coefficient was computed and should indicate alpha $\alpha > .7$ (Sekaran, 2003) to be accepted as reliable. From the test, all constructs were found to be significant (refer to Table 3.5 and 3.6). These results demonstrate that the instrument were consistent. Therefore this instrument can be used for data collection of the main study.

Table 3.5: Case Processing Summary

		N	%
Cases	**Valid**	46	100.0
	Excluded	0	.0
	Total	46	100.0

Table 3.6: Reliability Test

Dimensions	Cronbach's Alpha	N of Items
Visibility	.75	3
Complexity	.87	5
Compatibility	.86	5
Flexibility	.79	4
Clarity	.89	8
Effectiveness	.87	5
Manageability	.84	4
Evolutionary	.85	5

Construct validity concerns with the relationship of the measure to the underlying attributes it is expected to assess. However, since the number of samples in the pilot study was not adequate to conduct the construct validity test, data from the actual main study (70 respondents) were accumulated with the pilot study (46 respondents), giving a total number of 116. In conducting the construct validity test, factor analysis was run by utilizing Principal Components Analysis extraction method with Varimax rotation (Hair et al. 2006). Three test indicators can be used are Kaiser-Meyer-Olkin (KMO), Barlett's test, and factor loading.

Firstly, the KMO test resulted in .692 for visibility, .816 for complexity, .789 for compatibility, .771 for flexibility, .887 for clarity, .831 for effectiveness, .834 for manageability, and .858 for evolutionary. KMO values over .60 are generally considered suitable and acceptable for the measures (Hair et al. 2006). Secondly, the Barlett's test of sphericity also gave the significance level of $p < .000$ for all constructs.

Finally, factor loadings were also analyzed for validity as illustrated in Table 3.7. The results explain that all items with loadings above .70, made evidences of well defined structure of the measure (Hair et al., 2006).

Table 3.7: Factor Analysis and Loadings for Each Item

Items	Loadings
Visibility	
The model allows me to determine the completeness of my project.	.863
The model allows me to intelligently judge the relevance and completeness of my project.	.863
The model makes reasoning clear and visible to me as a developer of mGBL.	.808
Complexity	
Learning the model is easy for me.	.831
I think the model is clear and understandable.	.810
Using the model does not require a lot of mental effort.	.859
The model is not cumbersome to use.	.763
Using the model does not take too much time from my normal duties.	.781

Compatibility	
The model enables me to work in the way I prefer.	.804
The model is compatible with the way I develop mGBL.	.793
Using the model fits well with the way I like to work.	.858
Using the model is compatible with all aspects of my work.	.805
Using the model is compatible with my past development experience.	.721
Flexibility	
The model is adaptive and responsive to changing in user needs.	.827
The model is flexible with minimal planning.	.762
All the concepts and components included are strictly necessary.	.784
Deviating from the established activities and phases in the model is possible.	.792
Clarity	
The phases in the model are easily followed.	.785
The model as a whole is workable.	.769
Steps or activities included are easy to apply.	.763
Adhering to the phases and activities is easy.	.740
The model provides specific guide to mobile technical specifications.	.817
The model provides specific guide to learning content development.	.850
The model provides specific guide to game testing (educational aspect).	.881
The model provides specific guide to game testing (mobility, playability and usability aspects).	.854
Effectiveness	
Using the model increases my job performance and productivity.	.882
Using the model enhances the quality of my work.	.883
Using the model makes it easier to do my job.	.765
The advantages of using the model outweigh the disadvantages.	.856
Using the model produces the mGBL, for which it is intended for.	.788
Manageability	
The model to be capable of being managed or controlled.	.863
Changing requirements in the model over time is possible.	.846
The model provides manageable guidelines.	.900
The model allows self-monitoring to be followed.	.887
Evolutionary	
The model allows continuous feedback from users.	.811
The model is capable of incremental change, to cope with new ideas or technological opportunities.	.891
The model provides opportunity for improvements learned from experience.	.858
The model provides communication and collaboration between developers and users continuously to incorporate the evolving requirements.	.836
The model is tolerant of minor errors and alterations.	.778

In summary, from all the tests conducted, the dimensions and items used are feasible for the study.

3.7.5.5 Instrument for Heuristics Evaluation Strategy

In order to measure the perception of users on the mGBL prototype, the proposed heuristics evaluation strategy was used. Although in practice, heuristics method relies on experts as the respondents (Korhonen & Koivisto, 2006), in this study the heuristics are utilized in twofold; first to design the mGBL based on those heuristics, and second to use the heuristics as items in an instrument. The evaluation ran in a natural setting while users play the mGBL. In addition, this provided a better sense to users without having any formal circumstances. Four dimensions were measured: Game Usability (GU), Mobility (MO), Playability (PL), and Learning Content (LC), as in the instrument provided in Appendix E.

i) Game Usability (GU) Components

The GU components (Table 3.8) measure the interface and game controls aspects which the player interacts with the game. Game interface allows player to play smoothly and react based on user actions. In general, good game usability ensures that the player has interest to play the game until the end.

Table 3.8: Game usability components (Korhonen & Koivisto, 2006)

No.	Game Usability Components	Descriptions
GU1	Audio-visual representation supports the game	The games should look visually appealing. All graphics and audio should support game play and story; be consistent and informative to player.
GU2	Screen layout is efficient and visually pleasing	The screen design should present all necessary information to player and follow the general principles of good screen layout design.
GU3	Device user interface (UI) and game UI are used for their own purposes	The player interacts properly with the game user interface and device functions. Full-screen mode is preferable.
GU4	Navigation is consistent, logical, and minimalist	All buttons and navigations should be organized reasonably, provide more clarity and easier to remember. The navigation should also be intuitive and natural.
GU5	Control keys are consistent and follow standard conventions	Standard control keys can be used since the player already knows from other games they have played.

GU6	Game controls are convenient and flexible	The game controls are possible to be customized. The controls also should be designed based on device's capacities.
GU7	The game gives feedback on the player's actions	It is preferred if game user interface has a quick response on player's actions. The feedback can be presented in graphics, audio or tactile.
GU8	The player cannot make irreversible errors	The game should provide confirmation message for actions that can cause serious and permanent damage. Recovery is allowed when mistakes happen.
GU9	The player does not have to memorize things unnecessarily	The player's memory should be used at minimum. Game user interface design and challenges are considered in this aspect.
GU10	The game contains help	The game provides instructions to player for playing the game. It is unnecessary for player to read manuals frequently.

ii) Mobility (MO) Components

Next, in Table 3.9, the MO components concern about the issues that affect mobility of the game. Mobility can be defined as the ease of a player to enter to the game world and the accessibility of the game from anywhere and at anytime.

Table 3.9: Mobility components (Korhonen & Koivisto, 2006)

No.	Mobility Components	Descriptions
MO1	The game and play sessions can be started quickly	The game sessions can be started quickly and easily, preferably in less than five seconds. There is a possibility to skip the game introduction.
MO2	The game accommodates with the surroundings	Mobile games are played everywhere and this should accommodate the surroundings. The game audio volume can be conveniently adjusted or muted. The game should also put up with the device settings for instance, in silent mode.
MO3	Interruptions are handled reasonably	Interruptions such as incoming calls and messages are allowed during the play session. It is possible for the player to pause the game at any time and continue to play later.

iii) Playability(PL) Components

The ten PL components (Table 3.10) test how the game is playable, run smoothly and consistently, meaningful, and not bored to player. The PL is important because it is dynamic and occurs when the player interacts with the game mechanics and rules.

Table 3.10: Playability components (Korhonen & Koivisto, 2006)

No.	Playability Components	Descriptions
PL1	The game provides clear goals or supports player created goals	The game goals are provided clearly because having a clear goal in player's mind is the core of an enjoyable experience. The goals can be either short-term or long-term.
PL2	The player sees the progress in the game and can compare the results	The game provides the game progress. The progress can be showed as high-score lists, rankings, character levels, or different titles.
PL3	The players are rewarded and rewards are meaningful	The game should provide rewards as a player progresses in the game. It should be meaningful for the player and should be adjusted to the challenge.
PL4	The player is in control	The player should know what is happening in the game world. The players will be able to decide on actions they have to take for continuing in the game world.
PL5	Challenge, strategy, and pace are in balance	The game should not bore the player and he can choose the difficulty level. All game strategies and the pace can be adjusted to the player's need.
PL6	The first-time experience is encouraging	The game can create a good first impression of the game within the first five minutes. The first play session should make the player desire for the next play session.
PL7	The game story supports the game play and is meaningful	The players can make their own decisions in the game. The story is meaningful and fits to the game elements.
PL8	There are no repetitive or boring tasks	The task repetitions without changing any conditions are not advised. This will give boring tasks to players.
PL9	The game does not stagnate	The player must know that the game progression and the game ending session should be clearly indicated. There is also a possibility of restarting the game again.
PL10	The game is consistent	The consistency in game world is important. The game actions, flow, and design should work in a consistent and logical way.

iv) Learning Content (LC) Components

Lastly, the LC components (Table 3.11) are specifically concentrated on measuring the learning content. The learning content should provide informative, useful, and understandable content to users when playing the mGBL.

Table 3.11: Learning Content (LC) Components

No.	Learning Content Components	Descriptions
LC1	The content can be learned easily	The game should provide an easy learning content, not too complicated as preferable for the intended users.
LC2	The game provides learning content	The game provides learning content, so that the users learn a new knowledge from the game. It could be any information that is of interest to the users.
LC3	The learning objective from the game is achieved	The learning objective from the game is achieved after the game ends.
LC4	The content is understandable	The learning content is easy to understand and as expected by the users.

3.8 Phase 5: Conclusion & Analysis of Findings

In the final phase (Figure 3.4), claims and evidences were justified through analysis of findings. The analysis techniques that were used were based on the evaluation stage. The general descriptive analysis and content analysis were used for the preliminary studies and expert review; factor analysis for pilot study, ANOVA for the experimental study (four groups); and other descriptive statistical analysis for general analysis. SPSS Version 15 was used to analyze the data and produce charts and graphs. All analyses of the results are discussed in detail in the following chapters.

3.9 Samples and Unit of Analysis

The unit of analysis can be viewed as the main entities being studied, about which data are gathered (Yin, 2003). The unit of analysis and sample in this study at individual level are:

a) School students who participated in the preliminary study. The targeted samples for the preliminary study were respondents of age between 13 and 17. They were 591 students of Malaysian secondary schools.
b) Experts who took part in the expert consultation. Expert consultations were conducted through online in order to provide empirical evidence from game industries (mGame developers) about the phases and activities in mGame development. There were 6 respondents of the mGame developers, with each from Malaysia, Germany, United State of America, United Kingdom, Ukraine, and France.
c) School students who were involved in the heuristics evaluation strategy. They were 20 respondents, representing samples of game players.
d) Undergraduate students who participated in the pilot study. The pilot study involved 116 students who were studying Bachelor of Multimedia degree in Universiti Utara Malaysia. They were representing potential game developers.
e) There were 77 undergraduate students who participated in the pre-selection survey on the preferred choice of methodology for developing mobile game. They were the same students who participated in the experimental study. They were to represent potential game developers.
f) Pre-evaluation review involved 7 academicians who have experiences in multimedia of software engineering. Appendix F shows the list of the academicians.
g) Experts who were involved in the review stage. Three game developers (from the game industries) and one academic expert (in game design) participated in the review. Appendix G lists down the four experts.
h) Undergraduate students who participated in the experimental study. The experimental study involved 70 students who were assigned into four different groups (one experiment group and three control groups). They were taking game development course. They were also to represent potential game developers.

3.10 Summary

In a nutshell, this chapter deals with the study approach which is adopted from the design science research methodology. The approach delineates the phases running in the methodology. Five major phases were performed in order to achieve the research objectives, which encompassed (i) awareness of problem, (ii) suggestion, (iii) development, (iv) evaluation, and (v) conclusion. Each phase is described further with details of the activities involved during the study. The following chapters discuss the deliverables and results of this study.

CHAPTER 4

The Proposed Model: mGBL Engineering Model

4.1 Introduction

This chapter details out the proposed mGBL engineering model which comprises phases, components, activities, and deliverables. This model is proposed intentionally for guiding developers in developing mGBL applications. A better mGBL application delivery is also expected by implementing the proposed model. The development of the model was based on the problem and solution discussed in Chapter 1, review on mGBL characteristics comparative study in Chapter 2, and expert consultation with mobile game developers which is described in this chapter.

In developing the mGBL engineering model, few activities (as listed in Table 4.1) were conducted prior to proposing the model phases, components, flows, and activities. Phases are distinct general stages of the model that can be performed in order (from phase one to three), while components can be described as constituent parts of the model that contribute to each phase and give specific stages of each phase. These components are seen fundamental to be included during the product development. On the other hand, flows in the model define the way and manner of progress from one phase or activity to another. Activities in the model are specific steps or processes that are suggested to be conducted during the product development.

Table 4.1: Activities performed prior to proposing the model

Elements	Activities	Chapter discussed
Phases	• Expert consultation • Comparative study of mobile game development methodology	Chapter 4 Chapter 2
Components	• Content analysis of the literature • Comparative study of the GBL model, Mobile Game Methodologies, ID Models	Chapter 2 Chapter 2
Flows	• Expert consultation • Comparative study of the GBL model, Mobile Game Methodologies, ID Models	Chapter 4 Chapter 2
Activities	• Expert consultation • Comparative study of the GBL model, Mobile Game Methodologies, ID Models	Chapter 4 Chapter 2

All these model elements were combined and made up as the mGBL engineering model. The gathered model elements were also reviewed by the expert consultation which is described next.

4.1.1 The Expert Consultation

Expert consultation was conducted in order to provide empirical evidence from existing companies (mGame developers) that follow their own mGame development methodology. The main objective of this task is to identify phases and steps involved in developing mGame which are currently practiced by mGame developers. The task was conducted online and two months were allocated for data collection period. The research instrument used was a questionnaire with 12 questions which include demographics profile of the respondents, and close and open-ended type questions in regards to the mGame development steps. Table 4.2 shows the profile of the companies and their responses for the questions addressed.

There were six respondents (mGame developers), each from Malaysia, Germany, United State of America, United Kingdom, Ukraine, and France. From the profiles, only two companies (Malaysia and Ukraine) have experienced in developing educational mGame. Regarding the questions related to the development method,

first, the respondents were asked about their current practice of the mGame development methodology. All of the respondents (100%) have their in-house development methodology for mGame development that are adaptation of a general system development life cycle (SDLC) or agile methodologies.

Table 4.2: Responses from the experts

Company	**A**	**B**	**C**	**D**	**E**	**F**
• Company base	Malaysia	Germany	USA	UK	Ukraine	France
• Year established	2008	2001	2000	2003	2000	2003
• Number of mobile game developed	2	1	400	157	90	15
• Do you follow any mobile game development methodology?	Yes	No	Yes	Yes	Yes	Yes
• Do you use in-house mobile game development methodology?	Yes	Yes	Yes	Yes	Yes	Yes
• Do you develop educational game?	Yes	No	No	No	Yes	No
• In your opinion, does educational mobile game development requires specific methodology?	Yes	No	Yes	Yes	Yes	Yes

An analysis was run to examine the variety of mGame development methodologies by looking at the phases, activities, and flows involved. Regarding the steps implemented by the developers, most of them relatively use the similar general main phases; pre-production, production, and post-production. The first phase is the pre-production where the preliminary arrangements concerning conception and planning, are made upon the inception of an mGame development. The second phase is production where the mGame is technically produced which includes code and content integration. The third phase is post-production, which is the final stage in mGame development, and typically involves finalizing the mGame before it is marketed.

Flow and cycles of development model show the connection from one process and activity with another. The flows also illustrate how the data moved from one process to another, and the intention is to make sure that the product development moves or runs smoothly with unbroken continuity. The results show that in terms of flows and cycles of the model, the experts suggested that the flows of the model

must be iterative and flexible, providing meaning, and easily understood. For general phases, the flows are executed sequentially, while the components and activities in each phase can be adjusted according to the developers preferences.

The activities involved as suggested by the respondents in developing mGame can be summarized subjected to these three phases as found in Table 4.3.

Table 4.3: Activities and phases suggested for mGame development

1. Pre-production Phase	2. Production Phase	3. Post-production Phase
• brainstorming idea • creating concept • creating storyboard • writing game pre-script • researching target audience • planning schedule	• preparing multimedia elements • coding • developing game engine • integrating game features • developing game levels • testing	• publishing • deployment • testing in live version • testing of devices • assuring quality

Apart from that, the respondents were also asked about the differences between developing entertainment-based game and learning-based game. Majority of the respondents agreed that there are variations between activities of developing both cases. Some of them justify that when developing learning-based games, it should consider psychological factors, content expert advices, and suitability for the target users. All of these reasons are to ensure that the audience is being educated and they learn while playing learning-based game.

In summary, the expert consultation has given some significant contributions to the proposed model. In consequence, this activity has identified the key elements of mGBL engineering model such as phases, activities, and flows for the development of mGBL applications. The detail of the proposed model is described in the next section.

4.2 The Proposed mGBL Engineering Model

The proposed mGBL engineering model comprises phases, components, activities and deliverables for the development of mGBL application. It is divided into two layers, where the first inner layer is called as general phases; pre-production, production and post-production. The second layer consists of components to be included for each respective phase as illustrated in Figure 4.1. The three phases are executed in a sequential manner starting from pre-production phase followed by production phase and then post-production (the clockwise-direction arrows represent the flows of the phases). After completing the first phase, all designs are sent for review before second phase take place. Then any amendments are made and corrected after review. If the design are approved and signed off, the production phase is carried on next. The similar review activity should also be conducted after completing the production phase. All errors and inaccuracies of technical aspects of the game are rectified before it continues to the final phase.

The engineering model also includes components which are numbered from 1 to 12, namely:

i) Requirement Analysis & Planning
ii) Mobile Interaction & Technical Analysis
iii) Learning Content Design
iv) Game Features Design
v) Learning Content Development
vi) Game Assets Development
vii) Coding & Core Mechanics Development
viii) Game Features Integration
ix) Game Porting & Deployment
x) Playability, Usability & Mobility Testing
xi) Educational Testing
xii) Distribution

These components are flexible and iterative, which can be customized based upon developer's preferences. These components are also mapped to the AI four stages: i.e. discover, dream, design, and delivery (refer to Figure 2.5 in Chapter 2). In addition, the mGBL engineering model suggests the expanded guidelines by providing specific objectives, activities, and deliverables for each component.

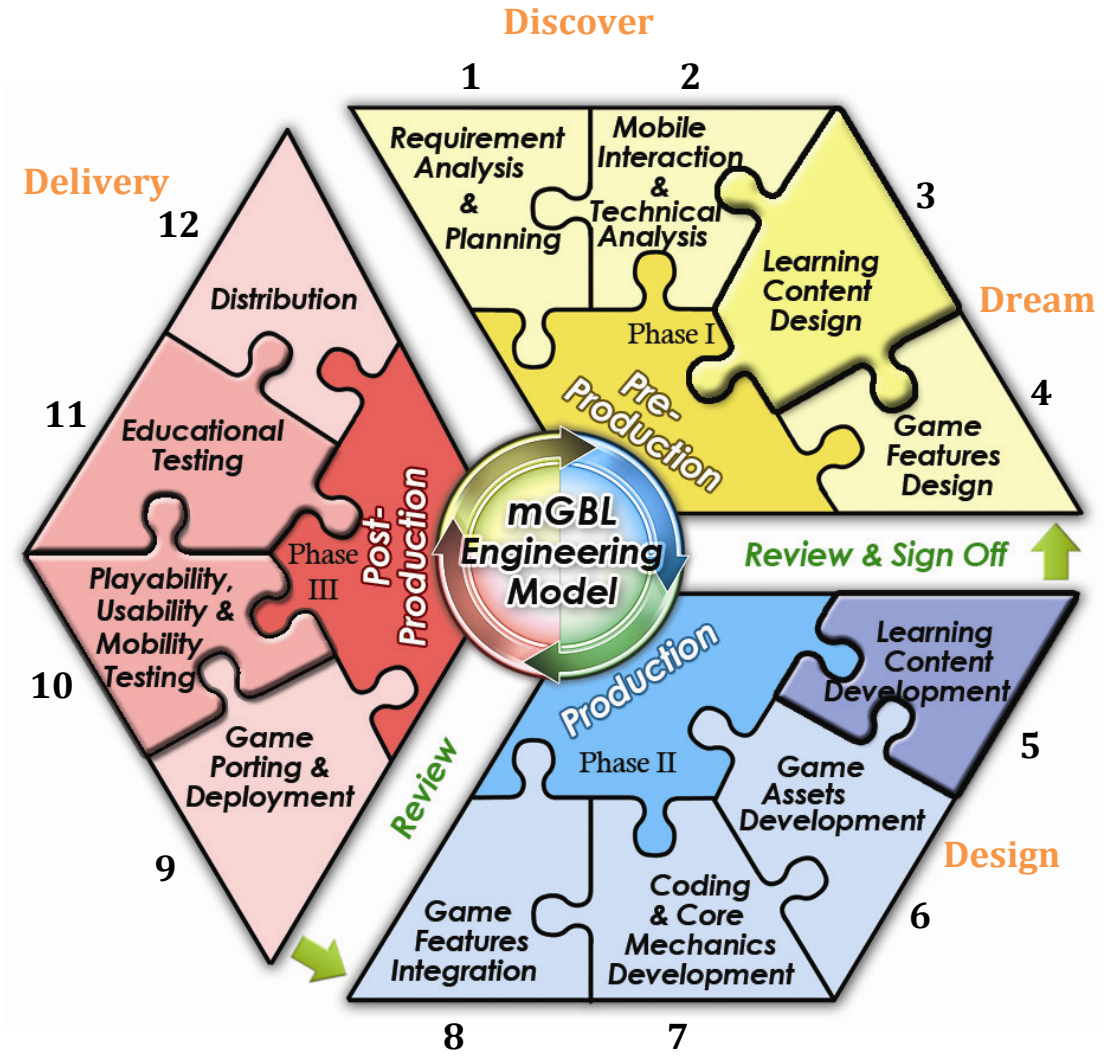


Figure 4.1: mGBL Engineering Model

4.2.1 Pre-Production Phase

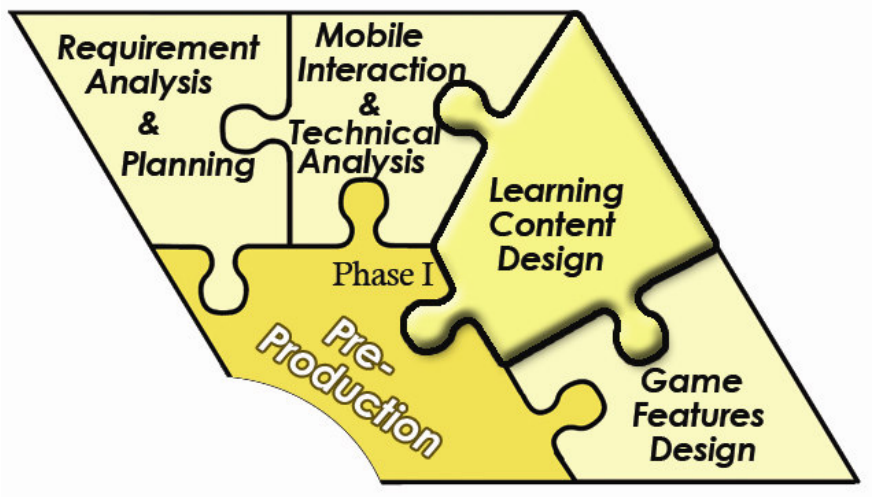


Figure 4.2: Phase 1, Pre-Production

In pre-production phase (Figure 4.2), four components are identified which are essential to be considered at the initial stage of mGBL development, namely Requirement Analysis & Planning; Mobile Interaction & Technical Analysis; Learning Content Design; and Game Features Design. At this phase, creating the mGBL concept is a vital activity which will be referred to in the next production phase.

In relating to the AI stages, the first two components (component 1 and 2) are embraced in the discover stage. At this stage, the concentration is more towards putting activities in finding out creatively the best idea for the new game, discovering new potentials and possibilities of team member's skills, and analyzing prospective game requirements. In the dream stage, creativity is needed to design the game features and learning content. All ideas are sketched down initially on papers and reproduced in proper documents. Designers are encouraged to be bold and risk-taking in their imaginations.

i) Component 1: Requirement Analysis & Planning

The component is initially about conceptualizing idea of game, discovering the target audience, and planning the game development (Figure 4.3). The very first step is about game conception. The main objective at this stage is to identify a concept of the game. It is the general idea, theme, scope or storyline of a game being developed that will stand as the framework for game design. This can be done through brainstorming with team members.

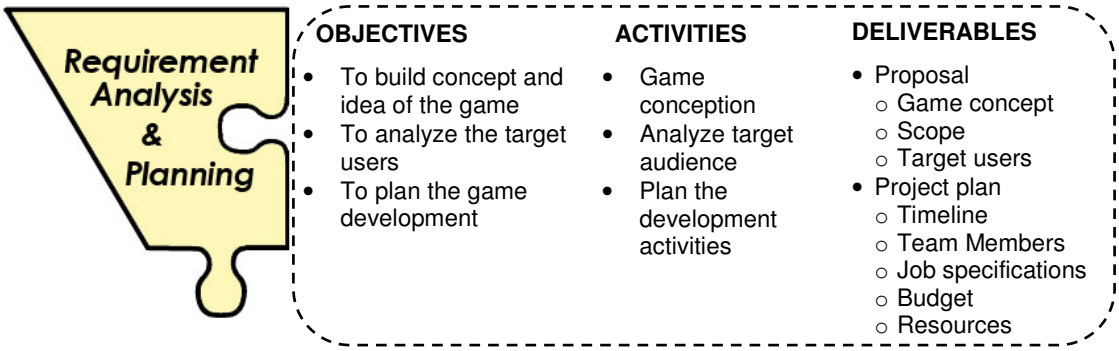


Figure 4.3: Component 1- Requirement Analysis & Planning

When the general game concept is decided, the target users or market segment should be chosen. Basically, the question of who will use and play the game should be answered. Next, the management of the project is also important to be specified at this stage, where all schedules and talents are identified. Planning of schedule is to define the guidelines for all stages in the development. This choice will define the direction for the entire game development efforts.

ii) Component 2: Mobile Interaction & Technical Analysis

This component is very important in considering the mobile devices for the game to be played on. Figure 4.4 shows the objectives, activities, and deliverables of this component. In game interactions, developer should consider the capabilities of mobile devices and it is suggested that the game interaction is therefore be as simple as possible. The basic rules of the game interactions should be easy to learn and remember, with easily grasped controls. Such interactions are based on device

capabilities such as keypads, joystick-like navigation keys, arrow keys, numeric keys (2 for up, 8 for down, 4 for left, and 6 for right) which are the natural choice for control and easy for players to learn.

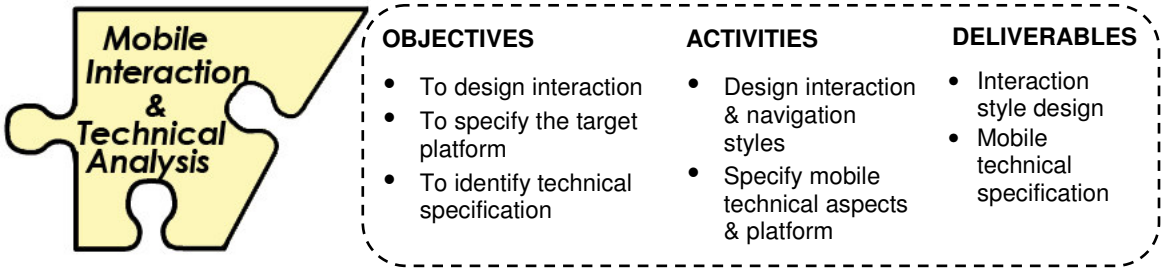


Figure 4.4: Component 2- Mobile Interaction & Technical Analysis

Regarding technical analysis, the developer should also analyze and cater for the limitations of the mobile devices. The limitations of the mobile platform must be approached properly and these limitations include (Forum Nokia Library, 2010; Gong & Tarasewich, 2004):

- **Different platforms for different devices.**

  Examples of mobile operation platforms are: Symbian, Windows Mobile, Apple's iOS, Android, Samsung Bada, and Binary Runtime Environment for Wireless (BREW).

- **Small and different screen sizes**.

  Mobile phone displays come in many shapes, sizes, and modes (portrait or landscape). The best approach in dealing the diversity of mobile screen size is to group the devices into common characteristics. It is ideal to the target devices that have web or Flash applications, because the game display is adjustable to the screen size.

- **Limited input controls**.

  The input controls come in limited capabilities based on the targeted devices. These input controls include keypads, joystick-like navigation keys, arrow keys, numeric keys, and touch screen.

- **Limited colour and sound support**.

  Unlike computers, mobile phones have limited colour display and sound support although currently in the market has variety of display and sound technologies are available with a large number of devices. In addition, it is practical to consider few issues such as colour brightness, depth, and sound quality.

- **Limited application size**.

  The size for the game should be small and not heavy for mobile platform. Therefore, the game should be simple, have short play time, yet fun to the players.

- **Interruptible.**

  While game is in progress, players can accept phone call and messages. Therefore, the game must be able to pause and resume without crashing and causing play problems.

- **Evolving technologies**.

  Mobile technologies are rapidly evolving nowadays and this situation becomes one of the limitations on the game design. In response to this limitation, designers should take full advantage of current technologies, and often need to produce multiple versions of the same game for the best effect.

iii) Component 3: Learning Content Design

The main tasks for this component are specifying the subject domain, defining learning outcome and objectives, designing the learning content, and specifying the mGBL characteristics. Figure 4.5 illustrates the objectives, activities, and deliverables of this component.

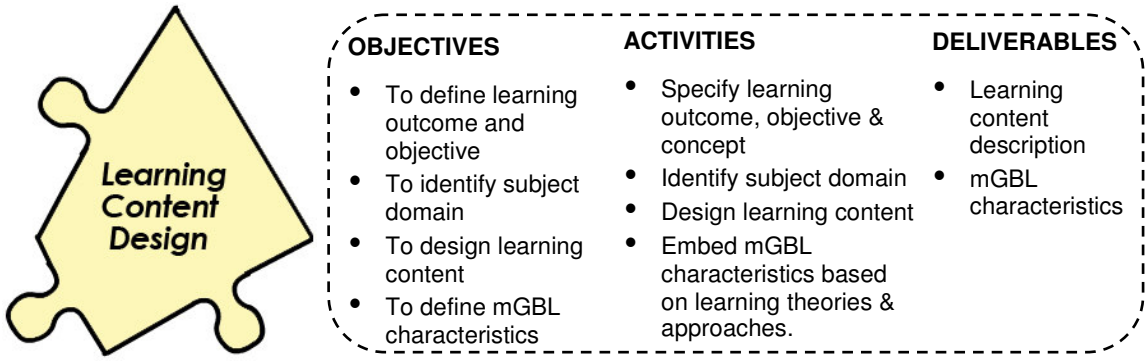


Figure 4.5: Component 3- Learning Content Design

The subject domain could be a school's subject, general knowledge, or any other types of information to be included in the game for learning purpose. When the subject domain has been chosen, the learning outcomes, objectives, and contents should be specified and designed. At this stage, learning content expert of the subject domain should be consulted for verification.

Table 4.4: Learning theories for mGBL learning content design

Learning Theories		
Behaviourism	**Cognitivism**	**Constructivism**
• State game objectives. • Provide hints or cues that guide players to the desired behaviour. • Use consequences to reinforce the desired behaviour. • Provide good system feedback and response. • Provide the concept of repetition and game reward. For example, player practices in a game through repetition while receiving rewards after each proper response.	• Organize new information/ learning content in game. • Link new information to the existing knowledge (game tasks previously completed). • Provide good screen design and navigation in the game. • Supply variety of game resources for choices. • Provide interesting storyline to keep user attention to continue play. • Integrate learning and game experience in attempting to build intrinsic player motivation. • Player engages in a discovery process through the game experience that integrates learning and play.	• Pose good problems - realistically complex and personally meaningful to player. • Create interesting learning activities. • Model and guide the knowledge construction process through game play. • Offer different levels of difficulties in the game. • Offer great game play and challenges. • Provide game challenges that offer player to solve problem in game environment. The challenges can be solved through player's experiences in previous game levels.

In ensuring the learning content is meaningful in the game, learning theories characteristics as listed in Table 4.4 should be embedded in the mGBL learning content. The list of characteristics is useful for designer in order to achieve the learning objectives of the mGBL.

In addition to learning theories, learning approaches (as described in Table 4.5, Table 4.6, and Table 4.7) are also considered relevant to mGBL learning content and characteristics. Although not all characteristics can be adapted to a single mGBL, a few elements are obvious for implementation in mGBL learning content and characteristics.

Table 4.5: Multiple Intelligences connect to mGBL learning content

Intelligences	mGBL Characteristics
Linguistic	In a game, the linguistic elements can be in a form of written words and narrations such as instructions, user guides and game play.
Logical-mathematical	Strategy in game is one of essential features which need players to have logical thinking. Solving problem in mathematical strategy is another desirable game content.
Interpersonal	In a game sometimes needs players to interact with other players (multi-player) or their own (single player). Therefore, competition and collaboration might occur to get the game victory.
Intrapersonal	Challenges in a game encourage players to solve problem by exploring and interacting within the game. This interaction might include emotional and mental challenges.
Spatial	Game always gives visual space in various formats such as colours in 2D or 3D. This space makes players interact actively in the space provided.
Bodily-kinesthetic	This aspect give players to interact physically in the game with bodily movement such as hands, foots and other body parts.
Musical	This aspect is important to game. Audio and musical effects give fun elements to players. The aspect can be in a form of background music, sound effect, or feedback.
Naturalist	This concept provides the experience with flora and fauna in a game. Apart from that, the geographical elements are also included in this aspect.
Existential	Player should feel as a good and important character in a game world. This aspect provides the responsibly to the game environment that should have for game players.

Apart from that, the nine events of instructions can also be associated with mGBL learning content and characteristics. The nine events of instructions are also helpful in designing the flow of the game play that is aligned with the learning content.

Table 4.6: Gagne's Nine Events of Instructions associated with mGBL

Events	mGBL Characteristics
Gain attention	In a game, attractive introduction screen accompanied with sound effects or music startles the senses with auditory or visual stimuli. For example, montage screen and interesting graphics could be used. Sometimes, a game starts with challenging introduction that gives curiosity to players.
Inform learners of objectives	The instructions and game rules are provided in game, as well as objectives of the game to be achieved. These initiate the internal process of expectancy and motivate players to complete the game.
Stimulate recall of prior learning	A simple way to stimulate recall is to challenge players in different levels of difficulties in a game. The higher the level, the harder efforts are needed to complete the task. This process makes players learn and remember the previous tasks completed in previous game levels.
Present the content	This aspect gives players various types of challenges for their skills. Game content should be organized meaningfully. To appeal to different learning modalities, a variety of challenges should be used if possible.
Provide "learning guidance"	Additional guidance should be provided in a game. Guidance strategies include the use of examples, user manual, or tips. A good game is when players do not refer to game manual as they can learn by themselves.
Elicit performance (practice)	In a game the players are required to practice the new skill to finish the game. Practice provides an opportunity for players to confirm their correct understanding, and the repetition further increases the likelihood of their retention.
Provide feedback	It is important to provide good feedback in a game. Feedback in a game can be formed in scores, graphics screen, timing and audio.
Assess performance	Assessment acts as one of the feedback systems in a game. Players should be informed of their level of performance so that they can play until game ends.
Enhance retention and transfer	This aspect is provided in a game with a various types of level. Players need to remember and use their skills to further playing the game. They can use their own strategies to succeed in the game.

In relating PBL approach to mGBL characteristics, few aspects particularly those listed in Table 4.7 of PBL environments could be utilized for enriching mGBL elements.

Table 4.7: PBL characteristics mapped to mGBL

	Problem Based Learning Characteristics				
	Learning is student-centred	**Learning through authentic problems**	**New information is obtained through self-directed learning**	**Learning occurs in small groups**	**Teachers are facilitators**
mGBL Characteristics	• Storyline. • Offer tools to monitor problem solving status.	• Learning content. • Storyline • Adventure theme.	• Learning content. • Adventure theme. • Provide feedback on tasks and overall progress.	• Multiplayer game. • Provide help tools to support task completion.	• Use an avatar or character to present problems and tasks. • Provide help tools to support task completion.

Another important aspect that should be considered at this stage is the mGBL learning model (Figure 4.6). The learning model is built on experiential learning theory as proposed by Kolb (1984). Through experiential learning theory, mGBL supports learning by doing in the game environment. The learning model provides a learning sequence that maximizes the learning process in a significant and meaningful way.

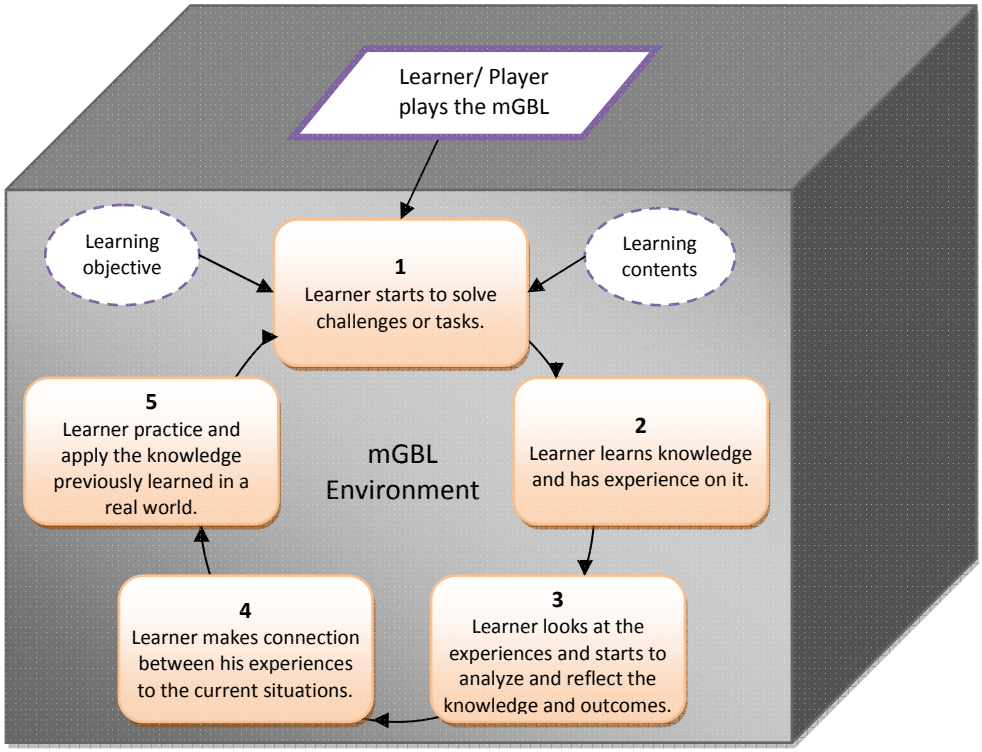


Figure 4.6: mGBL Learning model adapted from Kolb's experiential learning theory

iv) Component 4: Game Features Design

In this component (Figure 4.7), the main idea is to specify and design the game features. The activities that are performed are creating storyboard, writing game scripts, designing game play, game flow, and game environment. Creating a game script and storyboard will help the team understand the game to be developed and will help them plan the design screen by screen. The game script describes the scenes, plans the dialogue, describes the mood, and sets the background music.

Game flow is used to lay out the flow of the game and show the various logical paths the player can make use of. The game flow helps the designer understand what happens in the game and what decisions need to be made. In game environment or world, it is an imaginary place in which the events of the game occur. A game world can have different dimensions such as culture, aesthetic, moral

values and whether it is highly abstract, or highly representational to the real environment (Adam, 2009).

Figure 4.7: Component 4- Game Features Design

4.2.2 Review and Sign-Off After Pre-Production Phase

A review before production phase is termed as a design review. The general purposes of a design review are to identify any defective information in the design and to validate the design. Any amendments and corrections are made before proceeding to the next production phase. The review process can be conducted internally by the developer and externally by client. Some activities conducted for the design review process are:

- Assessment of the overall design in pre-production phase.
- Refine and finalize the game requirements.

Apart from the review process is a sign-off in which the sign-off makes the client of the project responsible for the completion of pre-production phase. The client who has the authority to sign can be held responsible for the design document and its quality. When design document is signed-off, it ensures that the original specifications and requirements criteria for the game development are met in a formal acceptance using a consent form (Grudin, 1991).

A sign-off consent form might include the following elements:

- A title that describes the document to approve (for example: a design document).
- The objectives of this document.
- Some descriptions of what is being agreed upon, including a description of what has been reviewed.
- Some explanations of how changes to the documentation may be handled after the form has been signed-off.
- Space for signing and dating.

The sign-off procedure will make the design completed and can further proceed to the production phase.

4.2.3 Production Phase

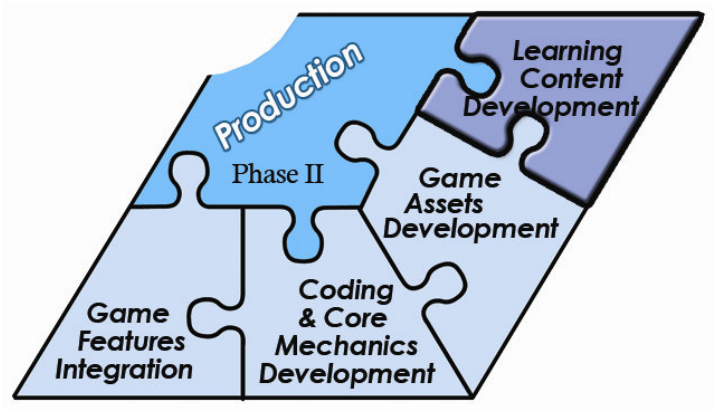


Figure 4.8: Phase 2, Production

The next phase is the development of the mGBL (as depicted in Figure 4.8) where it is coded and integrated with features as specified in the previous phase. Components should be included in this phase are Learning Content Development; Game Assets Development; Coding & Core Mechanics Development; and Game Features Integration. The most important component in this phase is the learning content development which focuses on the learning concept and contents.

The AI stage that maps to the production phase is the design stage. In the design stage, the main objective is to deliver the dream as imagined at the earlier stage. This is the starting point where the game is developed based on the dreams and desires that are generated earlier. During this stage, the actual development of the game is performed using particular development tools.

v) Component 5: Learning Content Development

The learning content will be developed at this stage is based on the learning content designed in previous phase which includes mGBL characteristics (based on learning theories and approaches) and mGBL learning model (adapted from experiential learning theory). Developing learning content means writing the details of the content that will integrate in the mGBL. The learning content should align with the game play and game tasks. In game, it can be a wide variety of interactivity, challenges and exploration in mGBL environment.

The development of the contents should be referred to the content experts who are proficient in their fields of knowledge (Keppell, 2001). Content experts are valuable to be referred to as they can help in editing the content and advising on learning resources, game tasks or activities, and advising on how to deliver the contents.

At this stage, all learning contents are properly and clearly described to be associated with the play and flow of the game. Figure 4.9 exhibits the objectives, activities, and deliverables of the component. At the end of this stage, learning content materials are ready to be utilized in the mGBL development.

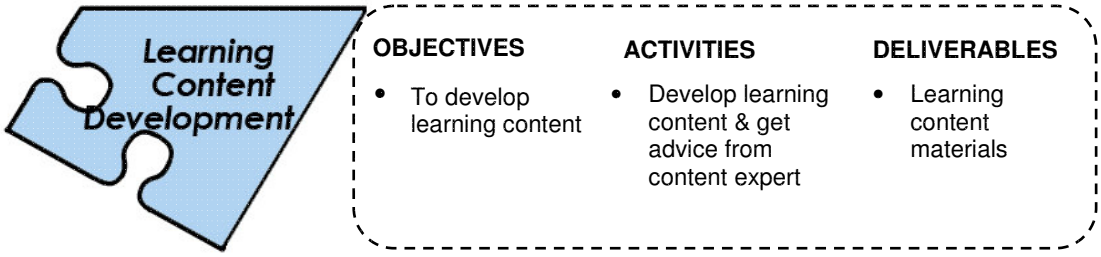


Figure 4.9: Component 5- Learning Content Development

In addition to that, the list below suggests some useful considerations to develop the learning content (Reigeluth, 1999; Reigeluth, 2008) that can be applied for mGBL learning content:

- Establishing objectives for the learning content.
- Selecting the most appropriate learning content based on game play.
- Creating usable and appropriate content to meet mGBL objectives.
- Getting content experts help to be referred to.
- Maintaining and continuously improving the learning content.
- Integrating learning content into game play.
- Creating the learning contents that are balanced with game play and give variety of challenges.
- Considering that overall learning content should not be in a formal and complex ways.
- Providing information that makes it easier for leaner to navigate in the game and understand the learning objectives.
- Using simple and direct content styles which suit for the mobile technology restrictions.

vi) Component 6: Game Assets Development

Game assets or objects are developed at this stage (see Figure 4.10) which can refer to the game features design in the pre-production phase. Game assets are the components that are made up a game. Different kind of game assets can be

included such as artworks including graphics and animations, sound effects and background music, texts and instructions, dialogs and narrations, and any kind of components that are presented to the player. This also includes the development of characters in the game (if any). It may be possible to use other assets that were developed for other games (with own copyright) or assets that are freely available to the public.

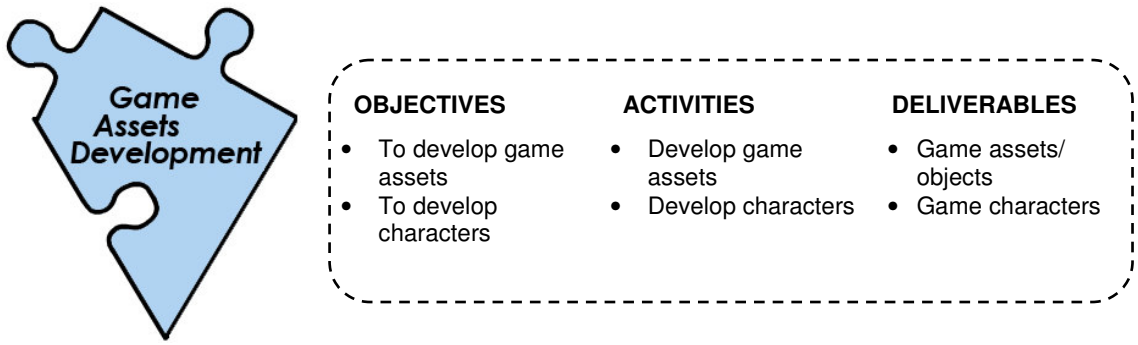


Figure 4.10: Component 6- Game Assets Development

vii) Component 7: Coding & Core Mechanics Development

The activities conducted in this component (Figure 4.11) are more related to the game logic and technical aspects of the game development. At this stage, game rules, levels, challenges, and awards are developed. The main point here is to create an enjoyable, fun and positive experience, and spark-free of any misunderstanding of the game play and flow (Garris et al., 2002). Rules, levels, and challenges are listed completely and this may come in various modes such as simple, medium or hard challenges.

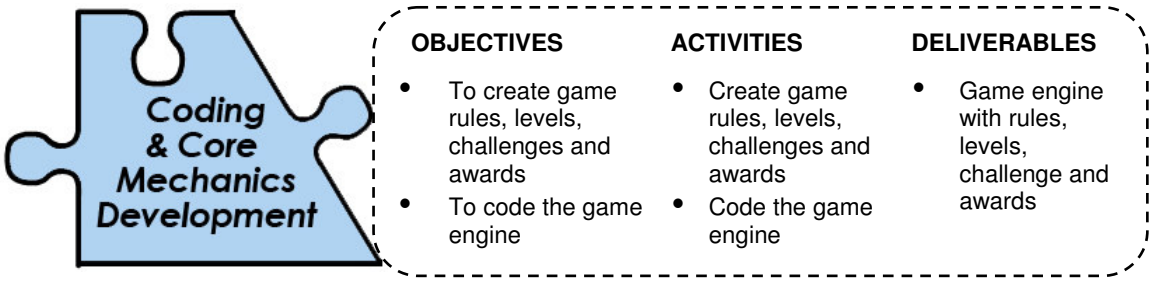


Figure 4.11: Component 7- Coding & Core Mechanics Development

When all things in the previous paragraph are defined, they are coded in a game engine. Game engine can be defined as a software system designed for creating and developing games (Garcia et al., 2010). The core functionalities typically provided by a game engine includes a rendering engine for graphics and a physics engine such as collision detection and response, sound, scripting, animation, artificial intelligence, networking, streaming, memory management, threading, and localization support. Sometimes, the process of game development is frequently economized by reusing the same game engine to create different games.

viii) Component 8: Game Features Integration

After all the learning content and game assets have been developed, the integration development phase would then take place. All game resources can be integrated through authoring or programming tools. There are different kinds of tools or software development kit (SDK) for mobile game development such as Flash, Visual Studios, Java ME SDK, Android SDK and many more. These tools can be utilized based on the targeted platform for game playing. Another important feature should be included in the game is the help system which includes instructions and manual. The objectives, activities, and deliverables of the eighth component are illustrated in Figure 4.12.

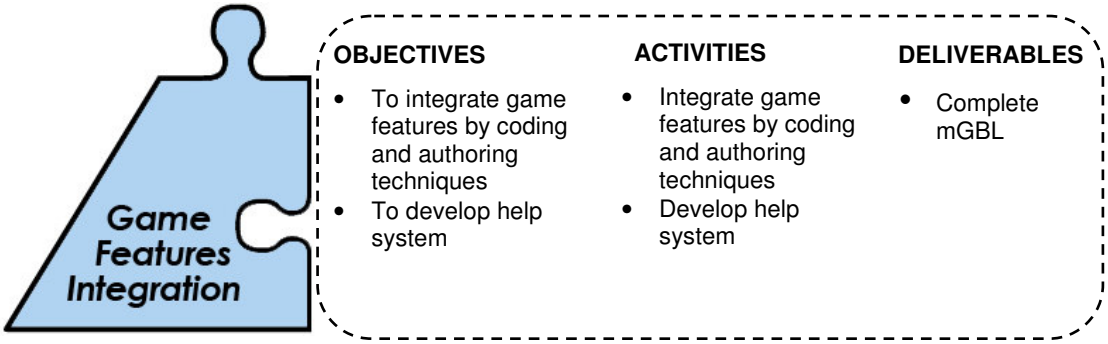


Figure 4.12: Component 8- Game Features Integration

4.2.4 Review After Production Phase

The review process at this point is more focused on the technical aspects of mGBL product itself before it is being formally tested in post-production. The main objective of this review is to find out the logical or technical errors of the mGBL and can be performed by developers. Any errors should be fixed and corrected prior to move on to the post-production phase.

4.2.5 Post-Production Phase

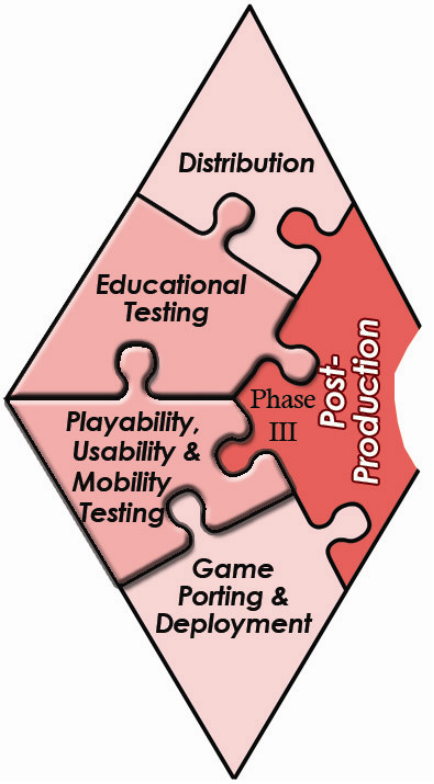


Figure 4.13: Phase 3, Post-Production

Finally in this phase (Figure 4.13), the core activity is the testing procedure to ensure its quality before releasing to the market. Game Porting & Deployment; Playability, Usability & Mobility Testing; Educational Testing; and Distribution are the main components in this phase. Deployment step is also essential at this stage to avoid the incompatibilities of running on different platforms of mobile devices.

The platforms vary for different types and categories such as Symbian, Windows Mobile, Java, and Palm OS.

The post-production phase also maps to AI as the delivery stage. It is where the finished game is completed and ready to be marketed. The game should go through a number of testing procedures to make sure it is playable and error-free.

ix) Component 9: Game Porting & Deployment

The biggest challenge in mobile game development is the porting and testing in mobile platform and devices. Unlike other gaming devices, in mobile gaming there are a lot of mobile devices available in the market. Porting to a good number of devices is a must for developers to reach global audience (Rapid Soft System, 2008). Some porting options that can be made are:

i) Flashlite or browser porting to devices with Flash player installation.
ii) Symbian porting to devices with Symbian OS.
iii) Android porting to devices with Android OS.
iv) iOS porting to iPhone or iPad.
v) J2ME porting to devices that support Java platform.
vi) Brew porting to devices with Brew OS.
vii) Cross platform porting (J2ME to Brew or Brew to J2ME)
viii) Operator specific porting (Celcom, DiGi, Maxis, etc)

When porting is successfully completed, the game is ready to be deployed and run on the targeted devices. Figure 4.14 shows the objectives, activities, and deliverables of the component.

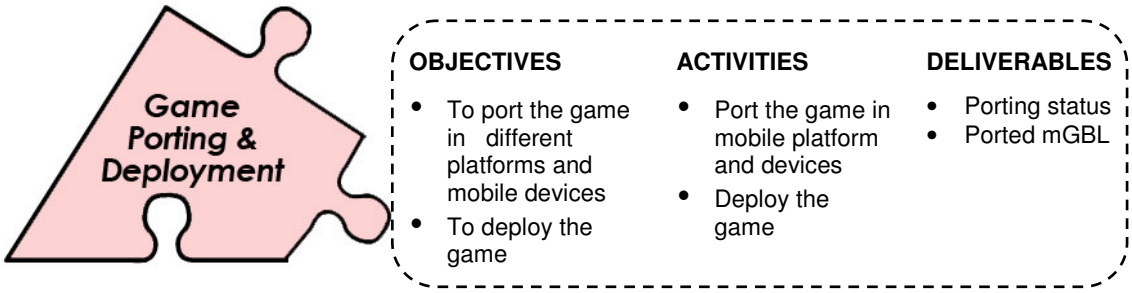


Figure 4.14: Component 9- Game Porting & Deployment

x) Component 10: Playability, Usability & Mobility Testing

Testing component has great impacts over the final products in ensuring their quality without bugs or errors. Three types of testing are suggested for mGBL; playability, usability and mobility testing (see Figure 4.15).

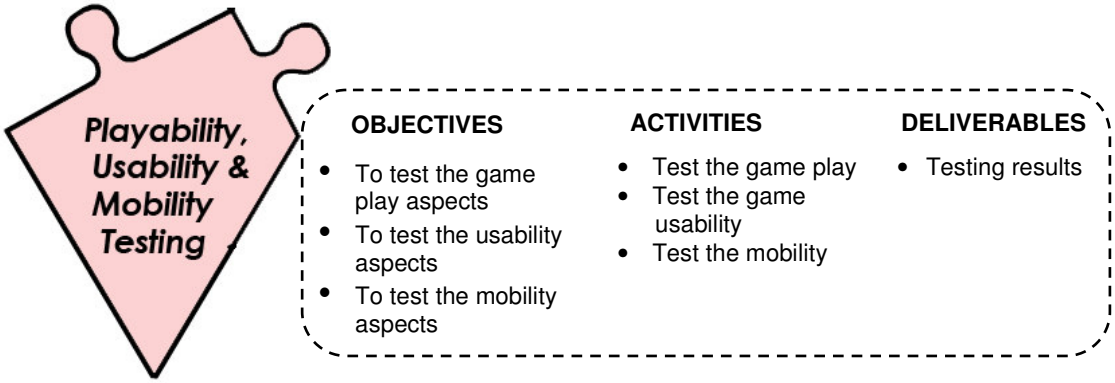


Figure 4.15: Component 10- Playability, Usability & Mobility Testing

Playability test is very common among all types of games, where it has become an established part of the quality control process. In playability testing, there are ten components as described in Table 3.10 (Chapter 3). The aim of this testing is to determine whether the game is playable, runs smoothly and consistently, meaningful, and not bored to the player. The playability is important because it is dynamic and occurs when the player interacts with the game mechanics and rules.

In testing the game usability, the components (Table 3.8, Chapter 3) test the interface and game controls that the player interacts with the game. This testing focuses on the user interaction with the game to identify any issues. Usability is

about maximizing effectiveness, efficiency, and satisfaction. In games, usability is about delivering a better and deeper experience with fewer problems, interruptions or challenges that should not be part of the game. In general, good game usability ensures that the player has interest to play the game until the end (Korhonen & Koivisto, 2006).

The mobility testing components in Table 3.9 (Chapter 3) concerns about the issues that affect mobility of the game. Mobility can be defined as the ease of a player to enter to the game world and the accessibility of the game from anywhere and at anytime. The testing focuses on the play time sessions, surroundings while playing, and issues of interruptions (Korhonen & Koivisto, 2006).

All these three types of testing are considered as heuristics evaluation strategies for mGBL (Section 3.7.5.5 in Chapter 3 details this stage).

xi) Component 11: Educational Testing

In the case, when mobile game is related to learning, it is recommended to determine whether the game educates the player while playing it. Therefore this component (Table 3.11, Chapter 3) caters to this objective by testing the educational and learning contents of the mGBL (another aspect in heuristics evaluation). Figure 4.16 shows the objectives, activities, and deliverables of the component. In general, the learning content should provide informative, useful, and understandable contents to users when playing the mGBL. Although other issues (such as pedagogical and interaction aspects) should be considered for testing of learning aspect, this testing only focuses on the content delivered in the game.

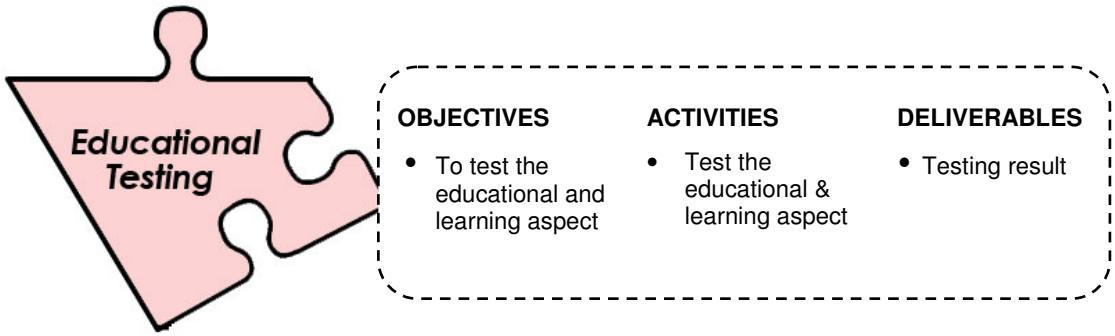


Figure 4.16: Component 11- Educational Testing

xii) Component 12: Distribution

Distribution is a final stage where the game is released and distributed in the market. The distribution can be made personally or through distribution companies. The final product is packaged digitally and can also be distributed to web-based application stores that are widely available. Figure 4.17 exhibits the objectives, activities, and deliverables of the component.

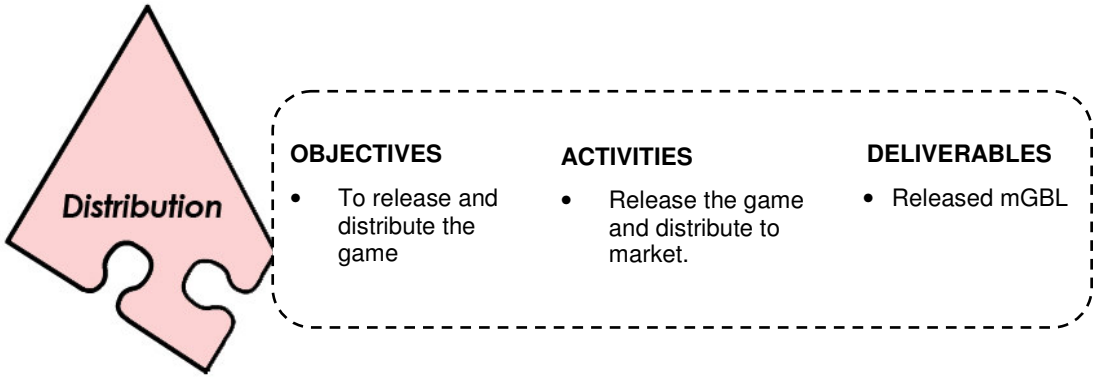


Figure 4.17: Component 12- Distribution

4.2.6 Flow of Documents and Deliverables

In addition to the details described in the previous sections, the mGBL engineering model also provides the flow of documents and deliverables to be referred to for documentation and references (Figure 4.18). The diagram shows the general flow of the mGBL development and how deliverables are processed and related. It

illustrates how the deliverables should move from one item to another following the connecting arrows.

4.3 Summary

This chapter describes the proposed mGBL engineering model that includes phases and components to be followed. The engineering model is proposed specifically to provide developers with systematic approach for designing and developing mGBL applications. Three phases (pre-production, production, and post-production) consisting twelve components with specific activities and deliverables in a sequence of combination to mould the model are described in detail. The mGBL engineering model maps to the AI four stages: discover, dream, design, and deliver. This is highly appropriate to appreciate the creative idea of game development, which would be turned into functional artefact through inquiry process. Objectively, this model is intended for the game developers to follow through in developing mGBL applications.

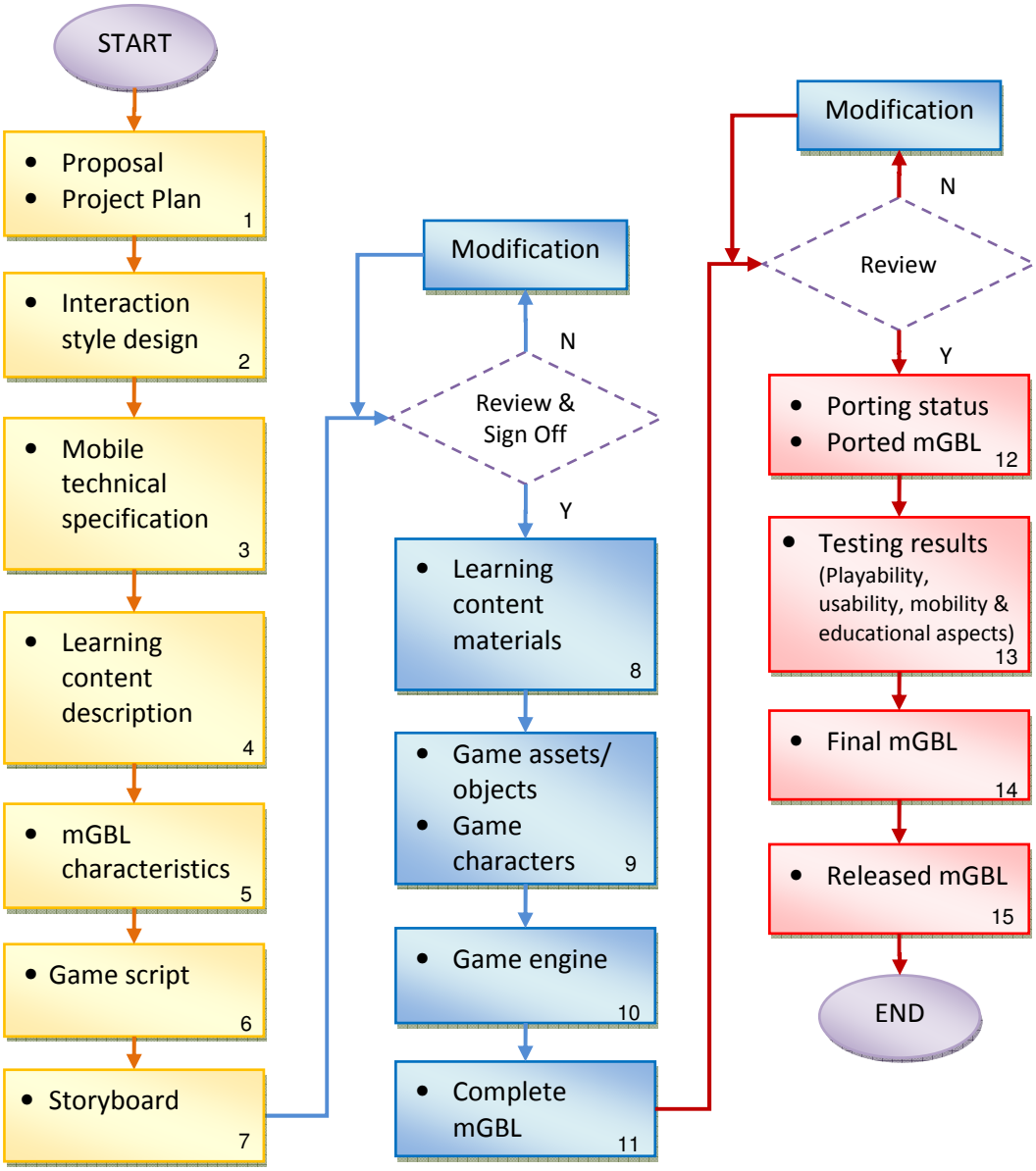


Figure 4.18: Flow of Documents & Deliverables

CHAPTER 5

Expert Review and Prototyping of mGBL Engineering Model

5.1 Introduction

This chapter discusses the review processes of mGBL engineering model including their findings and prototype development of mGBL application. In review processes, two activities were conducted: (1) pre-evaluation review, and (2) expert review. Both activities were formed in particular to evaluate the proposed model.

In addition, this chapter also describes about the prototyping. In prototyping, the development of a mGBL prototype followed the phases proposed in the mGBL engineering model. At the end, the prototype was examined using heuristics evaluation strategy in order to determine whether the proposed model is suitable for assisting in developing mGBL applications.

5.2 Pre-Evaluation Review

The pre-evaluation review of the proposed model was conducted to gain comments and suggestions for improvement. Therefore this activity acted as an initial evaluation of the proposed model which was conducted to seven academicians who have experiences in multimedia or software engineering domain (refer to Appendix F for the list of academicians). All seven respondents were asked (refer to Appendix C for the instrument) to comment on the following dimensions:

i) Visibility

ii) Clarity

iii) Effectiveness

iv) Flexibility

In general, all respondents stated that the model can be followed through, is workable, useful to follow, and could produce effective results. They also responded that the proposed model provides steps and guidelines that are easy to use and apply. The respondents also agreed that the proposed model is generally understandable, but they also commented and suggested few aspects for improvement. Some of their comments and suggestions about the proposed model (as seen in Table 5.1) are broken up into general aspects, iterative processes, and model components. Then, appropriate improvements were made to the model based on their comments and suggestions. The evaluation process continued to the next activity which is an expert review.

Table 5.1: Comments and Suggestions

Aspects	Comments and Suggestions
General comments and suggestions	• *Conceptually, the model is 'whole'-istic, covers all the important components for developing mGBL application.* • *The model looks comprehensive, conceptually it looks manageable, would love to see the result of actual implementation among mobile game developers with consideration of all the factors (time constraint, market demand, business competition, developers' attitude/awareness, resources…)*
Iterative processes	• *To put double arrow for each stage to show the process is iterative or state at any suitable section. For example; if requirements are not satisfied in the design document review phase, developer needs to go back to analysis activity.* • *Unclear iteration between the phases and in each of the phases. For intra phase for example the pre-production phase, does each step (1-4) has to finish first and wait for the review process and then it iterates or… It is iterative based on the yellow jigsaw puzzle that might means they are connected? It doesn't seem that clear to me.*
Components	• *In the first steps of requirement analysis, are the requirement gatherings from users included which i think it is the first step of most development) are incorporated in those 3 objectives? It does not look clear to me that the requirement gathering will be conducted in the phase. Which it goes straight to concept (or it might have been detail out in it?)* • *What about the maintenance and support after the distribution steps? Or is it all gathered in the review process that will then be incorporated into the next version that will begin with the first phase? It would be nice though to have those incorporate in the model.*

5.3 Expert Review

The expert review ensures that the final implementation of the mGBL engineering model represents an approach to the development that should have proven benefiting and establishing effectiveness of the artefact.

5.3.1 Methods and Instruments

Three developers from mobile game industries and one from higher learning institution involved as the experts (refer to Appendix G). They have strong background in developing mobile games and educational courseware. The instrument used for the expert review is described in Section 3.7.5 (Chapter 3) which includes eight dimensions, namely; visibility, complexity, compatibility, flexibility, clarity, effectiveness, manageability, and evolutionary.

5.3.2 Expert Review Findings

The four experts completed the task after four different explanation sessions between them and the researcher. As illustrated in Table 5.2, the mean results show that all experts lie towards strongly agree, with Expert A (9.37), Expert B (8.78), Expert C (8.12), and Expert D (8.55).

Table 5.2: Mean scores of the mGBL engineering model

Dimensions	Expert A	Expert B	Expert C	Expert D	Mean
Visibility	9.00	9.00	8.00	8.67	8.67
Complexity	9.60	8.60	8.60	8.60	8.85
Compatibility	9.80	8.80	8.40	8.00	8.75
Flexibility	8.75	8.75	7.50	8.50	**8.38**
Clarity	9.75	8.25	8.63	8.88	**8.88**
Effectiveness	9.00	9.00	8.00	8.40	8.60
Manageability	9.25	9.00	8.25	8.75	8.81
Evolutionary	9.80	8.80	7.60	8.60	8.70
Mean	9.37	8.78	8.12	8.55	8.70

All dimensions score relatively high with above 8 out of 10. The highest score among those dimensions is clarity with average of 8.88 and the lowest score is flexibility (8.38). These results revealed that the proposed model is clear and compatible with the developers' way of works. However, it seems that the proposed model lacks flexibility.

In addition, Figure 5.1 illustrates a radar graph which provides a straightforward and valuable way to illustrate the different means given by experts. The data values increase the further away you get from the zero centre of a radar graph. It shows that Expert A gave highest score for all attributes compared to other experts. This could due be due to his familiarity with the phases in the model which are similar to the phases he followed. However, Expert C gave the lowest score for 5 of the dimensions (visibility, evolutionary, manageability, effectiveness, and flexibility). This could be due to his lack of experience as he has the least number of years of experience.

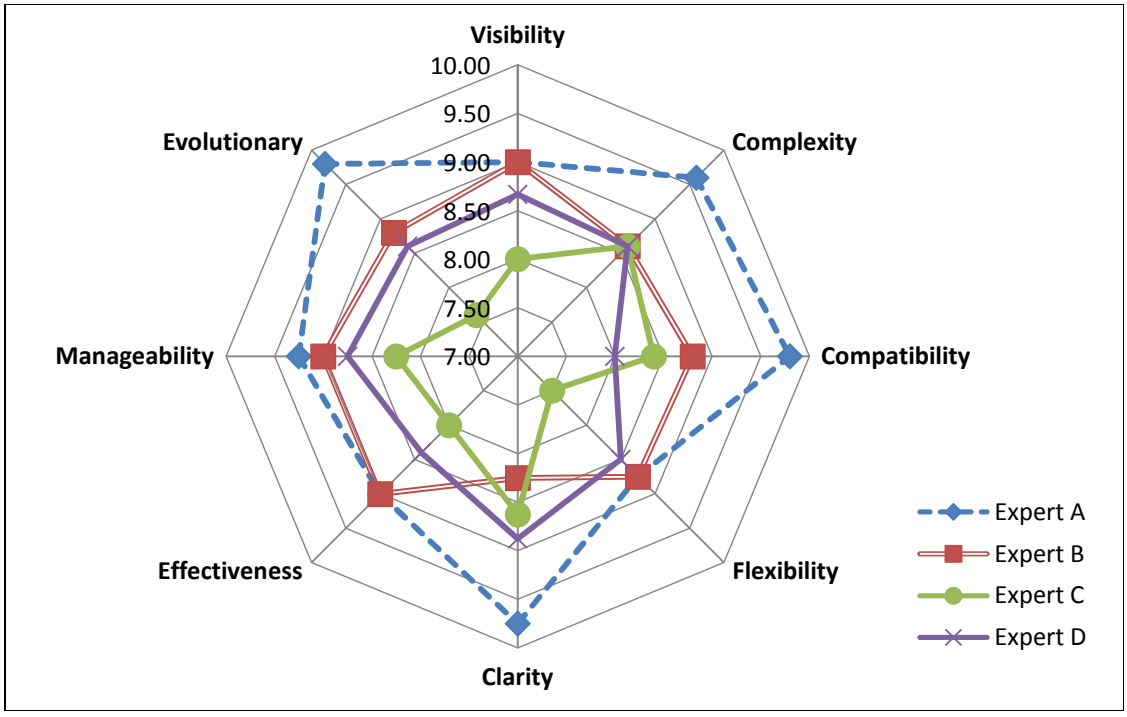


Figure 5.1: Radar graph for the evaluation score

Consequently, some corrections and adjustments were made to the model based on the feedbacks received from the experts. For example, previously the model did not indicate clearly the flow between phases, and then the arrows were made available. Another adjustment was made by changing the term “game components” to the “game assets”. After that, the model was used in the prototype development.

5.4 mGBL Prototype Design and Development

The design and development phases of the mGBL prototype applied the mGBL engineering model proposed in Chapter 4. Each phase in the model has components embedded in mGBL development. A mGBL application about local content that could foster the concept of 1Malaysia (http://www.1malaysia.com.my) was produced. The game is named 1M’sia which is abbreviated from one Malaysia. The mGBL development is primarily based on the concept of “edugaming” by Fabricatore (2000) and “game-based learning” by Prensky (2001); which focuses on intertwining learning and gaming.

5.4.1 Pre-Production Phase

In this phase, the requirement was analyzed, the mGBL concept was produced, the target audience was discovered, and the game development management was planned. In term of creative ideas and management, the developer team and the client had few discussions and brainstorming sessions to discover prospective mGBL requirement, unique features, and learning content. These sessions discovered the determination of how the AI theory (discover and dream stages) influenced the pre-production phase and successfully produced innovative mGBL design ideas.

i) Component 1: Requirement Analysis & Planning

The game concept was designed to be fairly simple in "side-scroller" interaction with a single character game control. The primary objective of the game is to promote the values of 1Malaysia that were incorporated in the mGBL contents. In general, the game is generated into two game plays which are simple quiz and mix-and-match. The player acts as a Malay character and then is triggered with several situations which provide the 1Malaysia values.

The target user was defined as ranging from 9 years old to adult who can play and have interest with mobile game. In term of project management, development schedule and team members were identified. The schedule was initialized for two months with a group of developers from a local company. In this phase also, the theory of game and play as explained in Chapter 2 were considered.

ii) Component 2: Mobile Interaction & Technical Analysis

The game interactions were designed considering the capabilities of the general mobile. The interactions are based on device capabilities by using joystick-like navigation keys for moving to left and right, and enter key for selection. These keys are the natural choice for mobile phone control and easy for players to navigate in the game. Based on views from the technical analysis, few limitations of the mobile devices were approached properly, including:

- **Mobile platforms or operating system**.

  The targeted platforms for the mGBL are considered for all platforms which have installed Flash player software.

- **Screen sizes**.

  To deal with the diversity in screen sizes, the mGBL was developed using Flash tool because the game display size is adjustable to the screen size of mobile phone.

- **Input and navigation controls**.

  The chosen input controls include joystick-like navigation keys and selection key where all mobile phones have the capabilities.

- **Colour and sound support**.

  The mGBL was designed in simple two-dimensional graphics using web-safe colors. While for sound and music of the mGBL, MP3 format was used.

- **Application size**.

  The size for the mGBL was prepared in small and not large for running in mobile platform. This is why the mGBL was developed using Flash, since Flash file is relatively small.

- **Interruptible**.

  The mGBL can be interrupted such as phone calling and text messaging while playing in progress

- **Evolving technologies**.

  By using Flash tool, the mGBL can be easily enhanced for future needs such as the availability of mGBL versions.

iii) Component 3: Learning Content Design

The main tasks for this component were specifying the subject domain, defining learning objectives, designing the learning content, and specifying the mGBL characteristics. The subject domain of the mGBL is a general knowledge of local content where the values of 1Malaysia concept are chosen for the learning content of the mGBL. The objective is to foster the concept of 1Malaysia to the target audience. At this stage, learning content expert to the subject domain was consulted for verification. In addition, learning theories characteristics that mapped with the mGBL as discussed in Chapter 2 were embedded in the mGBL learning content design in order to achieve the learning objective. Although not all characteristics were adapted, few elements were obvious for implementation in the 1M'sia mGBL characteristics. Such characteristics are illustrated in Table 5.3.

Table 5.3: 1M'sia mGBL Characteristics

Learning Theories and Approaches	1M'sia mGBL Characteristics
Behaviour	In 1M'sia mGBL, objectives are stated and broken down into game steps. The game also provides hints that guide players for playing and give good feedbacks and responses.
Cognitive	1M'sia mGBL provides simple screen design, interface and navigation to successfully running in mobile devices.
Constructive	1M'sia mGBL models and guides the knowledge construction process through the game environments. It also offers great game play and simple challenges by learning 1Malaysia values and concepts.
Multiple Intelligences	Four intelligences mainly linguistics, spatial, musical, and existential are adapted in 1M'sia mGBL. The linguistic elements in a form of written words such as instructions, user guides and game play. The 2D space in 1M'sia mGBL makes players interact actively in the space provided. Audio and music effects give fun elements to players. Finally, the player is made to believe that he is the main character of the game.
Events of Instructions	All nine events of instructions are adapted in the 1M'sia mGBL. The game starts with gaining attention to the player by providing attractive introduction screen accompanied by sound effects. The game ends with the assessment marks or game score.

iv) Component 4: Game Features Design

In this component, the main idea is to specify and design the game features. In general, the player acts as a Malay character and then is triggered with several situations which provide the 1Malaysia values. Such situations are an ATM machine, a traditional costume shop, a house, a group of people, a school, and religious places. The player then has to enter the situation for the game environment. The player's skills and knowledge will determine how well he is able to do the right things, and the values will either be mastered or not.

In game flow, it lays out the flow of the game and shows the navigation structures the player can interact. Figure 5.2 to 5.11 show the 1M'sia game flows. At the end of the game main environment, the player is shown to his own score of the level of his 1Malaysia concept comprehension. If the score is more than 70%, the player is stated as having adequate comprehension of the concept. Else, the player can try

again to achieve an acceptable level of comprehension. The language used for the 1M'sia game is Bahasa Malaysia for obvious reason.

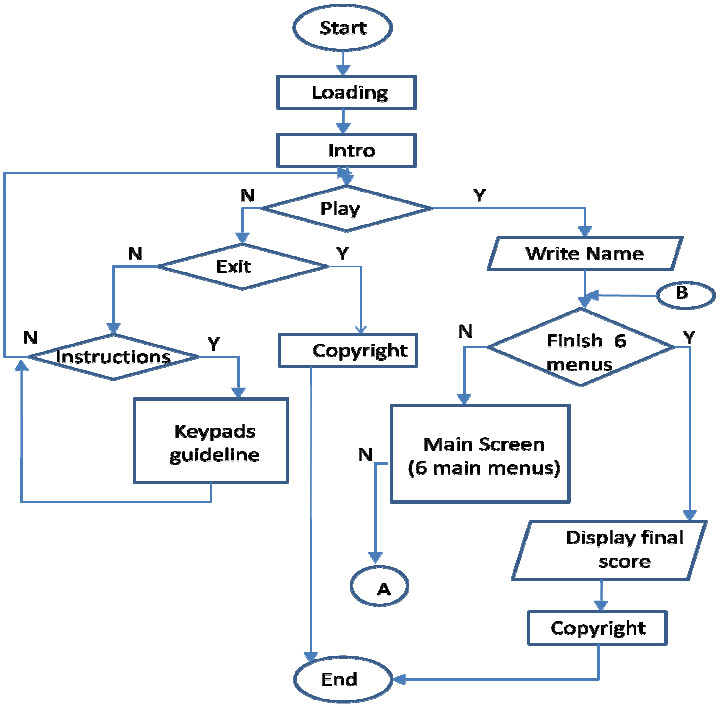


Figure 5.2: 1M'sia main environment game flow

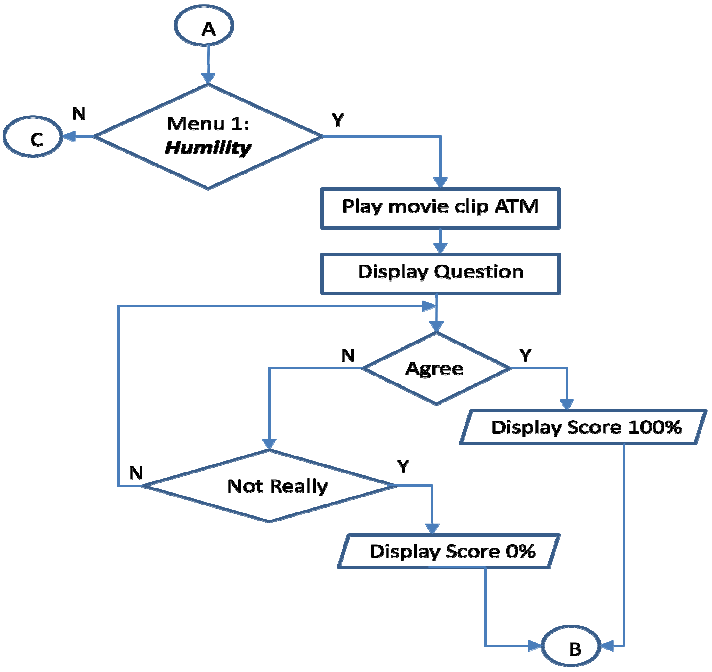


Figure 5.3: Menu 1- Humility

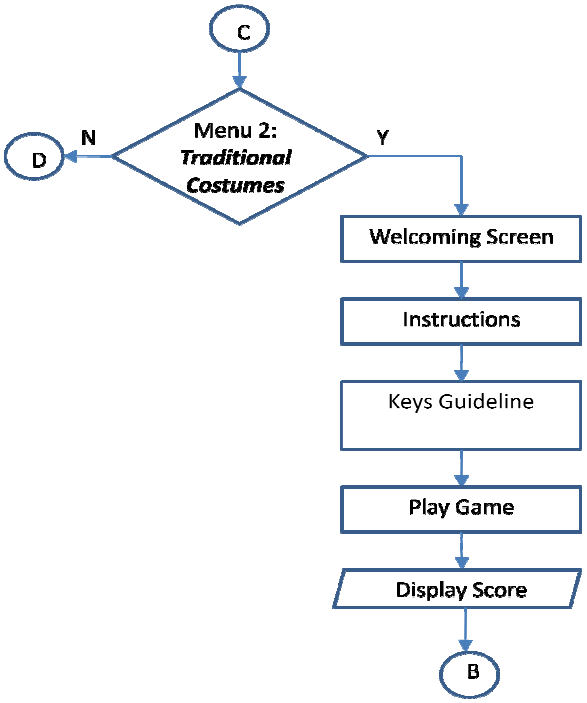


Figure 5.4: Menu 2- Traditional Costumes

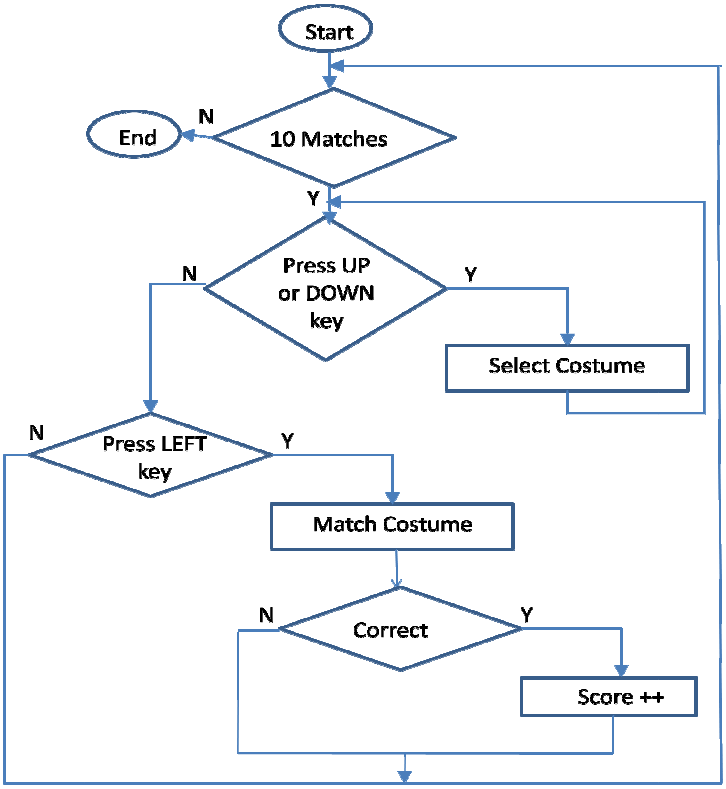


Figure 5.5: Mix & Match Game of Traditional Costumes

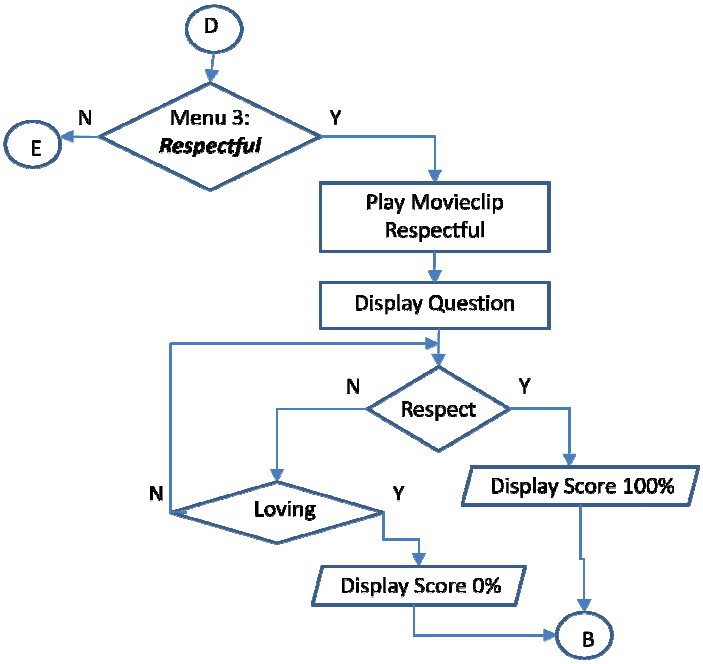


Figure 5.6: Menu 3- Mutual Respect to Others

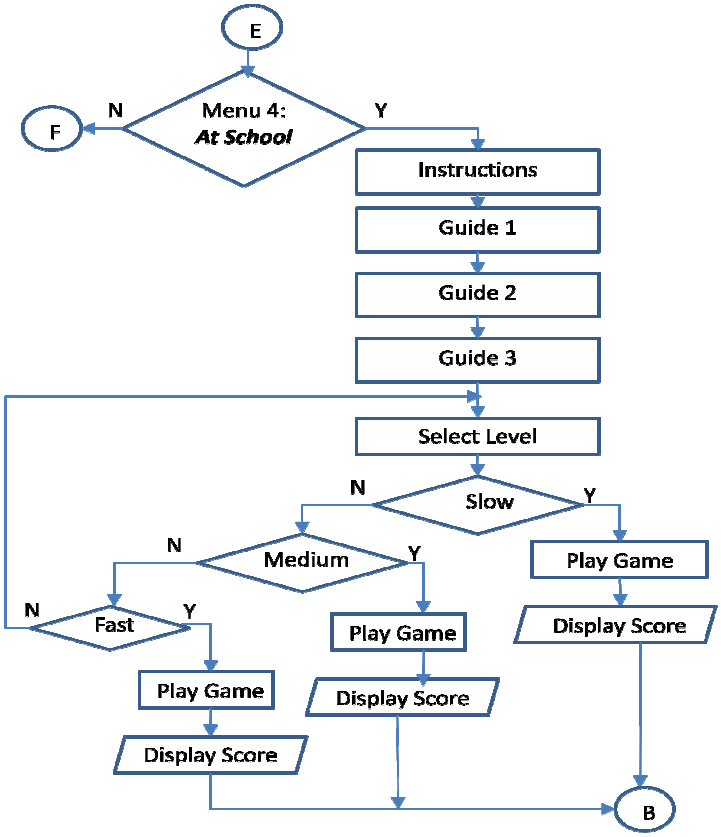


Figure 5.7: Menu 4- At School

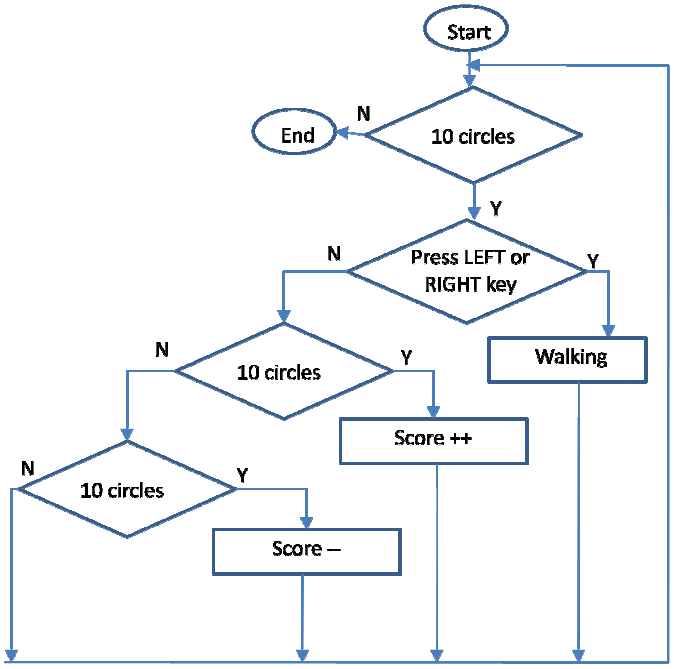


Figure 5.8: Pick & Run Game of School Rules

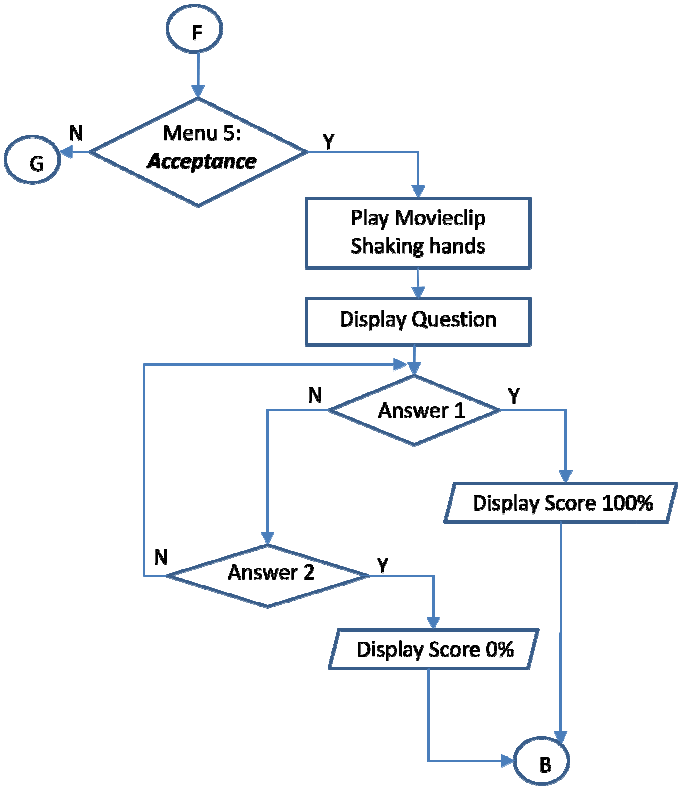


Figure 5.9: Menu 5- Acceptance

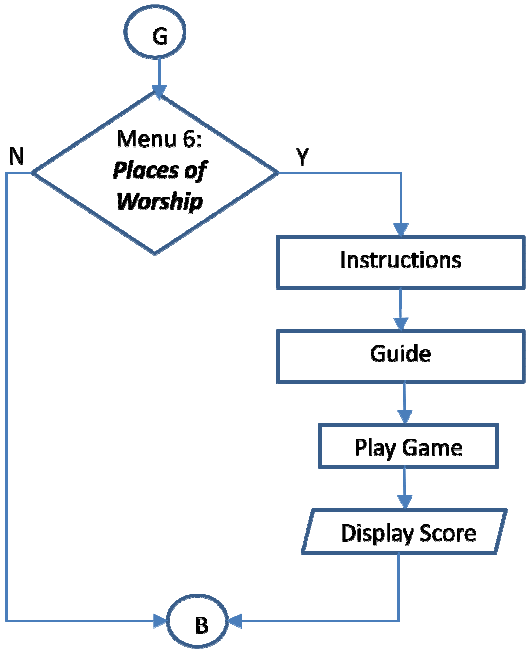


Figure 5.10: Menu 6- Religious Places

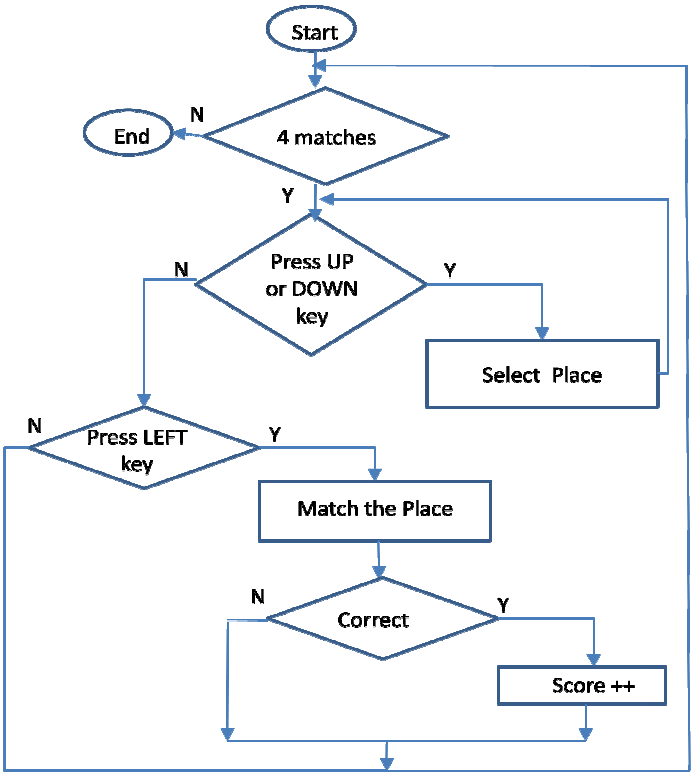


Figure 5.11: Mix & Match Game of Religious Places

5.4.2 Review and Sign Off After Pre-Production Phase

A design review was conducted to identify any defective information in the design and to validate the design. All amendments and corrections were made before proceeding to the next production phase. After completing the review process, the client of the project agreed with all the designs produced in the pre-production phase and further sent to the actual production.

5.4.3 Production Phase

Codes and integration of features are realized in this phase. The mGBL features such as game assets, game environment, and learning content were developed using various kind of tools such as Illustrator, Photoshop and Flash. Relating to the AI theory, this phase transforms the dream as imagined in the previous phase into reality in the form of a functional mGBL.

v) Component 5: Learning Content Development

The learning content developed at this stage was based on learning content previously designed. In this stage, 1Malaysia learning contents were properly and clearly described to be associated with the play and flow of the game. Figure 5.12 shows the aspiration values of 1Malaysia concept.

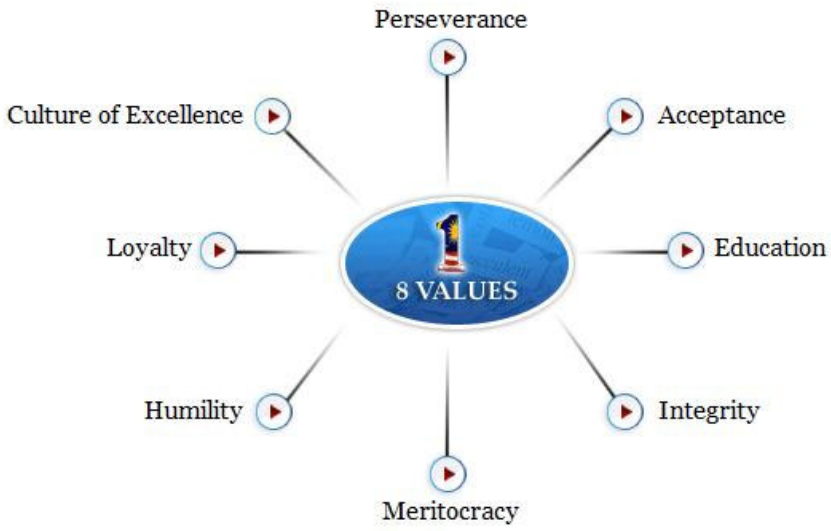


Figure 5.12: The aspiration values of 1Malaysia concept

The 1Malaysia formula was conceptualized for implementation in this prototype, in two main aspects. The first is through the assimilation of the (i) Principles of Unity, while the second aspect is the assimilation of (ii) Aspirational Values. Such values that are incorporated in the mGBL include:

- Principles of Unity
  - Acceptance amongst all races and people of Malaysia. The game shows how to shake hands with different races.
  - Humility in forming up decisions and actions. The game shows the importance of queuing in public places to get services.
  - Mutual respect for others. The game guides the players to know and respect other cultures as well as elderly people.
- Aspirational Values
  - Integrity in all matters and transactions. The game portrays the responsibility on tasks or jobs.
  - Culture of education. The game shows correct and wrong rules in school.

- Culture of precision in terms of time management and improving efficiency. The game demonstrates the time management policy.

vi) Component 6: Game Assets Development

Game assets or objects were developed at this stage. They were referred from the game features design in the pre-production phase. In this stage, all game sources were developed to represent the Malaysian environment using various tools such as Illustrator, Photoshop, and Flash. The game sources include vector images and graphics, text, sound, and music which provide the learning content. The main objects of the game were the characters. These characters were reused and reproduced from another project by Norshuhada and Syamsul Bahrin (2010). The main character was decided as male and portrays a Malay ethnic group (Figure 5.13). Other characters and objects were developed also corresponding to the Malaysian environment.

Figure 5.13: Main Character

vii) Component 7: Coding & Core Mechanics Development

The game logics and technical aspects of the game were developed based on the game flow (Figure 5.2 to 5.11). At this stage, game rules, levels, challenges, and awards were developed. The game rules are simple; when a player answers and acts correctly, scores will be awarded. Rules in some situations such as in school , the challenges has various level of difficulties such as easy, medium, or hard for the player to choose.

viii) Component 8: Game Features Integration

After all the learning content and game assets have been developed, the integration phase took place. All game resources were integrated using Flash. The tools can be utilized based on the targeted platform for game playing. Another important feature should be included in the game is the help system which includes instructions and manual.

5.4.4 Review After Production Phase

The technical review was conducted by the developer's team members and found very few minor errors. These technical errors were fixed and corrected before it was sent to the post-production phase. Overall, the game technical testing was successfully conducted. As a result, the game is running properly and it contains no major errors.

5.4.5 Post-Production Phase

The main activities for the final phase were the testing procedures in ensuring the quality of mGBL before it is disseminated. The testing aspects conducted in this phase include porting, playability, usability, mobility, and educational testing. This phase relates to the AI delivery stage.

ix) Component 9: Game Porting & Deployment

The 1M'sia mGBL was ported into several platforms and devices such as:

- Computer web browser with Flash player installed. As expected, it was successful with no error and compatibility issue.
- Nokia e71, e63, 5800 with Symbian s60. All devices are by default already installed with Flash player and this made the devices compatible for the mGBL. Although the porting on e71 was successful, the screen with landscape orientation did not fully project the mGBL which was designed in portrait orientation.
- Sony Ericson Xperia X1 with Windows Mobile. The device and its operating system did not affect the mGBL for playing. Therefore, the porting to the device was successful.
- BlackBerry with BlackBerry Operating System. As anticipated, the mGBL was successfully ported on the device without any error.

When porting testing was successfully completed, the mGBL was sent for deployment and run in the targeted devices, which was a Nokia e63. Nevertheless the mGBL was only compatible with mobile devices which have installed Flash player. The main objective of conducting the testing was achievable by knowing that the game was playable on targeted mobile devices.

x) Component 10: Playability, Usability & Mobility Testing

Three types of testing were conducted on the 1M'sia game, namely: playability, usability and mobility testing. These three testing types were implemented through heuristic evaluation strategy. Section 5.6 details this further.

xi) Component 11: Educational Testing

In addition to playability, usability, and mobility testing, the educational testing was also performed, and this is explained in section 5.6.

xii) Component 12: Distribution

For the purpose of this study, the 1M'sia mGBL was developed as a prototype that can be enhanced and improved for further full development before it can be distributed.

5.5 Screen Shots of 1M'sia mGBL

The following screen shots (Figure 5.14 to 5.21) depict the user interface and screens of the 1M'sia mGBL. At first when the game is loaded, the main page is displayed. Players can continue to start playing the game by pressing the start button or selecting other buttons for instructions. The game will start at the main game environment, and players can control the game by pressing the arrow and selection keys.

Figure 5.14 shows the main environment of the 1M'sia mGBL. Figure 5.15 and 5.17 are examples of situations that players will be triggered. For example in Figure 5.15, when a player enters the situation, a short animation will be displayed that shows the 1M'sia value and then a simple quiz is presented. The example shown in Figure 5.16 is a Humility quiz. Once the answer is selected, the score will be displayed. After that the player will get back to the main environment to proceed to the next situations provided in the main game environment.

Figure 5.18 and 5.19 show examples of a mix-and-match game where the player needs to match the correct traditional costumes for the specific ethnic group in Malaysia. The game immediately informs the player whether the answer is right or wrong. Figure 5.20 shows the school rules game that requires a player to collect as many correct rules as possible. In Figure 5.21 a short summary is given at the end of the game, where the player is informed of his total score in percentage. The score indicates the level of player comprehension of 1Malaysia values.

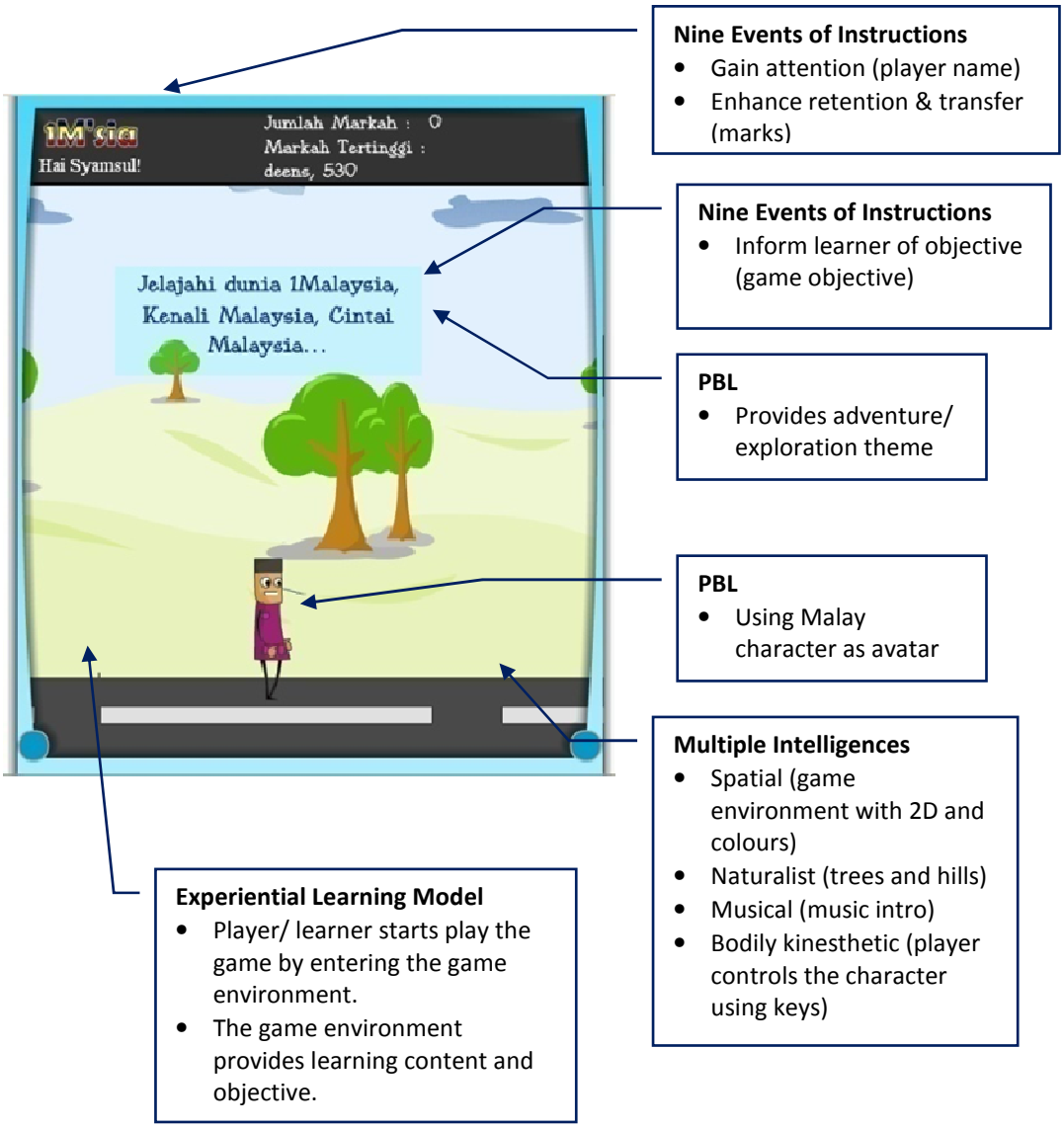


Figure 5.14: Main environment of 1M'sia

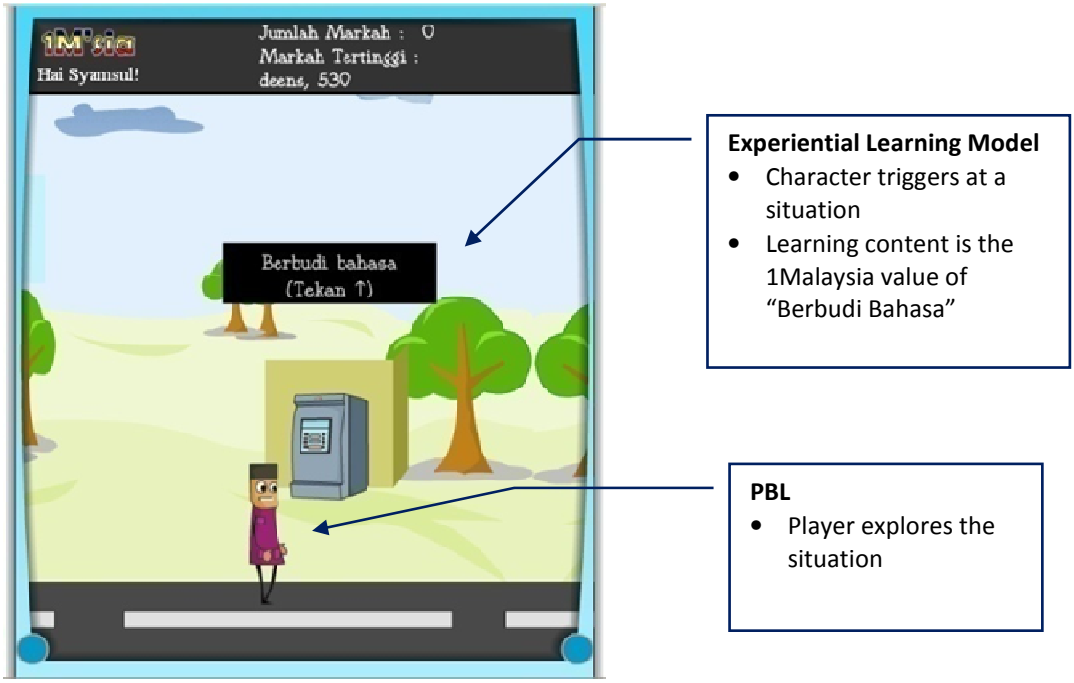


Figure 5.15: Situation and value in 1M'sia

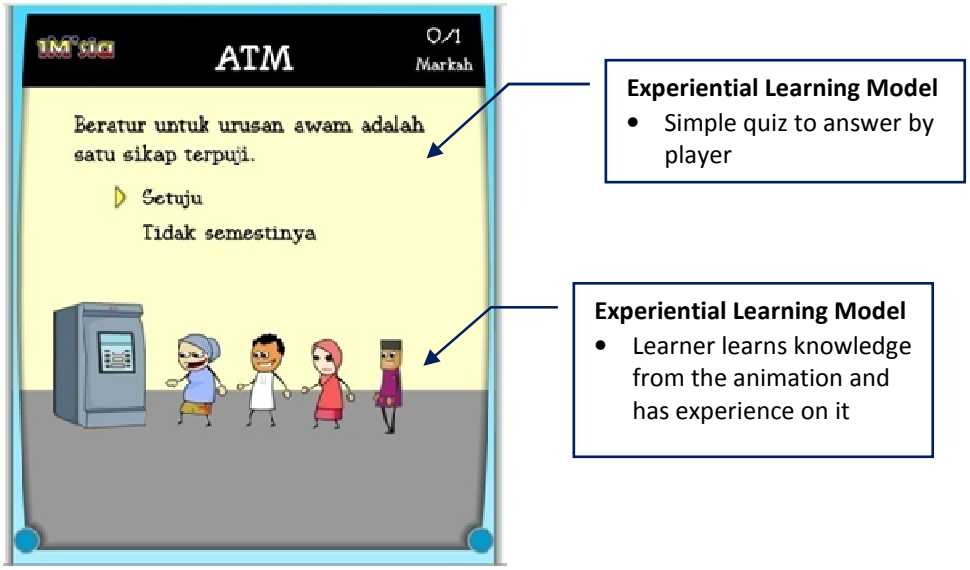


Figure 5.16: Humility simple quiz

Experiential Learning Model

- Character triggers at a situation
- Learning content is the 1Malaysia value of "Traditional Costumes"

PBL

- Player explores the situation and make decision

Figure 5.17: Traditional costume store

PBL

- Player explores the correct answers

Multiple Intelligences

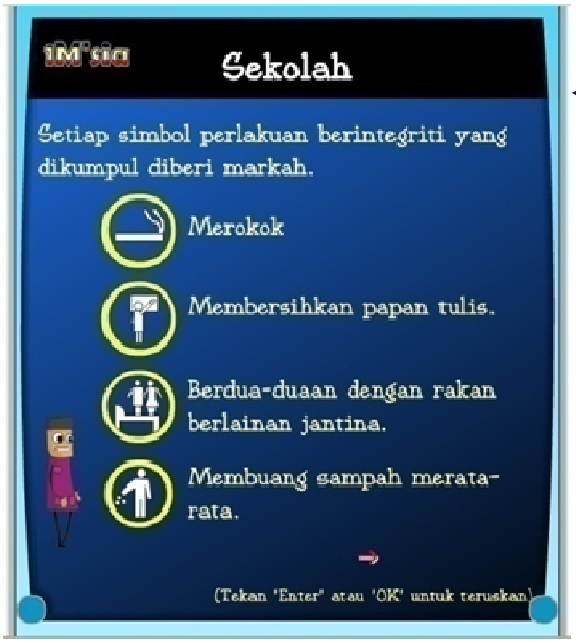
- Spatial (game environment with 2D and colours)
- Musical (background music and sound effect)
- Bodily kinesthetic (player controls the selections using keys)

Figure 5.18: Mix-and-match game

Experiential Learning Model
- Player learns about "Traditional Costumes" in Malaysia

Nine Events of Instructions
- Game provides feedbacks (with sound effects and marks) to the given answers (correct or wrong)

Figure 5.19: Correct answer



Nine Events of Instructions
- Game provides instructions and help to the player before the game begins.

Multiple Intelligences
- Using symbols for recognizing the good and bad manners

Figure 5.20: School rules game

Figure 5.21: Final score

5.6 Heuristics Evaluation for mGBL

Heuristics evaluations are commonly applied in usability evaluation. A usability evaluation is conducted to users in order to find out how the users can easily and efficiently reach the application objectives. There are many usability evaluation methods; most are originally developed by Nielsen and Molich (1990); and Nielsen (1993). In fact, the most utilized and useful usability heuristics was proposed by Nielsen (Nielsen, 1994; Muller et al., 1995). These heuristics however are more focused on the general applications and are not specific to game. Specifically to educational games, Malone has created the first heuristics for evaluating educational games (Malone, 1980). In addition to not being developed for evaluating mGBL, the existing heuristics do not deal with mobility issues and do not cover learning content evaluation. Therefore, in evaluating the 1M'sia mGBL, a set of heuristics were adapted from Korhonen and Koivisto (2006); and Koivisto and Korhonen (2006) by adding a new component that deals with learning content and

context in mGBL. In particular, the heuristics evaluation strategy used in this study consists of four dimensions as described in 3.7.5.5 (Chapter 3): Game Usability (GU), Mobility (MO), Playability (PL), and Learning Content (LC).

5.6.1 Evaluation Sessions

The evaluation sessions were conducted in an exposition. Twenty visitors to the researcher's booth were selected to represent 3 age groups (9-11, 12-14, and 15-17 years old). All the selected visitors played the 1M'sia game using the devices provided. Once they were done with playing, they were asked questions as in the instrument shown in Appendix E. They were asked by the researcher according to the items in the instrument. In some cases, questions were reworded to better explain to the respondents especially the younger ones (age 9-12). From their reactions and responses, the instrument is completed one by one either Yes, No or Not Sure responses. Figure 5.22 to 5.23 visualize the evaluation session taking place at the exposition.

Figure 5.22: Visitors playing 1'Msia mGBL

Figure 5.23: Visitors playing 1'Msia mGBL

Figure 5.24: Conducting the evaluation

5.6.2 Findings

The demographic profiles of the visitors who participated are illustrated in Table 5.9. Their ages ranged from 9 to 17 years old, whom are the targeted users of the 1M'sia mGBL.

Table 5.4: Demographics profiles

		Gender		Total
		Male	Female	
Ages	9-11	3	3	6
	12-14	4	4	8
	15-17	2	4	6
Total		**9**	**11**	**20**

The first component of the evaluation is game usability. In general, the game should enable players to control the game smoothly and display all necessary information such as game status and possible actions. The highest score with 'Yes', is GU6 (Game controls are convenient and flexible) and the lowest score is GU2 (Screen layout is efficient and visually pleasing).

Figure 5.25 depicts the scores based on users' answers (either Yes, No, or Not Sure). It is noticeable that the main usability problem of 1M'sia mGBL was the GU2 (Screen layout is efficient and visually pleasing) because some texts on the screen are quite small and difficult to read. However, in general, the results show that the usability components of the 1M'sia mGBL is considered on the high side.

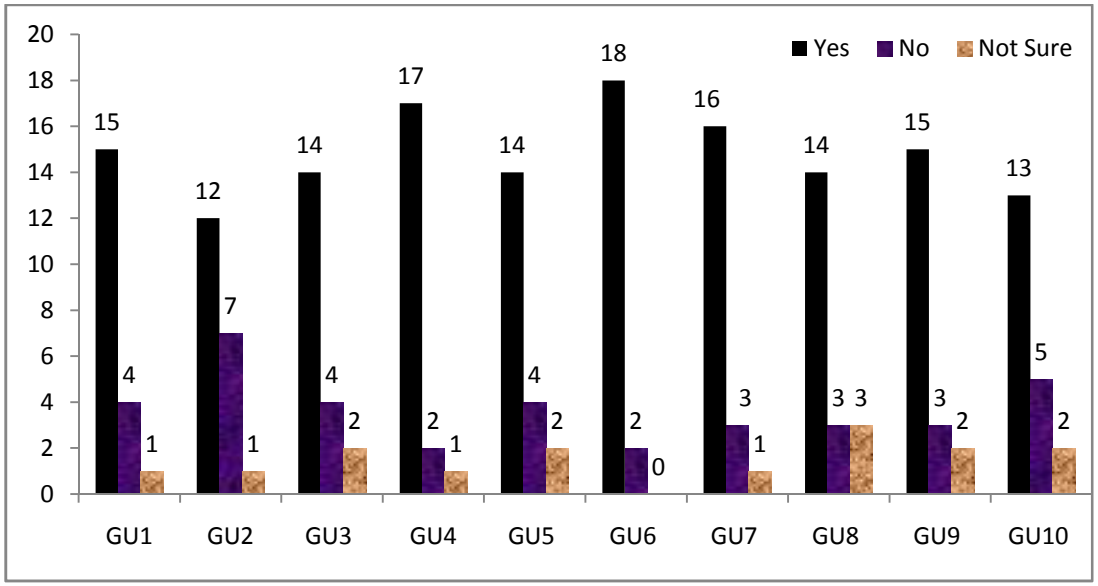


Figure 5.25: Game usability components

The second component is the related mobility issue. The overall results indicate that the 1M'sia mGBL highly meets the mobility components (Figure 5.26). However, four respondents said the game session could have started more quickly (MO1). This can be explained in terms of files loading time, which can sometimes be longer when a player enters the game environment for the first time.

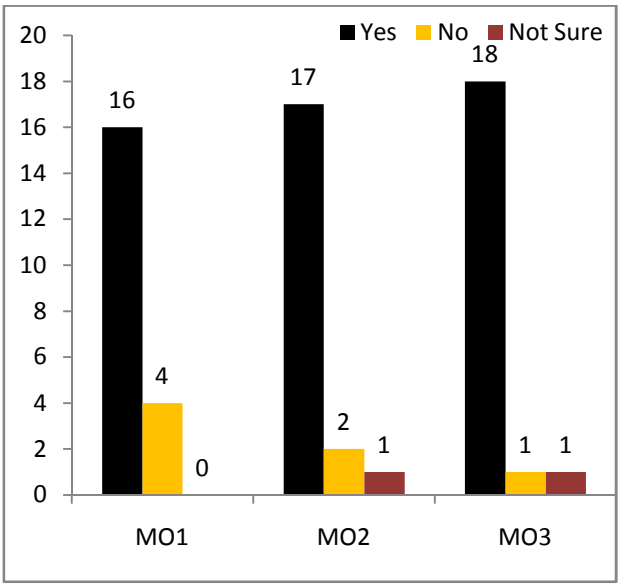


Figure 5.26: Mobility components

The next component is the playability aspect. The overall results indicate high responses. The highest score is PL4 (The player is in control) and the lowest is PL7 (The game story supports the game play and is meaningful). Figure 5.27 depicts these values.

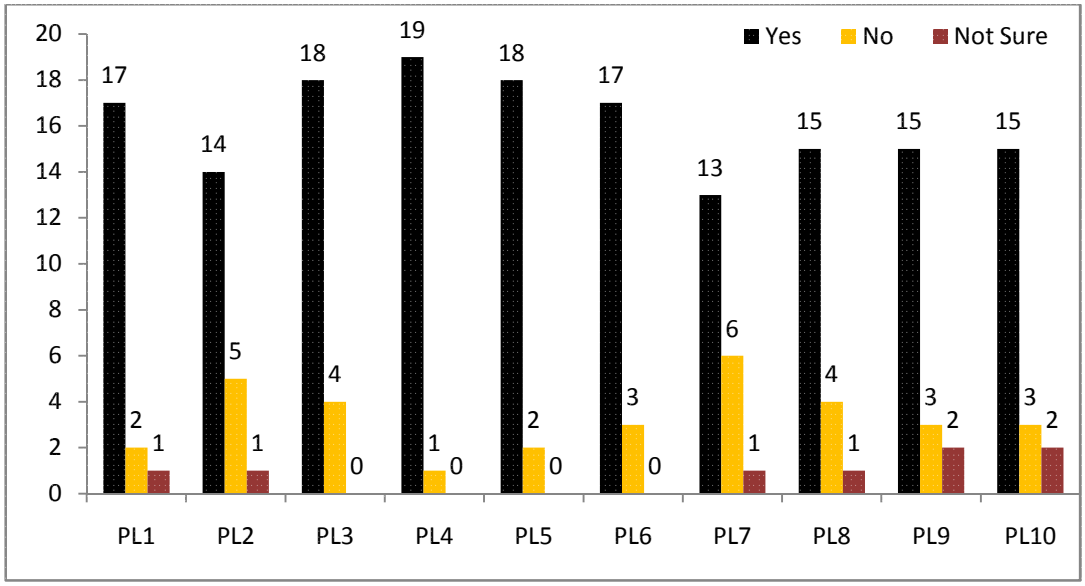


Figure 5.27: Playability components

Based on the overall results as exhibited in Figure 5.27, it can be concluded that the respondents agreed that the game provides clear goals, meaningful rewards, the player is in control, and challenges and pace are in balance. Although this is the case, some of the respondents felt that the game story does not really support the game play, and they also found that there is no possible way provided by the game to compare scores among players.

Lastly, the important component for learning objective is the learning content (Figure 5.28). It is obvious that the overall results indicate that the learning content is highly informative, understandable, and easy to learn. The highest score is LC4 (The content is understandable). However, some of the respondents felt that the learning content moderately interest them, suggesting that the 1M'sia concept just moderately capturing their interest.

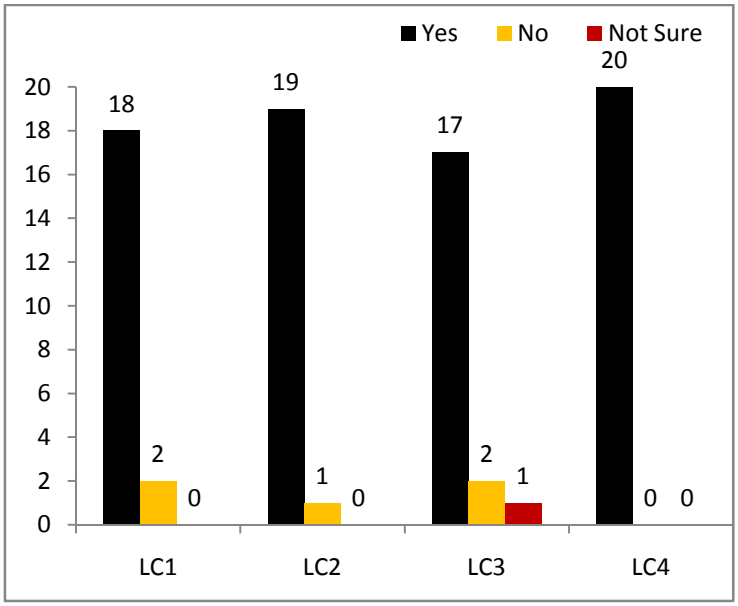


Figure 5.28: Learning content components

5.7 Summary

This chapter describes two parts of evaluation strategies; expert review and prototyping. The expert review was conducted involving mobile game developers and an academician from different organizations. Generally, the proposed mGBL Engineering Model was found well accepted by all experts participated in the study. In the second part which is prototyping, this chapter also describes the design and development of the mGBL prototype by implementing the mGBL Engineering Model. The development stages employed into the mGBL development were successfully implemented, easy to follow, and provided an easy guideline for developers. In addition, heuristics evaluation is also proposed for evaluating the mGBL application. The strategy is intended to evaluate mGBL with respect to game usability, mobility, playability, and learning content. Overall, the evaluation sessions were successfully conducted and indicate positive results. In the next chapter, an experimental study which acts as another evaluation strategy of the proposed model is further presented together with the findings.

CHAPTER 6

Experimental Study of mGBL Engineering Model

6.1 Introduction

This chapter contains the outcomes of the experimental study. Before the experimental study was conducted, a pre-selection study on the preferred choice of methodology for mobile game development was carried out, which is described in the next section. The outcomes of the pre-selection study were used as the basis for the experimental study.

6.2 Pre-Selection Study for Preferred Choice of Methodology for mGBL Development

The main objective of this survey was to find out the most preferred choice of the mGBL methodology and model from the views of potential developers. The 15 methodologies and models as described in Chapter 2 were grouped into three categories, namely; mobile game methodologies, ID models, and GBL models. Each category consists of five models.

The sample of this study included 77 undergraduate students of Bachelor of Multimedia undertaking Game Application Development course at Universiti Utara Malaysia. They were required to develop a mobile game for their final projects by implementing one of the chosen methodologies and models. Therefore, this study was conducted to note their perceptions and opinions of the selected

methodologies and models. An explanation session was arranged to describe the 15 methodologies and models for better understanding. Then, the students were asked to rank (from 1 to 5) the models based on their preferred choice (refer to Appendix C).

The demographic profile of the respondents is illustrated in Table 6.1. About 63.6 % of the respondents were female and the remainder were male with range of age between 20 to 26 years.

Table 6.1: Demographics profile of respondents

Gender (with age range from 20 to 26 years)	
Male	28 (36.4%)
Female	49 (63.6%)
Total	77

The analysis of the findings was run based on the ranking order from 1 to 5. The results of the mobile game methodologies category indicate that the highest rank was the Game Life Cycle, followed by the Best Practice for Mobile Game Development, and the lowest was the Design-Protect-Build-Test-Market-Sell Model. This implies that the Game Life Cycle is highly likely to be adopted. The lowest rank suggested that some of the students might experience certain difficulty in understanding the methodology. Table 6.2 shows the rank of all 5 models in this category.

Table 6.2: Preferred Rank of the mobile game development methodologies

Methodologies	Rank
• Game Life Cycle (Janousek, 2007)	1
• Best Practice for Mobile Game Development (Dholkawala, 2005)	2
• Scrum Methodology (McGuire, 2006)	3
• Game Development Methodology (Dynamic Ventures, Inc., 2007)	4
• Design-Protect-Build-Test-Market-Sell (Edwards & Coulton, 2006)	5

On the other hand, Table 6.3 shows the results for the ID models. The highest rank was the ADDIE model, and the lowest was the Morrison, Ross & Kemp model. These

results denote that the ADDIE model was the chosen model for developing mobile game among other models.

Table 6.3: Preferred Rank of the ID models

Methodologies	Rank
• ADDIE model	1
• ASSURE (Heinich & Molenda, 1993)	2
• Dick & Carey Model (Dick & Carey , 1996)	3
• ARCS (Keller, 1993)	4
• Morrison, Ross & Kemp Model (Morrison, Ross & Kemp, 2004)	5

Further, Table 6.4 displays the results for the GBL models category. Among the five of the GBL models, the Input-Process-Output model was ranked highest, and the lowest was the Experiential Gaming Model. The results show that respondents preferred to choose the Input-Process-Output model as their guideline for developing mobile game.

Table 6.4: Preferred Rank of the GBL models

Methodologies	Rank
• Input-Process-Output (Garris et al., 2002)	1
• Four Dimensional Framework for GBL (de Freitas & Oliver, 2006)	2
• FIDGE Model (Akilli & Cagiltay, 2006)	3
• Digital GBL Model for History Educational Games Design (Nor Azan et al., 2009)	4
• Experiential Gaming Model (Kiili, 2005)	5

Therefore, the results of this study suggested that the most preferred choice of the methodologies and models for mobile game development, are Game Life Cycle methodology, ADDIE model, and Input-Process-Output model. From this, the experimental study was conducted to compare the chosen three with the proposed mGBL engineering model as described in the next section.

6.3 Experimental Study

An experimental study was conducted involving the implementation of the proposed model with a group of undergraduate students who were taking Game Application Development course at Universiti Utara Malaysia. 70 students participated in the study and they were divided into four groups for comparison as illustrated in Table 6.5. Group A, B, and C were allocated as the control groups while group D was the experimental group. They were required to use the given model (based on results of the pre-selection study) as a basis for designing and developing mGBL applications for their final project. This study was carried out concurrently for all groups and took a whole semester. Each group was given detailed descriptions of their model and both the course instructor and the researcher helped students in terms of the technical aspects for developing mGBL.

Table 6.5: Experimental and control groups

Group	N	Types of Development Model
A (control)	18	Analysis, Design, Development, Implementation, Evaluation (ADDIE)
B (control)	20	Input-Process-Output (IPO)
C (control)	14	Game Life Cycle (GLC)
D (experimental)	18	mGBL engineering model
Total	**70**	

At the end of the project, students presented their projects and provided reflection to the instructor and the researcher. They were also required to complete the same instrument as administered to the experts in the expert review phase.

6.4 Findings of Experimental Study

The results presented in this section, only illustrate the analysis of the findings from the evaluation form. The objective of this analysis is to compare the implemented four models (ADDIE, IPO, GLC, and mGBL Engineering Model) based on the 8 dimensions (refer to section 3.7.5.5). Therefore one way analysis of variance (ANOVA) was carried out. Table 6.6 and Figure 6.1 present the mean of all models based on the 8 dimensions denoted by respondents. The results show that mGBL engineering model scored mean above 7.0 (out of 10) for all dimensions compared to other models. This suggested that the mGBL engineering model is highly accepted by the experimental groups.

Table 6.6: Means and Standard Deviations for Four Models and Eight Variables

	ADDIE		IPO		GLC		mGBL	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Visibility	6.722	1.300	6.483	1.374	6.714	1.563	7.833	1.195
Complexity	6.300	1.224	6.320	1.640	6.886	1.836	7.022	1.768
Compatibility	6.611	0.981	6.720	1.245	6.471	1.599	7.467	1.552
Flexibility	6.847	1.269	6.488	0.985	6.607	1.675	7.750	0.928
Clarity	7.236	1.044	6.469	1.173	6.277	2.091	8.035	1.317
Effectiveness	7.011	1.103	6.640	1.203	6.271	1.746	7.922	1.336
Manageability	6.792	1.412	6.675	1.095	6.589	1.890	7.917	1.406
Evolutionary	7.233	1.152	6.580	1.131	6.357	1.681	8.222	1.127

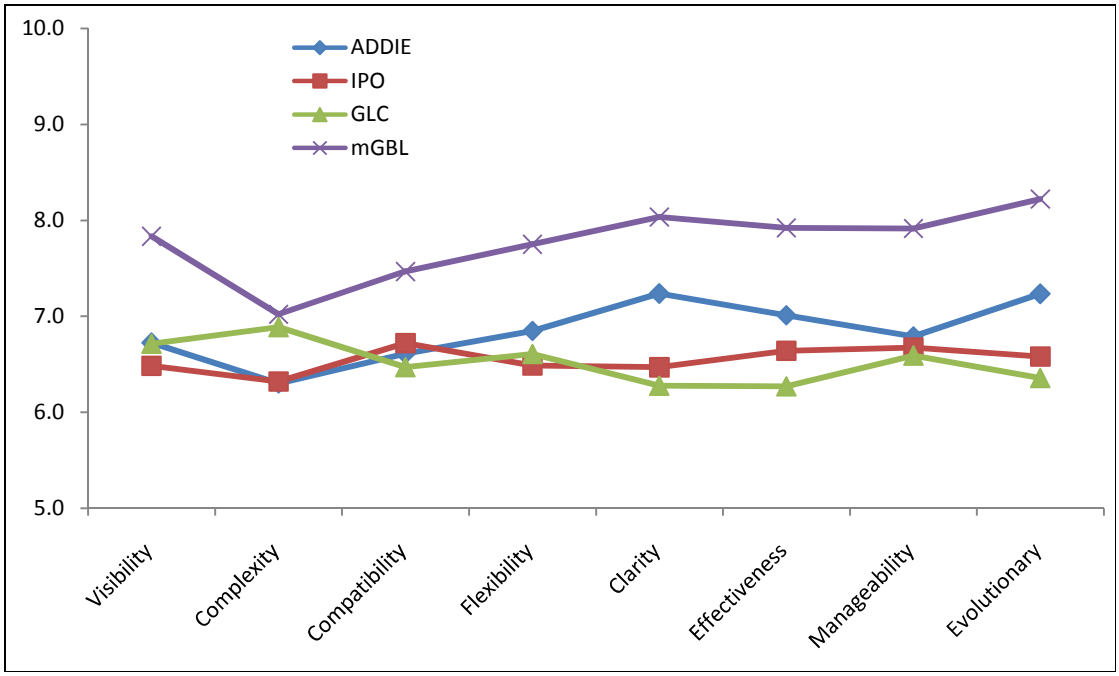


Figure 6.1: Comparison of mean scores between four models for eight variables

In order to find out whether there are significant differences between all groups, the one-way ANOVA test was used and the results are presented next.

6.4.1 Results from the One-Way ANOVA Test

One-way ANOVA was run eight times for each dimension and the results are illustrated in Table 6.7.

Table 6.7: One Way Analyses of Variance for Four Models on Eight Variables

Attributes	df	SS	Mean Square	F(3,66)	Sig.
Visibility					
Between Groups	3	20.102	6.701	3.666	.017*
Within Groups	66	120.629	1.828		
Complexity					
Between Groups	3	7.535	2.512	0.956	.419
Within Groups	66	173.460	2.628		
Compatibility					
Between Groups	3	10.199	3.400	1.869	.143
Within Groups	66	120.038	1.819		
Flexibility					
Between Groups	3	17.602	5.867	3.996	.011*
Within Groups	66	96.916	1.468		
Clarity					
Between Groups	3	33.178	11.059	5.571	.002**
Within Groups	66	131.023	1.985		
Effectiveness					
Between Groups	3	25.329	8.443	4.717	.005**
Within Groups	66	118.145	1.790		
Manageability					
Between Groups	3	20.377	6.792	3.278	.026*
Within Groups	66	136.745	2.072		
Evolutionary					
Between Groups	3	36.076	12.025	7.543	.000***
Within Groups	66	105.22	1.594		

* significant at the .05 level. ($p < .05$)

** significant at the .01 level. ($p < .01$)

*** significant at the .001 level. ($p < .001$)

The results show that there are significant differences ($p < .05$) between all groups in term of **Visibility** with $F(3, 66) = 3.666$, $p = .017$; **Flexibility** with $F(3, 66) = 3.996$, $p = .011$; and **Manageability** with $F(3, 66) = 3.278$, $p = 0.26$. For **Clarity** and

Effectiveness dimensions, there are very significant differences between all groups with F (3, 66) = 5.571, p = .002 and F (3, 66) = 4.717, p = .005 respectively. The results also indicate that the **Evolutionary** dimension is highly significant different with all groups with F (3, 66) = 7.543, p = .000.

However, two dimensions were found not significantly different (p >.5): **Complexity** F (3, 66) = 0.956, p = .419 and **Compatibility** F (3, 66) = 1.869, p = .143. This could be because the models were complex with many steps or activities heve to be followed, therefore not well-suited to the students who are novice developers.

In order to detect the differences among groups, a multiple comparison test using Tukey Least Significant Difference (LSD) was utilized. The test can be used to determine whether a significant mean difference exists between each pair of groups.

6.4.2 Results from Post Hoc Test: Multiple Comparisons

Table 6.8 shows the results of post hoc test and Figure 6.3 to 6.10 confirm the results. In **Visibility** dimension, comparing mGBL to ADDIE, IPO, and GLC, the mGBL is seen more visible with the mean difference in visibility is large (m>1.1). The significant values of ADDIE (p = 0.016), IPO (p = 0.003), and GLC (p = 0.023) show that this is statistically significant (Figure 6.2). However in term of **Complexity**, the mean difference between mGBL to ADDIE, IPO and GLC are relatively small (m < 0.7) and non-significant ADDIE (p = 0.186), IPO (p = 0.187), GLC (p = 0.814) even though mGBL is less complex than the three models (Figure 6.4). Meanwhile, in **Compatibility** dimension, although mGBL scored higher than ADDIE and IPO, the mean difference in compatibility is relatively small (m < 0.9) and the Sig. values (p > .05) shows that this is statistically not significant. In contrast, comparing mGBL to GLC, although the mean difference in compatibility is less than 1 (m= 0.995), the significant value (p = 0.042) shows that this is statistically significant (Figure 6.3).

mGBL also gained higher score compared to ADDIE, IPO and GLC in **Flexibility** and is statistically significant (Figure 6.5).

Table 6.8: Post Hoc Test- Multiple Comparisons

Types of Model		**Mean Different (I – J) for Each Dimension**							
(I)	(J)	Visibility	Complexity	Compatibility	Flexibility	Clarity	Effectiveness	Manageability	Evolutionary
mGBL	ADDIE	1.111* p= 0.016	0.722 p= 0.186	0.856 p= 0.061	0.903* p= 0.029	0.799 p= 0.094	0.911* p= 0.045	1.125* p= 0.022	0.989* p= 0.022
	IPO	1.350* p= 0.003	0.702 p= 0.187	0.747 p= 0.093	1.263* p= 0.002	1.566* p= 0.001	1.282* p= 0.004	1.242* p= 0.010	1.642* p= 0.000
	GLC	1.119* p= 0.023	0.137 p= 0.814	0.995* p= 0.042	1.143* p= 0.010	1.758* p= 0.001	1.651* p= 0.001	1.327* p= 0.012	1.865* p= 0.000

* significant at the .05 level. ($p < .05$)

When comparing mGBL with ADDIE, the mean difference in **Clarity** is small (m = 0.799) even though the positive sign indicates that mGBL is clearer than ADDIE. The significant value (p = 0.094) shows that this is not significant. However, when comparing mGBL to IPO and GLC, the mean difference in clarity is large and the Sig. value ($p < .05$) shows that this is significant (Figure 6.6). For the other three dimensions (**Effectiveness, Manageability, Evolutionary**), mGBL also has higher score compared to ADDIE, IPO, and GLC. The mean difference in effectiveness is quite large and the Sig. value ($p < .05$) shows that this is statistically significant. The positive sign also indicates that mGBL is more effective than GLC. Figure 6.7 to 6.9 illustrate the comparisons of all models.

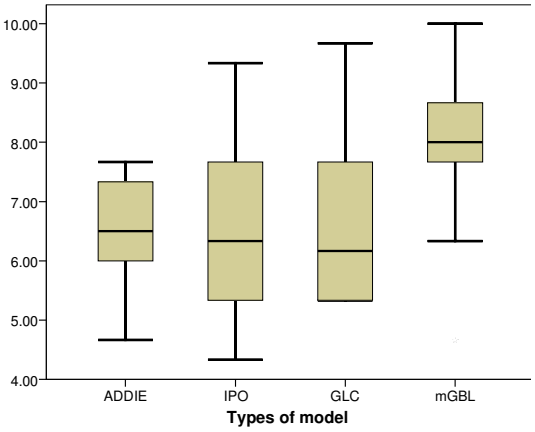


Figure 6.2: Scores of Visibility between mGBL and other models

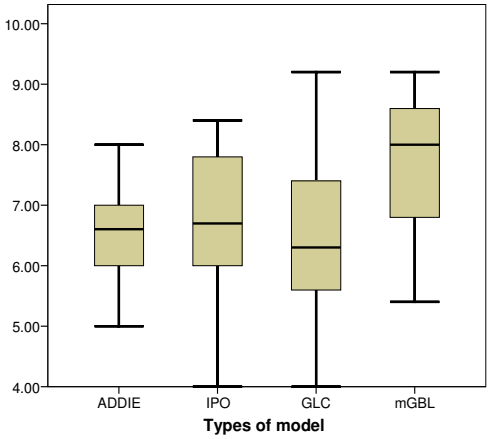


Figure 6.3: Scores of Compatibility between mGBL and other models

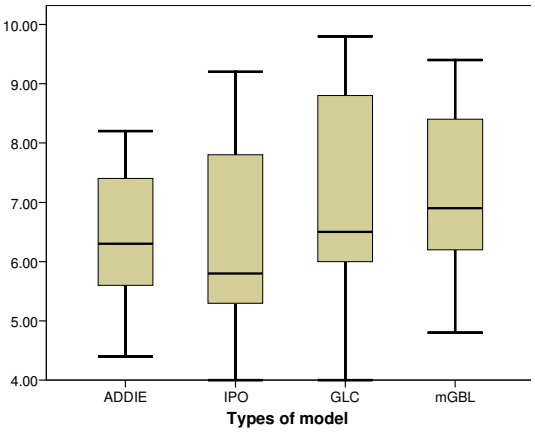


Figure 6.4: Scores of Complexity between mGBL and other models

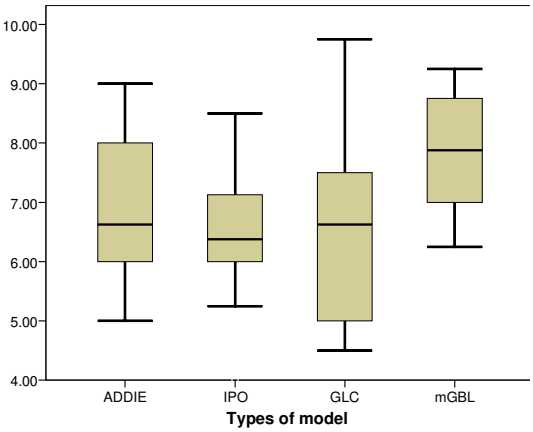


Figure 6.5: Scores of Flexibility between mGBL and other models

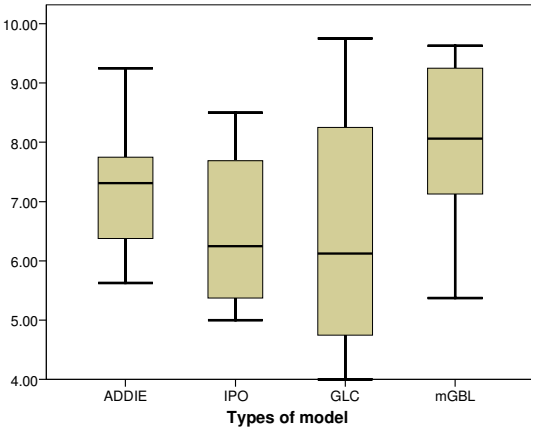


Figure 6.6: Scores of Clarity between mGBL and other models

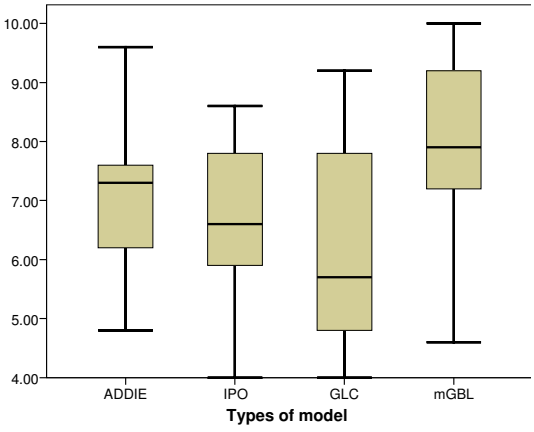


Figure 6.7: Scores of Effectiveness between mGBL and other models

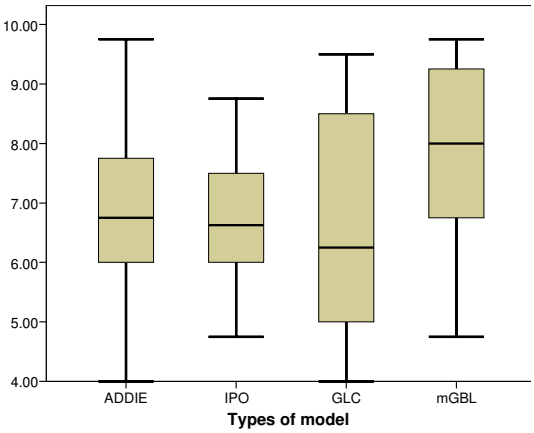


Figure 6.8: Scores of Manageability between mGBL and other models

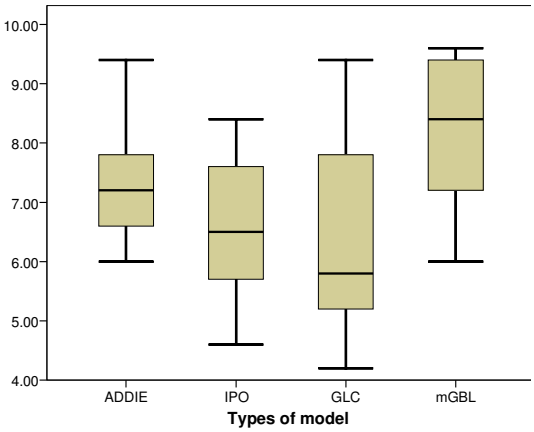


Figure 6.9: Scores of Evolutionary between mGBL and other models

A significantly higher mean score in visibility, flexibility, clarity, effectiveness, manageability, and evolutionary exhibited by students for mGBL engineering model, indicated that they understand how to implement the model for their game

development project. They also have completed their project in a systematic manner without having difficulties in finding the game requirements especially related to mobile game for learning. Nevertheless some minor issues with the mGBL engineering model did appear where a few students found some of them confused. These issues are related in particular to some aspects of technical testing for their project. Two examples of student projects are depicted in Figure 6.10 and 6.11.

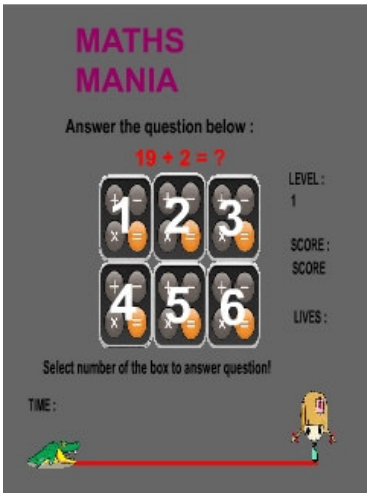


Figure 6.10: Maths Mania mGBL

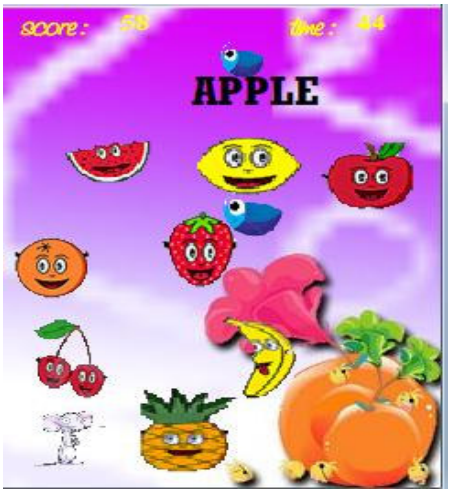


Figure 6.11: Hungry Mouse mGBL

6.5 Hypothesis Testing

In answering the forth research question, a hypothesis testing was conducted. The null hypothesis is as follows:

H_0: The proposed mGBL engineering model is not significantly applicable.

Based on results of the experimental study, it can be summarized that the 8 evaluation dimensions can be defined as a single term which is applicability. Therefore one-way ANOVA test was run another round (including all 8 dimensions) to test the applicability of the proposed model. Results as indicated in Table 6.9 were obtanied. In comparison of the applicability of the proposed model with other

models, the results show significant values where p = .007 (p < .05) and F (3, 66) = 4.341. Here, the results show that the null hypothesis would not be accepted. Therefore, it can be concluded that the proposed mGBL engineering model is significantly applicable in designing and developing mGBL applications.

Table 6.9: One Way Analyses of Variance for Four Models on Applicability

Attributes	df	SS	Mean Square	F(3,66)	Sig.
Applicability					
Between Groups	3	25.329	6.045	4.341	.007*
Within Groups	66	118.145	1.392		

*significant level at .05

6.6 Summary

This study evaluated the proposed model based on 8 dimensions, namely: visibility, complexity, compatibility, flexibility, clarity, effectiveness, manageability, and evolutionary. In the experimental study, the results indicated that six dimensions (visibility, flexibility, clarity, effectiveness, manageability, and evolutionary) were significantly different from all models; however two dimensions (complexity and compatibility) were not significantly different. These results showed that the mGBL engineering model scored a high overall mean. Hypothesis testing was also conducted and the results show that the null hypothesis was rejected. This implies that the proposed model could be implemented by potential developers to develop mGBL applications.

CHAPTER 7

Conclusion

7.1 Introduction

This study aimed to develop a mGBL engineering model that integrates ID model and systematic processes. Hence, this study was conducted based on four research questions:

i) How to engineer a mGBL in a systematic way?
ii) What are the main components of such mGBL engineering model?
iii) Which ID models should be included in the engineering model?
iv) Is the proposed mGBL engineering model applicable?

Therefore, this chapter describes the solutions proposed for each research question. In addition, this chapter also provides the summaries, discussions and research contributions. This chapter then ends with a discussion of future research and conclusions of the study.

7.2 Research Question 1: How to engineer a mGBL in a systematic way?

Various game development methodologies have been proposed by many researchers for a variety of genres, with each having its own requirements (Kiili, 2005; Quinn, 1994; Amory & Seagram, 2003). However, the research literature

contains very few studies on methodologies to develop educational games (Dempsey et al., 1996; Moser, 2002; Fletcher & Tobias, 2006) and specifically mGBL.

It is acknowledged that, developing game and educational game is a complicated task (Bjork et al., 2003; Moser, 2002). There are various tasks, activities, and components to be implemented to ensure the game is interesting. In developing educational game, the literatures suggest that the development should combine two models; game development model and ID model (Garris et al., 2002). This is because ID models contain valuable insights and guidelines for the development of instructions. While, in order to develop mGBL there are other issues need to be considered which are the restrictions of mobile technology.

Therefore mGBL can be systematically engineered by following a comprehensive model that integrates different types of components namely; ID model (Section 2.11), learning theories (Section 2.5, 2.6, and 2.7), game design and characteristics (Section 2.3 and 2.4), systematic processes (Section 2.12 and 2.13), mobile technology considerations (Section 2.13), and evaluation procedures (Section 5.6). The combination of these components ensures the mGBL is meaningful and beneficial to players.

7.3 Research Question 2: What are the main components of such mGBL engineering model?

In answering the question, few activities were conducted and have been discussed in this thesis. The main purpose of these activities was to identify components, phases, activities, and flows involved in developing mobile games which are currently practiced by the game developers. The activities include expert consultation (Section 4.2), content analysis of the literature (Chapter 2), comparative study of the GBL models (Section 2.12), Mobile Game Methodologies

(Section 2.13), and ID Models (Section 2.11). Consequently, these activities have identified the key components of mGBL engineering model such as phases, activities, and flows for the development of mGBL applications. The detail of the proposed model is described in Chapter 4.

The proposed mGBL engineering model comprises phases, components, flows, activities, and deliverables for the development of mGBL application. Phases are distinct general stages of the model that can be performed in order (from phase one to three). Components can be described as constituent parts of the model that contribute to each phase and give specific activities of each phase. These components are seen fundamental to be included. While flows in the model define the way of progress from one phase or activity to another. Activities refer to specific steps that are suggested to be conducted during the mGBL development. Deliverables are the outputs that are produced at each phase or component.

All these model elements were then combined and made up the mGBL engineering model. The proposed model with its elements and components were also reviewed and found well accepted by the experts. The mGBL engineering model proposes twelve components, namely:

i) Requirement Analysis & Planning
ii) Mobile Interaction & Technical Analysis
iii) Learning Content Design
iv) Game Features Design
v) Learning Content Development
vi) Game Assets Development
vii) Coding & Core Mechanics Development
viii) Game Features Integration
ix) Game Porting & Deployment
x) Playability, Usability & Mobility Testing

xi) Educational Testing

xii) Distribution

These components are flexible and iterative, which can be customized based upon developer preferences. These components are also mapped to the AI four stages: i.e. discover, dream, design and delivery. In addition, the mGBL engineering model suggests the expanded guidelines by providing specific objectives, activities, and deliverables for each component.

7.4 Research Question 3: Which ID models should be included in the engineering model?

Over the years, many ID models have been proposed (Bagdonis & Salisbury, 1994; Andrews & Goodson, 1995; Reigeluth, 1999; 2008) and ID models give an outline by presenting specific guidelines for developing instructions. In general, ID model includes the following phases: analysis, design, development, implementation, and evaluation (Reiser & Dempsey, 2007). Some example of ID models that were reviewed in this study are ADDIE, Dick & Carey, ARCS, ASSURE, and Morrison, Ross & Kemp model (Section 2.11). Regarding the models, although none of them are directly applicable for game development (Becker, 2006b), the general phases were embraced in the proposed mGBL engineering model. Therefore, the ID model phases including analysis, design, development, implementation, and evaluation were embedded in the proposed model which were converted as pre-production, production, and post-production phases (Section 4.2).

In prototyping (Section 5.4) the 1M'sia mGBL for example, the general ID model phases were applied in the development. In the analysis phase, users and game requirements were analyzed. The targeted users were from 9 to 15 years old and the objective of the game was to promote 1Malaysia concept. While in the design

phase, game concept and interactions were designed considering the capabilities of the targeted mobile platform. In the phase, subject domain and learning content were also designed.

In the development phase, the mGBL features such as game assets, game environment, and learning content were developed using various kind of tools such as Illustrator, Photoshop and Flash. Next, the 1M'sia mGBL was ported and deployed during the implementation phase. Finally in the evaluation phase, the 1M'sia mGBL was evaluated using the heuristics evaluation in terms of its usability, playability, mobility, and learning content. Through developing the prototype, it showed that the five main phases of ID model were successfully embedded in the proposed model.

In ensuring the learning content is meaningful in game, learning theories characteristics as listed in Table 4.4 (Section 4.2.1) should be embedded in the mGBL learning content. The list of characteristics is useful to designer in order to achieve the learning objective of the mGBL. In addition to learning theories, learning approaches such as Multiple Intelligence theory (Table 4.5), Nine Events of Instructions (Table 4.6) and PBL approach (Table 4.7) which are previously discussed in Section 4.2.1 are also considered relevant to mGBL learning content and characteristics.

The Multiple Intelligences theory provides nine different potential pathways to learning which can be considered in combination as mGBL content. While the Nine Events of Instructions are also helpful in designing the flow of the game play that is aligned with the learning content. PBL aspects may also be utilized to enrich mGBL elements.

Another important aspect that should be included in the proposed model is the mGBL learning model. The experiential learning theory is chosen to be included in the mGBL engineering model (Section 4.2.1). In response to the experiential learning theory, mGBL supports “learning by doing” in the game environment and provides a learning sequence that maximizes the learning process in a significant and meaningful way. In addition, game theories, play theories, and appreciative inquiry theory were also considered in developing mGBL.

7.5 Research Question 4: Is the proposed mGBL engineering model applicable?

The proposed mGBL engineering model has been evaluated through three stages namely; expert review (Section 5.3), prototyping (Section 5.4), and experimental study (Section 6.3). These three combined evaluation methods ensure that the final implementation of the mGBL engineering model represents an approach for the development of mGBL. In fact, the model has been proven benefiting in terms of its applicability.

Generally, the proposed mGBL Engineering Model has been well-accepted by all the experts involved in this study. The model was also employed by a game company while developing a mGBL prototype. The findings in the experimental study indicate that the mGBL Engineering Model scored means above 7.0 (out of 10) for all dimensions compared to the other three models (scores less than 7.0).

In answering the forth research question, a hypothesis testing was conducted. The null hypothesis is as follows:

H_0: The proposed mGBL engineering model is not significantly applicable.

Based on results of the experimental study, it can be summarized that the 8 evaluation dimensions can be defined as a single term which is applicability. Therefore, the one-way ANOVA test was run another round (included all 8 dimensions) to test the applicability of the proposed model. The results as indicated in Table 6.9 were obtained. In comparison of the applicability of the proposed model with other models, the results show significant values. Here, the results prove that the null hypothesis was rejected. Therefore, it can be concluded that the proposed mGBL engineering model is significantly applicable in designing and developing mGBL.

7.6 Objective of the Study – Revisited

The main aim of this study is to propose a mGBL engineering model. The model is developed to ensure the helpfulness in developing mGBL applications among developers. To achieve the main aim, five specific objectives were formulated: (1) to identify the main components of a systematic mGBL engineering model, (2) to embed related ID models as part of the components of the mGBL engineering model, (3) to construct a mGBL engineering model, (4) to evaluate the proposed model through: expert review, prototype development, and groups-treatment experimental design, and (5) to test the hypothesis that the proposed mGBL engineering model is significantly applicable.

At the end of this study, the main aim has been achieved through completion of the five supporting objectives. The first objective was achieved through the identification of the 12 main components of the mGBL engineering model. The identification was made through content analysis, comparative studies and expert consultation. Then, the second objective was accomplished through the incorporation of ID models, learning theories, and learning approaches in the proposed model.

Next, the third objective was accomplished with the construction of the proposed mGBL model by combining all the identified components. The forth objective was realized by performing the evaluation strategies through three stages namely; expert review, prototyping, and experimental study. These three combined evaluation methods produced positive and significant results.

Finally, the fifth objective was achieved through hypothesis testing whether the proposed model is significantly applicable. The testing result rejected the null hypothesis which concludes that the mGBL engineering model is indeed significantly applicable.

7.7 Limitations of Study and Recommendations for Future Works

There were some limitations in the study. These include in few aspects that can be suggested for improvements. First, the number of models and methodologies considered in this study is not exhaustive. While conducting the literature and experiment, only 15 models and methodologies were covered. The selection represents the design model and methodologies for the past 8 years (i.e. 2002-2009). Therefore, future study can further analyze other available models and methodologies related to mGBL development such as object-oriented models, agile development methods, and user-centred methods.

Secondly, only one industry participated in implementing the proposed model in the actual setting. The industry followed the phases and components of the model in developing one mGBL application. Although the implementation was conducted successfully, a case study was not conducted for biasness reasons as no comparative study could have been conducted. Therefore, in future more industries are suggested to apply the proposed mGBL engineering model in developing mGBL application. The four experts as selected in the expert review session could be as industries for developing mGBL application. Hence, a significant comparative

analysis from the results could be performed. In addition, the industries could also produce more than one learning contents with many levels and challenges for the mGBL.

Next, the actual knowledge gained by the players who played the mGBL was not adequately tested. The evaluation conducted to players was at a single session after they play the mGBL application. A comprehensive comparative evaluation which includes a pre and post-tests is suggested for further evaluation on the knowledge gained by the players. Another experimental study could be conducted for the pre and post-tests to the targeted group of users. Therefore, through the pre and post tests, results would be more significantly argued.

The forth limitation is about the selection of the three control models. The selection was based on a total of 5-hour explanation session in assumption that the respondents can understand all models. Although the respondents have knowledge background in system and multimedia development, with 15 models to be decided for only three preferred choices, time was highly limited for full comprehension. Therefore, the explanation session time should be pro-longed and can give ample time for the respondents to make their decisions.

Next, in the experimental study, 22 mGBL applications were developed by the control and experimental groups. Analysis of all these games should have been conducted to measure their playability, usability, mobility, and learning content aspects (heuristics evaluation). Had this been done, then a more detailed analysis of the proposed model would have been documented.

Sixth, for future work related to the components in the proposed model, it is recommended to study on the reusable aspects of the mGBL design and development as repository. This could address the reuse of game design, game

assets or objects, game engine, and learning contents. The study can also consider the issues of copyrights and intellectual properties.

Finally, further study can be done to associate the proposed model with other appropriate design tools such as Unified Modelling Language (UML), development tools such as Flash, and storyboard software such as Celtx. In addition, the model could be enhanced to cater for standardadization processes in developing mGBL such as International Organization for Standardization (ISO) and Sharable Content Object Reference Model (SCORM).

7.8 Conclusion

This research has produced and proposed a mGBL engineering model that consists of 12 components, including various theories and approaches such as multiple intelligence theory, nine events of instructions, PBL approach, appreciative inquiry theory, and experiential learning theory. In the model components, the design guides on mobile technology and heuristics evaluation in terms of playability, mobility, usability, and learning content were also included. The model provides many aspects that should be taken into account to develop good mGBL applications.

Although considerable and future works remain, this thesis demonstrates the applicability of applying systematic approach by using mGBL engineering model to develop mGBL applications. From the findings obtained in this study, there were indications that the proposed mGBL engineering model is significantly applicable to fellow developers to adopt into their mGBL development process. Therefore, it will ensure that they have a proper set of manageable phases, activities, and techniques toward to the quest for quality in mGBL applications.

In conclusion, it is hoped that this study will not only demonstrate the potential of mobile games for learning but also illustrate to the everyday educators to reach their students in motivating and engaging ways of learning.

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Appendix A

Instrument for Expert Consultation

INTRODUCTION

My name is Syamsul Bahrin Zaibon and I am a PhD student in Information Technology at Universiti Utara Malaysia. I am delighted to inform you that your company has been selected to participate in our research.

My research title is Mobile Game-based Engineering Model and intends to integrate the instructional design (educational value) as part of the phases in the development model. The aim is to determine a systematic way of developing the mobile game for learning.

One part of this research is to identify the methodology that is presently applied by different developers to develop mobile games. Although there are many methodologies which are currently used, seeking specific steps to develop such applications would provide alternatives. Through this study, I hope to compare the diversity of the methodologies.

You will see that the questions give you ample opportunity to use your expertise, experiences, interests and creativity. It would be greatly appreciated if you could complete the form and return it to us by email syamsulbahrin@uum.edu.my or fax +604-9284753.

The information supplied will be treated as confidential and will be used for research purposes which may be reported anonymously in academic publications.

Please feel free to contact me by email syamsulbahrin@uum.edu.my in regards to any queries or my supervisor at shuhada@uum.edu.my.

Thank you for your time and assistance.

QUESTIONS

1) Company base: ----------

2) Company established in ----------

3) Number of mobile games developed: ----------

4) Does your company follow any mobile game development method?

Yes ☐ *(If Yes, go to Question **5**)*
No ☐ *(If No, go to Question **7** onwards)*

5) Does your company use in-house mobile game development method?

Yes ☐ *(If Yes, go to Question **6** onwards)*
No ☐ *(If No, Please state the method you adopted*)
*and go to Question **7** onwards* ----------

6) Please illustrate the method that you use for developing mobile game.

7) What are the processes involved in developing mobile game in your company?

8) What are the development tools/ software used for developing mobile game in your company?

a) ----------

b) ----------

c) ----------

d) ----------

9) Has your company developed any **EDUCATIONAL** mobile game?

Yes ☐ *(If Yes, go to Question **10 & 11**)*
No ☐ *(If No, go to Question **11**)*

10) How was the content selection made?

Get from the content experts ☐
Base on popularity of the content ☐
School's subjects ☐
Others: ☐ Please specify: ----------

11) In your opinion, would the development method for educational game require specific step(s) as compared to entertainment game?

Yes ☐ No ☐

Please briefly justify your answer:

THANK YOU

Appendix B

Instrument for Pre-Evaluation Review

INTRODUCTION

Dear colleague, I am delighted to inform you that your company has been selected to participate in our research. My research proposes a Mobile Game-based Engineering Model which aims to suggest a systematic way of developing the mobile game for learning.

Therefore, this study is seeking your expertise to evaluate the proposed model. You will see that the questions give you ample opportunity to use your expertise, experiences, interests and creativity. It would be greatly appreciated if you could complete the form and return it to us by email (syamsulbahrin@uum.edu.my) or fax to +604-9284753.

The information supplied will be treated as confidential and will be used for research purposes which may be reported anonymously in academic publications.

Please feel free to contact me by email (syamsulbahrin@uum.edu.my) in regards to any queries or my supervisor at shuhada@uum.edu.my.

Thank you for your time and assistance.

SECTION A: Background of Respondents

1) Age: _____ years old

2) Highest education level: _____

3) Gender: Male ☐ Female ☐

4) i) Your multimedia or software development experience. Tick (✓) where appropriate.

		Types of Product					
		Multimedia Product	Learning Product	Game	Mobile Application	Mobile Game	Others
Skill levels	Novice	☐	☐	☐	☐	☐	☐
	Intermediate	☐	☐	☐	☐	☐	☐
	Expert	☐	☐	☐	☐	☐	☐

ii) Did you follow any development methodology for developing the product?

Yes ☐ Please state the methodology: ……..

No ☐

iii) What are the development tools/ software used for developing the products?

a) ----------

b) ----------

c) ----------

SECTION B: Questions on your perceptions

Based on your perceptions and understandings of the schematic figure of the **mGBL engineering model**, please comments:

i) Visibility
The model is visible to the game developers, so that the developers can judge the relevance and completeness of the game development.

---

ii) Clarity
The model as a whole is workable and the phases in the model are easily followed and steps or activities included in the model are easy to apply.

---

iii) Effectiveness
The model is perceived to increase productivity, effectiveness and quality of mGBL development.

---

iv) Flexibility
The model provides flexible development process with minimal planning and the model should be flexible and adaptable for future use.

General Comments/ Remarks:

Appendix C

Instrument for Pre-Selection Study on the Preferred mGBL Development Models

INTRODUCTION

Dear respondents, we are delighted to inform you that you have been selected to participate in our research (**mobile game-based learning)** and the aim is to determine a systematic way of developing the mobile game for learning.

At this initial stage, we just want you to give your opinions and perceptions regarding the selected model for developing mobile game-based learning. It would be greatly appreciated if you could complete the questionnaire based on your understanding and perception.

The information supplied will be treated as confidential and will be used for research purposes which may be reported anonymously in academic publications.

Please feel free to contact me by email (**syamsulbahrin@uum.edu.my)** in regards to any queries or my supervisor at **shuhada@uum.edu.my**.

Thank you for your time and assistance.

Please rank (from 1 to 5) your preferred choice of mobile game methodologies for mGBL development where 1 is the highest rank and 5 is lowest rank.

Mobile Game Methodologies	**Rank**
• Best Practice for Mobile Game Development (Dholkawala, 2005)	
• Design-Protect-Build-Test-Market-Sell (Edwards & Coulton, 2006)	
• Game Development Methodology (Dynamic Ventures, Inc., 2007)	
• Game Life Cycle (Janousek, 2007)	
• Scrum Methodology (McGuire, 2006)	

Please rank (from 1 to 5) your preferred choice of instructional design models for mGBL development where 1 is the highest rank and 5 is lowest rank.

Instructional Design (ID) Models	**Rank**
• ADDIE model	
• ARCS (Keller, 1993)	
• ASSURE (Heinich & Molenda (1993)	
• Dick & Carey Model (Dick & Carey , 1996)	
• Morrison, Ross & Kemp Model (Morrison, Ross & Kemp, 2004)	

Please rank (from 1 to 5) your preferred choice of game-based learning models for mGBL development where 1 is the highest rank and 5 is lowest rank.

Game-based Learning (GBL) Model	**Rank**
• Digital GBL Model for History Educational Games Design (Nor Azan et al., 2009)	
• Experiential Gaming Model (Kiili, 2005)	
• FIDGE Model (Akilli & Cagiltay, 2006)	
• Four Dimensional Framework for GBL (de Freitas & Oliver, 2006)	
• Input-Process-Output (Garris et al., 2002)	

THANK YOU

Appendix D

Instrument for Expert Review and Experimental Study

Dear Sir/Mdm

EXPERT REVIEW OF mGBL ENGINEERING MODEL

I am Syamsul Bahrin Zaibon and currently pursuing my PhD studies in Information Technology at Universiti Utara Malaysia. I am delighted to inform you that you have been selected to participate in this research.

My PhD research proposes the **Mobile Game-Based Learning (mGBL) Engineering Model** which aims to provide a systematic way of developing the mobile game for learning.

One part of this research is to evaluate the proposed model. Through this review, I hope to evaluate the model in a few dimensions as listed in the review form.

You will see that the review questions give you ample opportunity to use your expertise, experiences, interests and creativity. It would be greatly appreciated if you could complete this evaluation form.

The information supplied will be treated as confidential and will be used for research purposes which may be reported anonymously in academic publications.

Please feel free to contact me by email (**syamsulbahrin@uum.edu.my)** in regards to any queries or my supervisor at **shuhada@uum.edu.my**.

Thank you for your time and assistance.

SECTION A: Background of Respondents

1) Age: _____ years old

2) Highest education level: _____

3) Gender: Male ☐ Female ☐

4) Experiences: _____

SECTION B: Evaluations Form

Instruction: Please circle the appropriate scale for each item.

Dimensions	Strongly Disagree 1	2	3	4	5	6	7	8	9	Strongly Agree 10
1. Compatibility										
a. The model enables me to work in the way I prefer.	1	2	3	4	5	6	7	8	9	10
b. The model is compatible with the way I develop mGBL.	1	2	3	4	5	6	7	8	9	10
c. Using the model fits well with the way I like to work.	1	2	3	4	5	6	7	8	9	10
d. Using the model is compatible with all aspects of my work.	1	2	3	4	5	6	7	8	9	10
e. Using the model is compatible with my past development experience.	1	2	3	4	5	6	7	8	9	10
2. Visibility										
a. The model makes reasoning clear and visible to me as a developer of mGBL.	1	2	3	4	5	6	7	8	9	10
b. The model allows me to determine the completeness of my project.	1	2	3	4	5	6	7	8	9	10
c. The phases in the model are easily followed.	1	2	3	4	5	6	7	8	9	10
d. The model allows me to intelligently judge the relevance and completeness of my project.	1	2	3	4	5	6	7	8	9	10
3. Complexity										
a. Learning the model is easy for me.	1	2	3	4	5	6	7	8	9	10
b. I think the model is clear and understandable.	1	2	3	4	5	6	7	8	9	10
c. Using the model does not require a lot of mental effort.	1	2	3	4	5	6	7	8	9	10
d. The model is not cumbersome to use.	1	2	3	4	5	6	7	8	9	10
e. Using the model does not take too much time from my normal duties.	1	2	3	4	5	6	7	8	9	10
4. Effectiveness										
a. Using the model increases my job performance and productivity.	1	2	3	4	5	6	7	8	9	10
b. Using the model enhances the quality of my work.	1	2	3	4	5	6	7	8	9	10
c. Using the model makes it easier to do my job.	1	2	3	4	5	6	7	8	9	10
d. The advantages of using the model outweigh the disadvantages.	1	2	3	4	5	6	7	8	9	10
e. Using the model produces the mGBL, for which it is intended for.	1	2	3	4	5	6	7	8	9	10

5. Evolutionary										
a. The model allows continuous feedback from users.	1	2	3	4	5	6	7	8	9	10
b. The model is capable of incremental change, to cope with new ideas or technological opportunities.	1	2	3	4	5	6	7	8	9	10
c. The model provides opportunity for improvements learned from experience.	1	2	3	4	5	6	7	8	9	10
d. The model provides communication and collaboration between developers and users continuously to incorporate the evolving requirements.	1	2	3	4	5	6	7	8	9	10
e. The model is tolerant of minor errors and alterations.	1	2	3	4	5	6	7	8	9	10
6. Flexibility										
a. The model is adaptive and responsive to changing in user needs.	1	2	3	4	5	6	7	8	9	10
b. The model is flexible with minimal planning.	1	2	3	4	5	6	7	8	9	10
c. All the concepts and components included are strictly necessary.	1	2	3	4	5	6	7	8	9	10
d. Deviating from the established activities and phases in the model is possible.	1	2	3	4	5	6	7	8	9	10
7. Clarity										
a. The phases in the model are easily followed.	1	2	3	4	5	6	7	8	9	10
b. The model as a whole is workable.	1	2	3	4	5	6	7	8	9	10
c. Steps or activities included are easy to apply.	1	2	3	4	5	6	7	8	9	10
d. Adhering to the phases and activities is easy.	1	2	3	4	5	6	7	8	9	10
8. Manageability										
a. The model to be capable of being managed or controlled.	1	2	3	4	5	6	7	8	9	10
b. Changing requirements in the model over time is possible.	1	2	3	4	5	6	7	8	9	10
c. The model provides manageable guidelines.	1	2	3	4	5	6	7	8	9	10
d. The model allows self-monitoring to be followed.	1	2	3	4	5	6	7	8	9	10

ADDITIONAL COMMENTS:

_____

_____

_____

Appendix E

Instrument for Heuristics Evaluation (with the findings)

INTRODUCTION

The purpose of this instrument is to evaluate the **1M'sia game** using the heuristics evaluation.

The information supplied will be treated as confidential and will be used for research purposes which may be reported anonymously in academic publications.

Please feel free to contact me by email (syamsulbahrin@uum.edu.my) in regards to any queries or my supervisor at shuhada@uum.edu.my.

BACKGROUND

1. Gender?

Male	☐
Female	☐

2. Age? _____

3. Race?

Malay	☐
Chinese	☐
Indian	☐
Others.	☐
Please specify	_____

Please answer based on these dimensions.

Dimensions		Yes	No	Not Sure	Total
Game Usability					
GU1	Audio-visual representation supports the game	15	4	1	20
GU2	Screen layout is efficient and visually pleasing	12	7	1	20
GU3	Device user interface (UI) and game UI are used for their own purposes	14	4	2	20
GU4	Navigation is consistent, logical, and minimalist	17	2	1	20
GU5	Control keys are consistent and follow standard conventions	14	4	2	20
GU6	Game controls are convenient and flexible	18	2	0	20
GU7	The game gives feedback on the player's actions	16	3	1	20
GU8	The player cannot make irreversible errors	14	3	3	20
GU9	The player does not have to memorize things unnecessarily	15	3	2	20
GU10	The game contains help	13	5	2	20
Mobility					
MO1	The game and play sessions can be started quickly	16	4	0	20
MO2	The game accommodates with the surroundings	17	2	1	20
MO3	Interruptions are handled reasonably	18	1	1	20
Playability					
PL1	The game provides clear goals or supports player created goals	17	2	1	20
PL2	The player sees the progress in the game and can compare the results	14	5	1	20
PL3	The players are rewarded and rewards are meaningful	18	4	0	22
PL4	The player is in control	19	1	0	20
PL5	Challenge, strategy, and pace are in balance	18	2	0	20
PL6	The first-time experience is encouraging	17	3	0	20
PL7	The game story supports the game play and is meaningful	13	6	1	20
PL8	There are no repetitive or boring tasks	15	4	1	20
PL9	The game does not stagnate	15	3	2	20
PL10	The game is consistent	15	3	2	20
Learning Content					
LC1	The content can be learned easily	18	2	0	20
LC2	The game provides learning content	19	1	0	20
LC3	The learning objective from the game is achieved	17	2	1	20
LC4	The content is understandable	20	0	0	20

Appendix F

List of Experts in Pre-Review (Academicians)

No.	Expert	Qualifications	Gender	Expertise	Year of Experience
1.	A	BIT (UUM), MSc. IT (CMU), PhD (Monash)	Female	Software Engineering	12
2.	B	BIT (UUM), MSc. SE.(UTM), PhD (UiTM)	Female	Software Engineering	10
3.	C	BIT (UUM), MSc. SE (UTM)	Female	Software Engineering	10
4.	D	BIT (UKM), MSc. IT (UUM)	Male	Multimedia	12
5.	E	BIT (UUM), M. Info Tech (Sydney)	Female	Software Engineering	8
6.	F	BSc. IT, MM System (MMU), MSc. IT (UKM)	Female	Multimedia	10
7.	G	BSc. IT (MMU), MSc. IT (UUM)	Male	Multimedia	6

Appendix G

List of Experts in Expert Review (Game Industries)

No.	Expert	Position	Gender	Company/ Institution	Year of Experience
1.	A	Managing Director / Developer	Male	Digital Durian Sdn. Bhd.	6
2.	B	Developer	Female	Aspati Sdn. Bhd.	6
3.	C	Managing Director/ Developer	Male	Flavert Media Lab	7
4.	D	Head of Department, Computer Science and Mathematics	Female	UiTM Terengganu	10