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PLAYABILITY HEURISTIC EVALUATION SYSTEM FOR MOBILE GAMES

by

SARMAD SOOMRO

The undersigned certify that they have read, and recommend to the Postgraduate Studies Programme for acceptance this thesis for the fulfillment of the requirements for the degree stated.

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PLAYABILITY HEURISTIC EVALUATION SYSTEM FOR MOBILE GAMES

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SARMAD SOOMRO

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BANDAR SERI ISKANDAR,

PERAK

MARCH 2014

DECLARATION OF THESIS

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Date :	Date :

DEDICATION

I dedicate this research wok to my beloved **parents, teachers,** and **friends** who have always been a great moral and practical support in my life.

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ABSTRACT

Playability is an element that measures the ease of use by which a game can be played. To evaluate playability of a game, two methods are widely being used; Playtesting and Heuristic Evaluation. Playability Heuristics are required to perform heuristic evaluation on games. Existing playability heuristics for mobile games lack in identifying the playability problems such as usability, gameplay, mobility and multiplayer. This research aims to fulfill three main objectives: 1) To examine existing playability heuristics for various game genre, 2) To propose a new set of playability heuristics for mobile games. 3) To develop a web-based software system to automate heuristic evaluation. Two experimental studies were conducted. Experimental Study-I is an evaluation of mobile games with existing playability heuristics. While experimental Study-II is to validate the proposed playability heuristics. Fourteen participants participated in each of the experiments. Based on the results of Experimental Study-I, a new set of playability heuristics was proposed for mobile games. Experimental Study-II confirms that proposed playability heuristics are very much efficient in identifying playability problems extensively. A web-based software system named Playability Heuristic Evaluation System (PHES) has been developed to automate the process of heuristic evaluation. The proposed Playability Heuristics were incorporated into PHES. Playability tests on five mobile games were conducted to measure the efficiency and effectiveness of the system. The results show that, heuristic evaluation using PHES is more efficient than doing the heuristic testing manually as it saves a lot of time.

ABSTRAK

Kebolehmainan merupakan suatu elemen yang mengukur tahap kemudahan penggunaan sesuatu permainan. Untuk menilai kebolehmainan sesuatu permainan, dua kaedah sering digunakan secara meluas; Menguji-main dan Penilaian Heuristik. Heuristik kebolehmainan diperlukan untuk melaksanakan penilaian heuristik terhadap permainan. Heuristik kebolehmainan yang sedia ada untuk permainan mudah alih kekurangan dalam mengenal pasti masalah kebolehmainan seperti kebolehgunaan, corak permainan, mobiliti dan berbilang pemain. Kajian ini bertujuan untuk memenuhi tiga objektif utama: 1) Untuk mengkaji heuristik kebolehmainan sedia ada untuk pelbagai genre permainan, 2) Untuk mencadangkan satu set heuristik kebolehmainan baru untuk permainan mudah alih, dan 3) Untuk membangunkan suatu sistem perisian berasaskan sesawang untuk mengautomasikan penilaian heuristik. Dua kajian eksperimen telah dijalankan. Eksperimen Kajian-I adalah satu penilaian permainan mudah alih dengan heuristik kebolehmainan yang sedia ada. Manakala, Eksperimen Kajian-II adalah untuk mengesahkan heuristik kebolehmainan yang telah dicadangkan. Empat belas peserta telah mengambil bahagian dalam setiap eksperimen. Berdasarkan kepada keputusan dari Eksperimen Kajian-I, satu set heuristik kebolehmainan baru telah dicadangkan untuk permainan mudah alih. Eksperimen Kajian-II pula mengesahkan bahawa heuristik kebolehmainan yang dicadangkan amat berkesan dalam mengenalpasti masalah kebolehmainan secara menyeluruh. Suatu sistem perisian berasaskan sesawang yang dinamakan Sistem Penilaian Heuristik Kebolehmainan (PHES) telah dibangunkan untuk mengautomasikan proses penilaian heuristik. Heuristik Kebolehmainan yang telah dicadangkan telah digabungkan ke dalam PHES. Ujian kebolehmainan terhadap lima permainan mudah alih telah dijalankan untuk mengukur kecekapan dan keberkesanan sistem. Keputusan ujian menunjukkan bahawa penilaian heuristik dengan menggunakan PHES adalah lebih cekap daripada melakukan ujian heuristik secara manual kerana ia lebih menjimatkan masa.

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CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter provides an overview of mobile games, their background, as well as the importance and challenges presented by their evaluation. A problem statement is then formulated based on literature review and the preliminary studies. Research objectives and research questions are presented along with research focus. Following that thesis organization is presented. Finally, the chapter is summarized to present the importance and outcome of this study.

1.2 Importance of Mobile Games and Evaluation Techniques

A game can be described as a closed formal systems that subjectively represents a subset of reality (Eskelinen, 2001). The classification of a game varies over time and various definitions are presented. Researchers define games as activities that include rules, goals, objectives, fun, entertainment, fantasy, challenges, curiosity, competition, and strategy (Omar & Jaafar, 2008; Garris, Ahlers, & Driskell, 2002).

Over the last decade, mobile phone technologies emerged rapidly according to potential impacts not only on academic research, but also on commercial aspects. The "*anytime-anywhere*" availability of mobile phones has brought new dimensions and directions for user applications, most specifically for digital gaming (Comviva, 2009).

Recently, mobile games have received greater interest among users and have been played by everyone at every stage of life, childhood to adult. Researchers have shown that users opt and play different games for many reasons including relaxation, education, enjoyment, entertainment and learning (Desurvire et al. 2004). Games

are also being played to solve problems that exists in the real world by simulating many situations; for example, in medicine, education, military, business, hospital venues, etc. Moreover, games also play an important role in academia where a number of learning based games are available for teaching young children (Mohamed and Jaafar, 2010). Consequently, playing a game is to face the unexpected events in uncertain situation, where any player never knows that, what will be the next step, next objectives, and next strategy to achieve the objectives as expected (Koivisto, 2008; Korhonen, 2006; Federoff, 2002; Desurvire et al., 2001).

Researchers acknowledge that the growth of mobile games increases daily which appeals to game development companies who produce and commercialize games. However, it is a challenging task for these companies to produce good-quality games. Designing and developing a game are the initial stages of a game that are intended to create good-quality games and ensure sufficient features such as, fun, learning, convenience, reliability and, more importantly, playability. Playability is an element that measures the ease of use by which a game can be played. To examine playability in a game, two common methods are used: *Playtesting* and *Heuristic Evaluation*. Playtesting is a traditional method used widely in all gaming platforms. Playtesting undertakes to uncover design faults at the initial development stage, usually on an alpha version of the game. However, to conduct an effective evaluation, it is best to have a fully functional game that is playable.

The second most widely used method is heuristic evaluation as proposed by Nielsen and Molich (1990). This method attempts to inspect the software's interface. However, it is also applicable and proven efficient for evaluating games with '*playability'* heuristics. In this method, usability practitioners inspect possible playability problems in a game against the heuristics. However, it is not necessary that problems identified during evaluation are identical to problems a user might face when playing the game. However it is predictive of the occurrence of such problem types that might be confronted by end users (Korhonen, 2011). However, general usability heuristics cannot be directly applied to evaluate video games because application software and video games are very different in context. Hence, usability heuristics do not necessarily cover all aspects of games such as fun,

entertainment and enjoyment (Korhonen, 2011; Johnson & Wiles, 2003; Federoff, 2002). Heuristics evaluation has since received increasing interest by game researchers and usability experts. Several 'game-domain' heuristics have now been proposed by numerous researchers to evaluate playability of games (Desurvire & Wiberg, 2009; Pinelle, Wong, & Stach, 2008; Korhonen & Koivisto, 2007; Schaffer, 2007; Korhonen, 2006; Federoff, 2002; Desurvire et al., 2001).

1.3 Research Problem

Mobile games have attracted greater and growing interest among users for many emerging applications. Bearing in mind the significance of game applications, different sets of heuristics have been proposed for the evaluation of games in many studies. These heuristics provided a strong foundation for identifying various problems. Even so, literature suggested that existing mobile game heuristics lacks in identify playability problems (e.g. Usability, Gameplay, Mobility and Multiplayer) in mobile games (Korhonen, 2010 and Paavilainen, 2010).

Another important issue with present heuristic sets is that they contained marked ambiguity in descriptive terminologies, (e.g. "*The game supports communication*" and "*There are reasons to communicate*"). Such indistinct usage created confusion for evaluators who then attempt to identify problem that correlate with the stated heuristics. In addition, no standard exists that defines "how many heuristics are used for a particular game evaluation". This often translates as inappropriate (large and small) numbers of heuristics, and also creates various other hindrances for evaluators (Paavilainen, 2010). Using insufficient numbers of heuristics for evaluation may limit the identification of playability factors because of heuristic ambiguity. Whereas, using a large number of heuristics creates confusion for evaluators when they browse (Korhonen, 2010 and Paavilainen, 2010).

Furthermore, it is identified from preliminary studies (the detailed are presented in section 4.2) that existing playability heuristics did not support the evaluation of touchscreen mobile games. There is lack of touchscreen heuristic to evaluate present touchscreen games. This lack of focus on not evaluating important

feature of current mobile games may lead to problems for mobile games users and mobile game developing industry.

Playability heuristics are used to evaluate games with heuristic evaluation. Heuristic evaluation played a significant role in evaluating usability of software and websites and as well as evaluating playability of games. However, it has been criticized as non-effective method by Cockton, Lavery, & Woolrych (2002); Blandford, Vanderdonckt, & Gray (2001); Connell & Hammond (1999); Cuomo & Bowen (1994). Researchers have made several attempts to improve the effectiveness of this process but there still possibility of producing biased results. One of the major attempt was to automate the process of heuristic evaluation. Several usability assesment tools were developed and comercilized, for example: Tobbi, Loop11, Usefeel and URANUS. The literature reports (Sivaji, 2012) that each tool has pros and cons therefore, it is difficult to determine which of these tools are most effective usability assesment (Sivaji, 2012). Hence, simply purchasing a tool did not guarantee accurate results and each tool is designed to evaluate different applications, for example: desktop and web applications. It is also reported in literature that eight out of ten usability experts complained of difficulties when justifying which tool was better along with their costs (Sivaji, 2012). It is reviewed from literature that exisiting tools had never been used to evaluate games or results were not published yet. Therefore, a motivation is raised to develop a web-based software system to automate the process of heuristic evaluation for games. This web-based software system facilitate remote evaluations and results can be obtained anywhyere.

1.4 Research Objectives

The key objective of this study is to propose a new set of playability heuristics for mobile games and to develop a web-based software system that automates the process of heuristic evaluation. Based on the literature review, this study was undertaken to achieve three main objectives as follows:

1. To investigate existing playability heuristics for various mobile game genre

2. To propose a new set of playability heuristics for mobile games
3. To develop a web-based system that automates the process of heuristic evaluation and that incorporates the proposed set of playability heuristics

1.5 Research Questions

In order to investigate existing playability heuristics for mobile game and to investigate the need to improve/propose the process of heuristic evaluation for evaluating games, this study attempts to answer following research questions.

1. What are existing playability heuristics for mobile games?
2. Are existing heuristics applicable to evaluate current mobile games?
3. Is there any need to propose a new set playability heuristics for mobile games?
4. What is existing heuristic evaluation method for mobile games (Manual v/s automated)?
5. Is there a need to improve/propose process for evaluating mobile games?

Five questions were formulated to frame the boundary of this study that correspond to research objectives. Research question 1 and 2 correspond to first objective. Research question 3 correspond to second objective. Similarly, research question 4 and 5 correspond to third objective of this study.

1.6 Research Focus

Video games refer to activities that involve fun, fantasy, challenges, goals, objective, curiosity, competition and strategy. However, games are not only played for fun and enjoyment, but also as part of education including airline training, medicine, military training, hospital management, city management etc. To produce a good quality game is a challenging task for game developing companies. Several methods were introduced to evaluate games. Most popular are "*Playtesting*" and "*Heuristic*

Evaluation". The study focuses to evaluate mobile games of different types (genre).

1.7 Thesis Organization

Chapter 1 presents the background and importance of mobile games and their evaluation techniques. In addition, it contains a problem statement as well as research objectives and questions.

Chapter 2 presents a literature review of video games and playability heuristics for both computer and mobile games. Issues and limitations are discussed in the context of playability problems with mobile games. In addition, techniques and tools for evaluation of mobile games are discussed.

Chapter 3 presents the research design and phases along with various methods that have been used for data collection and analysis. These are discussed with a view to meet the objectives of this study.

Chapter 4 presents the results and discusses them with regard to the contexts of research problem and research questions, respectively. A new set of playability heuristics for mobile games is presented in detail along with the design and development of a web based system named Playability Heuristic Evaluation System (PHES). Subsequently, evaluations conducted with PHES and results are presented.

Chapter 5 presents the conclusions as well as recommendations for future work.

1.8 Research Flow

Figure 1.1 shows the flow of this study which is divided into five phases. Phase 1 comprises an analysis of existing playability heuristics for mobile games based on a preliminary studies and literature review. During Phase 2 six mobile games were evaluated by with two existing sets of playability heuristics for mobile games with heuristic evaluation. The outcomes of Phase 2 justified the need to propose a new set of playability heuristics for mobile games. Phase 3 consists of evaluation of six mobile games of different genre with the proposed set of playability heuristics.

Based on results from Phases 1, 2 and 3, a new new-based software system was then developed to conduct heuristic evaluations as described in Phase 4. Finally, Phase 5 is the conclusive evaluation of mobile games with the newly developed Playability Heuristic Evaluation System (PHES).

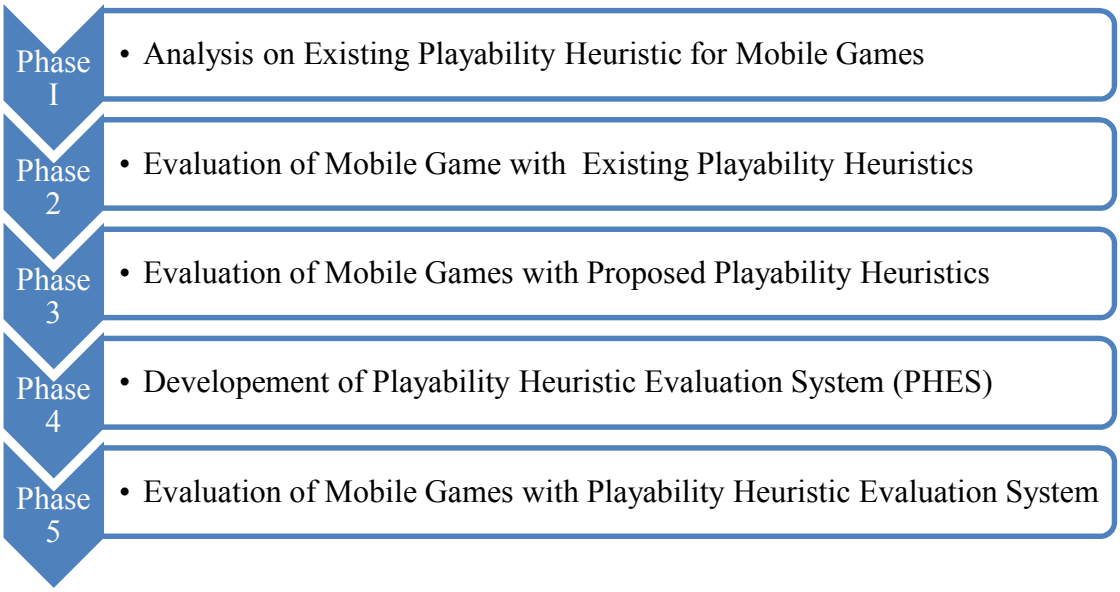

Figure 1.1: Research Flow

1.9 Operational Definitions

Heuristics - Heuristics are rules of thumb for reasoning, a simplification, or educated guess that reduces or limits the search for solutions in domains that are difficult and poorly understood.

Usability heuristics - Usability Heuristics apply principles which usability experts utilize to measure the benefits of a particular software product. They are also defined as 'design guideline rules' that help in the design of usable applications.

Heuristic Evaluation - Usability experts utilize heuristics to measure the benefits of a particular software product/games/websites.

Playability – Playability is the ease by which the game can be played or the quantity or duration that a game can be played.

Playability heuristics – Playability Heuristics are principles which usability/game experts utilize to measure the playability of the game.

1.10 Summary

This chapter presented a brief introduction of mobile games and methods of evaluating games. The chapter addressed two research problems, 1) that existing playability heuristics lacks in identifying playability problems in mobile games 2) there is need to improve/propose a new process of conducting heuristic evaluation on games. These gaps led to the formulation of the three research objectives as follows 1) to investigate existing playability heuristics for various mobile game genre, 2) to propose a new set of playability heuristics for mobile games and 3) to develop a web-based software system to automate the process of heuristic evaluation. Following that, research focus and research questions of this study were explained. Finally, as a guide to the content and the flow of the discussion in the following chapters, the organization of the thesis was provided.

The next chapter presented an extensive literature review of various set of heuristics for computer and mobile games and Evaluation techniques for games are also briefly discussed as to their benefits and limitations.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter consists of three main sections in which review of related research has been carried out. The first section concerns the contemporary use of mobile games. The second section comprehensively examines research on heuristics for various applications and games and identifies respective merits and demerits. The third section inspects games' evaluation methods and assesses the suitability with respect to subjects of study.

2.2 Background of Games

Video games comprise a significant portion of computer applications that have earned huge incomes as users spend much time and effort playing them (Barr, Noble, & Biddle, 2007). In general, games or video games refer to activities that involve fun, rules, goals, objectives, entertainment, fantasy, challenges, curiosity, competition and strategy. People play games for relaxation, entertainment and the alleviation of stress. This level of importance have brought video games into the mainstream of contemporary life styles globally. Games are not only played for fun and enjoyment, but also as part of education including, airline training, medicine, military training, hospital management, financial planning, city management etc. (Comviva, 2009).

The very first computer game was "*Tennis for Two*" developed in 1958 by "*William Higginbotham*". At that time developers were not aware with potential of games due to huge amount of equipment were required. The second generation of computer games encompassed the 1960s, beginning with games such as *Spacewar!*,.

Screenshot of games is shown in Figure 2.1.

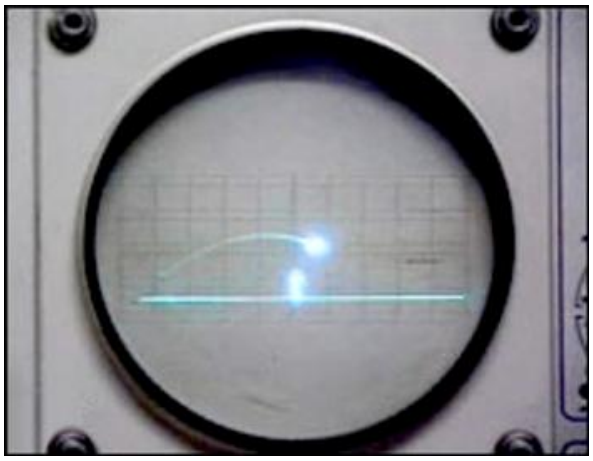

Figure 2.1: First Computer Games (Overmars, 2012)

With the increasing popular interest, many companies began their commercialization. The very first arcade game, named *Periscope*, was released by Sega in 1966. However, it was not a computer game but rather an arcade machine. 1970 to 1979 was considered the golden age of video arcade games, and the first arcade computer game, *Computer Space*, was released in 1971 but it was not a success because arcade machines' costs were considerable at the time. The very next year, the same creators did not forfeit and went on to found Atari: the *Ping Pong* game that was a huge commercial success. Breakthroughs came in 1976 when *Space Wars* used vector graphics for the first time. In 1978, a colour game was released named Space Invaders; and in 1980 the highly popular game, "Pac-Man", was released (Overmars, 2012).

By the 1980s, video games rapidly increased numerically but many companies developed bad quality products causing a huge crash in arcade gaming. An additional reason for the 'arcade' crash was the introduction of computer games. Cheap personal computers were released that were particularly suited for games because of memory, graphics and sound capabilities. In 1985, Nintendo released their Nintendo Entertainment System (NES) as shown in Figure 2.2, which was a huge success because it came in a package called *Super Mario Bros*.

Figure 2.2: Nintendo NES (Evan, 2012)

By the late 1980s, Nintendo released the first handheld *Game Boy*, bundled with the game *Tetris*, making it very popular. Tetris was designed by the Russian scientist, Alexei Pajitnov, and is considered the most addictive game ever ("Tetris: A History," 2012). From 1994 to 1996 the next generation of console games appeared on the market. Sega released Saturn in 1994; Nintendo released N64 in 1996; and Sony released Play Station in 1994. During the 1990s, PC games matured. The PC had an advantage over consoles because they were much more powerful; graphics resolution was better, they had more memory and hard disks to store game data, and much higher processor speeds. Numerous great games were produced for PCs including Lemmings, Sim City, Sid Meir's Civilization, Popoulos, Tomb Raider, Quake, Half-life, and Grand Theft Auto. PCs had other advantages: the mouse and keyboard. With a mouse and keyboard, different games became playable whereas the console specific genre of the time was limited (Overmars, 2012).

The next generation of games began in 2000 when Sony released PlayStation 2. It was a huge success because it had excellent sound qualities, a network adapter, and a DVD drive that could also play movie DVDs (Guardian, 2013). In 2001, Microsoft entered the market with Xbox. The Xbox was basically a PC in a console box: a very powerful machine. It had a DVD drive, a hard drive and a built-in, fast Ethernet.

But the Gaming Era changed when smart phones appeared and grew in

popularity among non-business users. Apple introduced the iPhone in 2007 which had a huge effect on mobile gaming. The device had 480 x 320 screen resolution, multi touch screen, and accelerometer, all of which made it an excellent device for gaming. This led to many challenges for developers to devise new ways of controlling games and creating new kinds of games. With increasing demand for mobile games, mobile phones also rapidly gained strength. The game, Angry Birds, is probably the largest success with over 100 million downloads. With the rapid evolution in science and technology, gaming platforms continued to mount and mature. Technological advancement, coupled with users' demands for quality gaming, have led to a continuous advance in gaming modalities. Most common gaming platforms are Computer games, Console games and mobile Games. Computer and Mobile games are further defined in following subsection.

2.2.1 Personal Computer Games

Personal Computer (PC) games are usually played on a general purpose computer with mouse and keyboard as basic input devices for game interactions, a CPU as processor, and a monitor for output display. First generation computer games (1960s to 1970s) were often text based or 'interaction fiction' where players interacted with the keyboard. Computers at the time could not facilitate graphics. During the early 1980s, personal computers become powerful enough for games with graphics and the very first popular games were *Space Invaders* and *Pac Man* (Overmars, 2012). Later, in the 1980s, major growth in computer game technologies occurred. A variety of personal computers then became available and a new era of three-dimensional (3D) interaction began. In addition, new input and output devices were developed such as color monitors, speakers and gamepads. Some major factors and feature that advanced gaming platforms during this era are described as follows.

- Changes in computer hardware

Development in hardware had a huge effect on the game industry allowing game designers to diversify and create more attractive games. During the early era of personal computers, memory power, storage and graphics were minimal but today's

consoles comes equipped with special 3D graphics cards and Blu-ray DVD disks to store game data, in addition to High Speed Internet connectivity for Multiplayer gaming.

- Changes in interaction design

Devices that control video games have also improved. Initial game consoles had special rotating knobs or simple joysticks and a few buttons. Nowadays, game controllers have multiple joysticks and lots of buttons. Moreover, in recent years these have been augmented by devices that measure movement, such as the Wii controllers of Nintendo, or the Kinect system of Microsoft. Obviously these items have had a strong impact on game play.

- Changes in the software tools

Initially game developers wrote every line of code themselves (often in assembly language), and drew every pixel of artwork. Nowadays, extensive game engines and middleware packages are available that allow for much more sophisticated games. Artists, animators and level designers use advanced tools that help them create complicated artwork efficiently.

- Changes in design of games

All these changes have, in turn, led to considerable changes in game design. Designers now use new hardware and interaction devices to create new forms of 'immersive' gameplay. They have created games that attract different demographic constituents and better understand what makes games interesting.

- Changes in game business

Game companies have considerably changed over the last fifty years. Initially, games were developed primarily by individuals. Nowadays, huge teams of specialists work on a single game. Development budgets have grown from a few thousand dollars to tens of millions of dollars per game. Furthermore, educational gaming programs have also appeared for professional training.

- Changed in the demographics of the players

From the start, games were primarily played by young males, but this has changed considerably in recent years. The number of female players now approaches the number of male players, and players' ages range from four to one-hundred. These developments have led to new game genres. Major computer game genres are presented in the following subsection.

2.2.1.1 Computer Games Genre

In the beginning of the computer gaming era, only a few game genres had developed such as adventure and arcade novelties. By the 1990s, new game genres were introduced such as first person shooter, simulations, real time strategy, and online multiplayer games. In recent years, new genres have been introduced such as role playing, puzzle, strategy, simulation, building, war, sports, racing and educational (Omar and Jaafar 2008 and Desurvire et al. 2001). The most popular computer game genres are presented below along with examples.

- Adventure

In adventure games, the player is the hero of the story and must solve puzzles in order to advance. These puzzles are often concerned with interacting and manipulating objects and game characters (Hanna, 2012). For example: *Fahrenheit, Alan Wake, The Cave*, etc.

- Action

Action games are generally fast-paced games that require actions to be performed reflexively. Example: *Splinter Cell, Gone Home, Dota, Bio Shok, Assassin's Creed*, etc.

- Action – Adventure

Action Adventure games sometimes require players to solve puzzles and explore in fast-paced action milieus. Examples: *Grand Theft Auto, Tomb Raider, Resident Evil, Prince of Persia, L.A. Noire, Remember Me,* etc.

- Fighting

In fight games, the player typically fights another human player or simulated computerized opponent. Examples: *Mortal Kombat, Street Fighter, King of Fighters, Tekken, Virtua Fighter*, etc.

- First Person Shooter

First Person Shooter games are action oriented where the player is behind the eyes of a simulated game character within a first person context. Usually, first person shooter games are fast-paced and typically demand quick reflexive actions. Examples: *Battlefield, Call of Duty, Counter Strike, Doom, Far Cry*, etc.

- Real Time Strategy

Real Time Strategy games typically have a number of objectives concerned with resource collection, base and unit building, and combat engagements with other players or simulated opponents. Examples: *Command & Conqueror: Red Alert, Warcraft, Age of Empires, Sid Meier's Civilization*, etc.

- Role Playing (RPGs)

In Role Playing Games, the player controls the actions of a character occupied in a fictional world. He/she is provided with flexible character development, problem solving skills, etc. Example: *Diablo, World of Warcraft, Mass Effect, Fallout*, etc.

- Simulation

These games simulate physical activities such as aircraft flight, football management, city management, hotel management, hospital management, railroading, etc. Examples: *Microsoft Flight Simulator, SimCity, Business Tycoon, Hotel Giant, Hospital Tycoon, Train Simulator*, etc.

- Racing

Racing games put the player behind the wheels where he/she can race with other drivers. Examples: *Need for Speed, Mario Kart, Dirt, GTR*, etc.

- Sports

These games are digital versions that simulate sporting experiences such as cricket, football, basketball, golf, tennis, skate boarding, etc. Examples: *Cricket Ashes, FIFA, Tiger Woods' Golf, Vitrua Tennis*, etc.

- Puzzle

Puzzle games are designed to solve problems and require intellectual skills such as logic, strategy, memory, pattern matching. Examples: *Tetris, Minesweeper*, etc.

- Traditional

Traditional games represent computerized version of card, board and word games. Examples: *Chess, Checker, Scrabble, Backgammon*, etc.

- Educational

Educational games are designed to teach in an interactive manner. Example: *Carmen Sandiego, Marvis Teaching Typing*, etc.

2.2.2 Mobile Games

According to Comviva (2009), advances in communication technology have made the mobile phone the next edge of digital gaming. The 'anytime-anywhere' availability of mobile phones coupled with advances in multimedia technologies gave a new dimension to mobile gaming. Mobile gaming fits today's global lifestyle and offers a time-efficient source of fun and enjoyment. Factors like availability and affordability have made mobile devices more useable compared to other devoted gaming platforms. Moreover, numerous technologies such as Wifi, 3G, multi-pixel cameras, high-quality sound and huge mobile storage have granted mobile phones a gaming platform with distinguished features. However, mobile gaming does have limitations of form such as ergonomics, small screen size and inconvenient control keys. But despite these limitations, mobile gaming growth has never slowed. Mobile games are available in various genres presented in following subsection.

2.2.2.1 Mobile Games Genre

Mobile game genres do not have a wide range compared to computer games genre because of the different form factor. In the beginning, arcade, board, adventure and sports simulation games predominated and as the gaming industry expanded, other genres were introduced; games such as action, shooter, role-playing and real-time strategy.

In this study a total number of nine mobile game genres were evaluated. One genre "Educational" is used in Preliminary Study-II and eight genres are used in Experimental Studies. Some game genre are combined e.g. Action and Adventure. Each genre is discussed below and also in Section 3.2.3 of chapter 3.

- Action - Adventure

The action-adventure genre merged elements of adventure games with those of various action games (Coriolis, 2012). The action-adventure genre requires action skills along with storyline, inventory, game characters, dialogue and other features (Adams, 2009).

Action-adventure games have a fast pace compared to adventure games and also include physical and conceptual tasks. A popular example for the mobile phone is *Temple Run*.

Temple run is a treasure hunting Action/Adventure single player game. In temple run, player takes on the role of an explorer who has stolen an idol from a temple. Player needs to run for life to escape from the evil demon monkeys (Imangi Studios, 2012). Screenshot of the game is shown in Figure 2.3.

Figure 2.3: Temple Run Screenshots (Source: Imangi Studios, 2012)

This game has good rating on android Google play store. Some reviews of users are presented as follows:

> "*A player commented that it is quite addictive game and fun level is very high in it.*" , (Imangi Studios, 2012).

> "*A player commented that it is an Amazing game with high ratings. This game is very addictive that I play for hours!*", (Imangi Studios, 2012).

- Strategy - Puzzle

A strategy-puzzle game requires skilled thinking and planning to achieve specific objectives in which the player makes strategic decisions under a given scenario. Players must plan a series of actions to overcome sequential challenges (Rollings & Adams, 2003). War Games are the most common example of strategic games; they also include resource management, city planning and transportation management. *Train Crisis* was a popular mobile strategy game in 2012.

Train crisis is a puzzle/strategy single player mobile game. Player needs to manage a series of railway carriages or wagons moved as a unit by a locomotive in a limited time frame (U-Play, 2012). Screenshot of game is shown in Figure 2.4.

Figure 2.4: Train Crisis Screenshots (Source: U-Play, 2012)

Some reviews of users are presented as follows:

"*A Player commented that game quality is Excellent. The Graphics and puzzles are really good. Exactly the kind of game I've been looking for*", (U-Play, 2012).

"A player commented that is Fun to play this cane but frustrating because little hard to hit the switches and lights at times. However, the overall quality of game is good and additive.", (U-Play, 2012).

"*A player commented that the great quality gam however, some levels are very challenging and require full attention,* (U-Play, 2012).

- Simulation

Simulation games reflect activities in real life for various purposes that involve training, analysis or forecasting. Usually, there is no specifically pre-defined goal; the player just plays around as a game character (Hanna, 2012). The most popular simulation games are war games, business games and role-play simulations. A popular simulation mobile game in 2012 was *Cafeteria Nipponica*.

Cafeteria Nipponica is a simulation genre single player mobile game. Player needs to run restaurant, find ingredients, research recipes and spices to run culinary business successfully. Player also needs to manage every details of restaurant such as furniture, decorations and staff, (Kairosoft, 2012). Screenshot of game is shown in Figure 2.5.

Figure 2.5: Cafeteria Nipponica Screenshots (Source: Kairosoft, 2012)

This game has good rating on android google play store. Some reviews of users are presented as follows:

"*A player commented that, the music and ingredient hunting is very interesting which make me keep coming to play this game eventually. The Discovering new foods is also strangely exhilarating for a pixelated game*", (Kairosoft, 2012).

"*A player commented that, the game has high level Fun and addictive, It is really good game. Just wish there were more restaurants to own. Game lifetime is too short*", (Kairosoft, 2012).

"*A player commented that, this game is amazing and addictive but it also difficult to manage in limited resources, sometime possess high loss. The Overall quality of game is fantastic and hope there will be more improvements in game*", (Kairosoft, 2012).

- Arcade

Arcade genre games have small stages, simplistic and spontaneous controls, and rapidly increasing game speed. Usually, arcade games have no storyline; the player just needs to clear levels (Hanna, 2012). The most popular arcade game of all the time was Pinball. In mobile games, *Block Breaker 3* was popular arcade mobile game in 2012.

Block breaker 3 is puzzle/arcade single player mobile game. Player needs to trigger switches and break through bricks & gateways to reach new areas as you push your way towards the top. To complete the game, player needs to achieve 100 levels , (Gameloft, 2012a). Screenshot of game is shown in Figure 2.6.

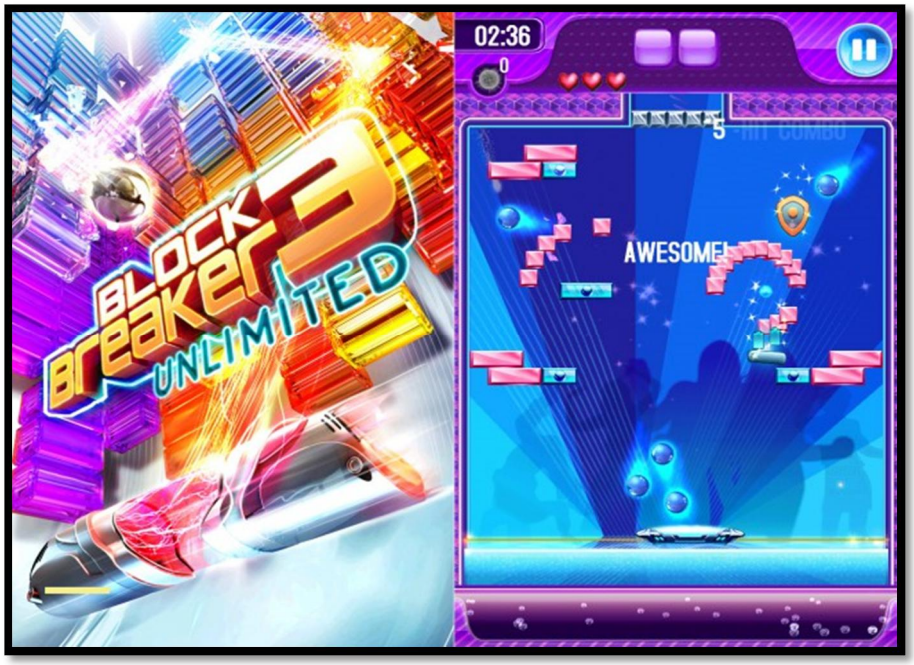

Figure 2.6: Block Breaker 3 Screenshots (Source: Gameloft, 2012a)

This game has good rating on android google play store. Some reviews of users are presented as follows:

"*A player commented that, it is Addictive game. The graphics of game are good and runs very smooth on low cast cellphone. This game is time killing game, love to player for hours",* (Gameloft, 2012a).

"*A player reported that, it is Cool and loving game but still new some improvements to make it more enjoyable",* (Gameloft, 2012a).

- Racing

In racing games, a player takes part in a racing competition whether by land, sea or air. Racing games are based on real world racing leagues in well-mannered settings. They can be either arcade racing, in which a player races with random opponents, or simulation based, in which players seek world class status (Hanna, 2012). The most popular mobile racing game is the *Asphalt Series*. In this study Asphalt 6 was considered for evaluation.

Asphalt 6 is racing single/multiplayer mobile game. Player needs to compete other opponents to get popular. Game contains number of playing styles. Player has

variety of car selection and customization through the game. Player can play either single player or multiplayer with other friends, (Gameloft, 2012b). Screenshot of game is shown in Figure 2.7.

Figure 2.7: Asphalt 6 Screenshots (Source: Gameloft, 2012a)

This game has good rating on android google play store. Some reviews of users are presented as follows:

"*A player commented that, this is just Wow!. The game and the graphics are amazing. Control keys are very easy to handle and it runs flawlessly",* (Gameloft, 2012b).

"A player commented that it is a Great game to play. Works perfect on Samsung Galaxy 2 and this game is much more better than need for speed", (Gameloft, 2012b).

"*A player commented that, it is one of the best racing game I have ever played on android. The game is paid version but it worth every penny. The game graphics are just stunning, never expected to see such graphics on mobile game",* (Gameloft, 2012b).

- Shooter

This genre is a sub-genre of action games. Shooter games usually involve weapons to eliminate enemy opponents. Players needs to achieve objectives by killing enemies with limited ammunition, weapons and character health (Comviva, 2009). The most popular mobile shooter game is *Modern Combat*. This game is further presented as follows.

Modern combat is first-person shooter, single/multiplayer mobile games. The game's single player mode takes place over thirteen levels, in locales such as Hollywood, Alaska, and the Middle East. The game is controlled virtual buttons on the screen, while the aiming is achieved by swiping the touchscreen. Game also contains gyroscopic controls but limited to certain devices. Game also can be played as multilayer mode containing six different maps and eight different game modes; "Battle", "Team battle", "Capture the flag", "Zone control", "Manhunt", "Bomb squad", "Destruction" and "Team Manhunt", (Gameloft, 2012c). Screenshot of game is shown in Figure 2.8.

Figure 2.8: Modern Combat 3 Screenshots (Source: Gameloft, 2012c)

This game has good rating on android Google play store. Some reviews of users are presented as follows:

"*A player commented that, The Best Game Ever, I have paid for it but it worth of it. The missions are challenging but it is fun to be play. This is best game I have ever play on mobile phone*", (Gameloft, 2012c).

"A player commented that, it is *Fun to play this game and also it has a great storyline. This game really improved the graphics and as well as the gameplay from previous version. The storyline is by far better than the Call Of duty franchise (Even if it's similar)*, (Gameloft, 2012c).

"A player commented that, the graphics quality and gameplay is just like computer game. *The storyline is like other computer games but is quite enjoyable to have games like this on a cell phone*"**,** (Gameloft, 2012c).

- Educational

Educational games deliver an approach of experimental learning, where knowledge results from interaction and feedbacks are entertaining. Educational games include some academic activities related to curriculum to any academic subject. i.e Math, English, Science, etc. educational games are also being used in universities and colleges to train students in major subjects like "City Planning", "Business Management", "Aeronautical", "Electrical" and "Computer Engineering", (Janarthanan, 2012).

In this study four educational games were evaluate in Preliminary Study-II. Game are further discussed in sections 3.2.2 of chapter 3.

2.2.2.2 Mobile Games using in Evaluations

In this study a total of ten mobile games are considered for evaluations. Four game of educational genre are considered for evaluation in Preliminary Study-II and six game of different genres are considered for evaluation in Experimental Study-I and Experimental Study-II. The games used in Preliminary Study-II are further discussed in section 3.2.2 of chapter 3. The game used in Experimental Studies are further discussed in section 3.2.3.2 of chapter 3.

The methods used in this study to evaluate mobile games are discussed in following sections.

2.3 Usability Evaluation Techniques

Usability is a significant core area in human-computer interaction. Scholars define usability as “the capability to be used by humans easily and effectively” (Shackel, 1991); “the effectiveness, efficiency and satisfaction with which a specified user can achieve goals, in a particular environment” (Bevan, 1995). The importance of usability has been discussed by many researchers who have proposed different approaches to usability evaluation (Federoff, 2002). One of the most widely used is “Heuristic Evaluation" as proposed by Nielsen and Molich. In the 1990’s, heuristic evaluation was only used to evaluate the interfaces of a software product, but in recent years it has gained great interest among researchers in various disciplines. In the past decade, heuristic evaluation method was widely used to evaluate games with playability heuristics (Korhonen, 2006).

Heuristics for various application, computer and mobile games are further discussed in following subsections.

2.3.1 Heuristics

Several definitions of heuristics are offered by researchers. It can simply be defined as “an experience-based technique for problem solving, learning, and discovery” (Foundation, 2013); or “ Heuristics are rules of thumb for reasoning, a simplification, or educated guess that reduces or limits the search for solutions in domains that are difficult and poorly understood” (Kunda, 1999).

Heuristics are mainly used to evaluate user interfaces by looking at the interface and offering recommendations according to experience. This approach is called heuristic evaluation (HE) and can be defined as evaluating interfaces heuristically. Various heuristics were proposed by several researchers over the last thirty years for different applications such as, software, websites, and games. However, each heuristic set is designed for a specific domain such as ‘playability

heuristics' that evaluate video games (Pinelle et al., 2008; Korhonen and Koivisto, 2007; Desurvire et al., 2001) . Heuristics that evaluate web based social games were proposed by Paavilainen (2010). Each heuristic set is domain specific and there are no generic heuristics that evaluate different applications. The very first usability heuristics were proposed by Jakob Nielsen as shown in Table 2.1.

Table 2.1: Usability Heuristics Proposed by Nielsen (2005a)

Heuristic	Description
Visibility of system status	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
Match between system and the real world	The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
User control and freedom	Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
Error prevention	Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
Recognition rather than recall	Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
Flexibility and efficiency of use	Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
Help users recognize, diagnose, and recover from errors	Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search,

	focused on the user's task, list concrete steps to be carried out, and not be too large.
Aesthetic and minimalist design	Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

2.3.1.1 Computer Games Heuristics

Researchers have observed that games require their own heuristics because general usability heuristics are not directly applicable to video games due to a lack of a comprehensive context. This means that general usability heuristics cannot identify playability problems related to gameplay, game story, game mechanics and multiplayer gaming (Korhonen, 2006 and Desurvire et al., 2001). Therefore, heuristics for computer games were proposed to evaluate the playability of video games. Playability resembles usability but it includes other factors such as fun, learning, enjoyment, entertainment, etc., but even so, there is still no standardized definition of playability. Several authors have defined playability in different ways but none can be considered de facto (Korhonen 2011,2006; Egenfeldt-Nielsen, Smith and Tosca, 2008; Fabricatore, Nussbaum and Rosas, 2002). One of the most appropriate definition is "Playability is the ease by which the game can be played or the quantity or duration that a game can be played" (Nacke et al., 2009). Several researchers have proposed heuristics for evaluating games and each heuristic set is briefly reviewed and discussed in following sub-sections with respect to domains. Table 2.2 shows a summary of various heuristics sets for computer, mobile and social games.

Table 2.2: Heuristics to Evaluate Games

Author, year	**Description**
(Federoff, 2002)	Federoff compiled a list of playability heuristics can be considered as first specific heuristics for video games due to its structure and modeling. The study was based on area of computer games; game interface, game mechanics and game playability and compiled a list of game heuristics that consist the three areas.
(Desurvire et al., 2004)	Developed Heuristics for Evaluating Playability (HEP).

(Korhonen & Koivisto, 2007; Korhonen, 2006)	Proposed a set of heuristics for mobile games based three categories: game mobility, game usability and gameplay. Later in 2007, Korhonen proposed 8 more heuristics for multiplayer mobile games.
(Song, Lee, & Hwang, 2007)	Compiled key factors of heuristics evaluation for game design and categorized game heuristics on four areas; game interface, game play, game narrative and game mechanic.
(Shengyuan, Xiaoyang, & Hongguo, 2007)	Heuristics for usability in games. These heuristics were based on literate and authors experience in the area of HCI. Schaffer divided these heuristics into five categories: general, graphical user interface, gameplay, control mapping and level design.
(Pinelle et al., 2008)	Developed heuristics evaluation for video game design that adapts usability inspections for games. These heuristics are specifically focused on game usability and was based on a structured analysis of usability problem from a large number of games.
(Pinelle et al., 2009)	Developed multiplayer usability heuristics for video games. Heuristics are validated by evaluating two multiplayer games with two groups.
(Paavilainen, 2010)	Proposed first heuristics for social games. This list consists of 10 heuristics.

The first heuristics for designing enjoyable user interfaces were proposed by Thomas W. Malone. These heuristics were based on three categories: challenges, fantasy and curiosity. Challenges explained as the goals are clear enough, does the interface provides sufficient feedback to a user to achieve goals, and it needs to have goals for an uncertain outcome. Fantasy referred to interface appeal to emotional fantasies concerning the interface ability to resemble a physical or imaginary system familiar to the user. Curiosity queried whether parameters such as audio and visual effects properly enriched both fantasy and interface (Pinelle et al., 2008).

Furthermore, it is reviewed that these heuristics were limited and only applicable to high level gaming issues. The focus of this study is based on heuristics for designing enjoyable user interface for mobile games. Nevertheless, other major issues remained uncovered.

Neilson and Molich (1990) established the four basic methods of evaluating an interface. The first method is formally can be done by some analysis techniques, automatically by a computerized system, empirically by experiments with test users and heuristically by looking at the interface and pass the comments according to its

own opinion. These methods have specific limitations including the automated approach that was completely inadequate except for a few original check points (Korhonen, 2011). Moreover, formal methods were not mature enough to generally apply to a practical software developmental process. Heuristic evaluation is an informal method of usability analysis in which a number of evaluators tested the system's interface and were then asked to comment.

Nielson and Molich (1990) proposed the first Usability Heuristics to evaluate User Interfaces. They applied a complexity rule based on two orders of magnitude and then concluded their heuristics with nine basic usability principles. An experimental study was conducted in which normal users applied the heuristics to analyze the user interface. The heuristic evaluation was done by a group of between three to five persons. The evaluation results stated that the heuristic evaluation was difficult and that only 51% of extant problems were identified. They then recommended that it was not a reliable method, especially when based on single-person responses. (Desurvire et al., 2004).

Clanton (1998) wrote that Human Computer Interaction (HCI) of games can be divided into three levels: Game Interface, Game Mechanics and Game Play. 'Game Interface' refers to perceptual and motor skills; how the joysticks works; and what instruments are to be shown onscreen. 'Game Mechanics' refer to the Physics of the game and to the functionality of the application's User Interface. 'Game Play' refers to the actual functions of the game: those 'things' that stimulate desire in the player to achieve a specific goal. Clanton proposed heuristics sets based on these three modules. Each heuristics set was generic for all game genres. Despite of that the heuristics lack to cover all aspects of games, leaving several major problems unidentified (Clanton, 1998). The concern here is that there should be certain delimitations defined for each genre.

Federoff (2012) was the first to compile a list of playability heuristics similar to usability heuristics as shown in Table 2.3. They were created by reviewing usability literature and executing a field study at a game development company. These heuristics covered three areas of computer games: game interface, game mechanics and game playability. The goal of the study was to examine implicit and

explicit heuristics used in game design and evaluation measures used by game development companies. Most of those heuristics covered gameplay, engagement, and storyline elements as well as some usability aspects (Federoff, 2002).

Table 2.3: Heuristics Proposed by Federoff (2002)

Heuristics Category	Heuristics
Game Interface	Controls should be customizable and default to industry standard settings
	Controls should be intuitive and mapped in a natural way
	Minimize control options
	The interface should be as non-intrusive as possible
	For PC games, consider hiding the main computer interface during game play
	A player should always be able to identify their score/status in the game
	Follow the trends set by the gaming community to shorten the learning curve
	Interfaces should be consistent in control, color, typography, and dialog design
	Minimize the menu layers of an interface
	Use sound to provide meaningful feedback
	Do not expect the user to read a manual
	Provide means for error prevention and recovery through the use of warning messages
	Players should be able to save games in different states.
Game Interface & Mechanics	Art should speak to its function
Game Mechanics	Mechanics should feel natural and have correct weight and Momentum
	Feedback should be given immediately to display user control
Game Mechanics and Play	Get the player involved quickly and easily

Table 2.3: Heuristics Proposed by Federoff (2002) – cont'd

Heuristics Category	Heuristics
Game Play	There should be a clear overriding goal of the game presented early
	There should be variable difficulty level
	There should be multiple goals on each level
	A good game should be easy to learn and hard to master
	The game should have an unexpected outcome
	Artificial intelligence should be reasonable yet unpredictable
	Game play should be balanced so that there is no definite way to win
	Play should be fair
	The game should give hints, but not too many
	The game should give rewards
	Pace the game to apply pressure to, but not frustrate the player
	Provide an interesting and absorbing tutorial
	Allow players to build content
	Make the game re-playable
	Create a great storyline
	There must not be any single optimal winning strategy
	Should use visual and audio effects to arouse interest
	Include a lot of interactive props for the player to interact with
	Teach skills early that you expect the players to use later
	Design for multiple paths through the game
	One reward of playing should be the acquisition of skill
	Build as though the world is going on whether your character is there or not
	If the game cannot be modeless, it should feel modeless to the player
	The game must maintain an illusion of winnability
	Every puzzle should relate to the story

However, the methodology appeared much like a case study that did not produce specific results but rather generalizations. Others have criticized it, including Koeffel, Hochleitner, & Leitner (2010); Paavilainen (2010); Wiberg, Jegers, & Desurvire (2009a). The main objection to these heuristics was that they could not be validated due to a lack of results as they were not validated by others because the results were not published. Due to this lack of validation, Federoff's heuristics became debatable. It was also reviewed that the number of heuristics were large in the model as compared to other sets of heuristic. This is problematic for evaluators during assessment. Evaluators have remarked that a large list of heuristics is difficult to browse and assign problems to. Moreover, In Federoff's heuristics, the game mechanics category consisted of only two heuristics that failed to identify problem. In addition, reviewers such as Koeffel et al. (2010); Paavilainen (2010); Wiberg, Jegers, & Desurvire (2009b); Schaffer (2007) remarked that Federoff's heuristics were ambiguous and could not be implemented in a design process.

Heuristics for Evaluating Playability (HEP) were proposed by Desurvire et al. (2001), shown in table 2.4. This was a comprehensive set of heuristics based on a literature review for productivity and playtesting heuristics specifically for computer games. These heuristics were divided into four categories: game play, game story, game mechanics and usability. The heuristics were reviewed by several game designers and usability/playability experts and then validated by evaluating flash prototype games and comparing results with findings from a standing user study. Results from the study indicated that HEP were more efficient for game play and usability issues. However, game story and game mechanic issues were not widely covered (only 50% of game mechanics and game story issues). HEP evaluation did identify more playability problems than a user study.

Table 2.4: Heuristics Proposed by Desurvire et al. (2001)

Heuristics Category	Heuristics
Game Play	Player's fatigue is minimized by varying activities and pacing during game play.
	Provide consistency between the game elements and the overarching setting and story to suspend disbelief.
	Provide clear goals, present overriding goal early as well as short-term goals throughout play.
	There is an interesting and absorbing tutorial that mimics game play.
	The game is enjoyable to replay.
	Game play should be balanced with multiple ways to win.
	Player is taught skills early that you expect the players to use later, or right before the new skill is needed.
	Players discover the story as part of game play.
	Even if the game cannot be modeless, it should be perceived as modeless.
	The game is fun for the Player first, the designer second and the computer third. That is, if the non-expert player's experience isn't put first, excellent game mechanics and graphics programming triumphs are meaningless.
	Player should not experience being penalized repetitively for the same failure.
	Player's should perceive a sense of control and impact onto the game world. The game world reacts to the player and remembers their passage through it. Changes the player makes in the game world are persistent and noticeable if they back-track to where they've been before.
	The first player action is painfully obvious and should result in immediate positive feedback.
	The game should give rewards that immerse the player more deeply in the game by increasing their capabilities (power-up), and expanding their ability to customize.
	Pace the game to apply pressure but not frustrate the player. Vary the difficulty level so that the player has greater challenge as they develop mastery. Easy to learn, hard to master.
	Challenges are positive game experiences, rather than a negative experience (results in their wanting to play more, rather than quitting).

Table 2.4: Heuristics Proposed by Desurvire et al. (2001) – cont'd

Heuristics Category	Heuristics
Game Story	Player understands the story line as a single consistent vision.
	Player is interested in the story line. The story experience relates to their real life and grabs their interest.
	The Player spends time thinking about possible story outcomes.
	The Player feels as though the world is going on whether their character is there or not.
	The Player has a sense of control over their character and is able to use tactics and strategies.
	Player experiences fairness of outcomes.
	The game transports the player into a level of personal involvement emotionally (e.g., scare, threat, thrill, reward,punishment) and viscerally (e.g., sounds of environment).
	Player is interested in the characters because (1) they are like me; (2) they are interesting to me, (3) the characters develop as action occurs.
Mechanics	Game should react in a consistent, challenging, and exciting way to the player's actions (e.g., appropriate music with the action).
	Make effects of the Artificial Intelligence (AI) clearly visible to the player by ensuring they are consistent with the player's reasonable expectations of the AI actor.
	A player should always be able to identify their score/status and goal in the game.
	Mechanics/controller actions have consistently mapped and learnable responses.
	Shorten the learning curve by following the trends set by the gaming industry to meet user's expectations.
	Controls should be intuitive, and mapped in a natural way; they should be customizable and default to industry standard settings.
	Player should be given controls that are basic enough to learn quickly yet expandable for advanced options.

Table 2.4 Heuristics Proposed by Desurvire et al. (2001) – cont'd

Heuristics Category	Heuristics
Usability	Provide immediate feedback for user actions.
	The Player can easily turn the game off and on, and be able to save games in different states.
	The Player experiences the user interface as consistent (in control, color, typography, and dialog design) but the game play is varied.
	The Player should experience the menu as a part of the game.
	Upon initially turning the game on the Player has enough information to get started to play.
	Players should be given context sensitive help while playing so that they do not get stuck or have to rely on a manual.
	Sounds from the game provide meaningful feedback or stir a particular emotion.
	Players do not need to use a manual to play game.
	The interface should be as non-intrusive to the Player as possible.
	Make the menu layers well-organized and minimalist to the extent the menu options are intuitive.
	Get the player involved quickly and easily with tutorials and/or progressive or adjustable difficulty levels.
	Art should be recognizable to player, and speak to its function.

Due to the limitations of presenting all information in one paper, more significant data regarding the development of these heuristics is absent and no information is presented regarding their modifications or where these heuristics were adopted. Were these heuristics the final? or initial version of the study? What modifications were made during their development? Furthermore, the authors mentioned that usability experts, playability experts and game designers reviewed these heuristics but failed to provide about the expertise. The authors often used "several" in their paper—a questionable quantity—and some of their heuristics were similar to Federoff's Heuristics. These are just some of the criticisms made by researchers such as Koeffel et al. (2010) and Paavilainen (2010).

Paavilainen (2010) raised the question of validity because PHE was validated

by only one evaluator and four other testers in a user study. In addition, only one game prototype was evaluated and did not allow for gameplay review. Hence, without validating gameplay, results were dubious. Due to this lack of validation and the absence of data, these heuristics were considered as problematic, as reported by Paavilainen (2010); Korhonen (2009); Wiberg, Jegers, & Desurvire (2009c); Schaffer (2007).

In 2008, a set of heuristics was proposed by Pinelle et al. (2008) to evaluate the usability of video games. This is shown in Table 2.5. Here the authors specified that earlier heuristics as proposed by Federoff (2002); Desurvire et al. (2001); Clanton (1998) had emphasized on fun and engagement of game but usability of game was not covered in details. Authors developed the heuristics by analyzing games from popular websites. Their research involved 108 games, eighteen of which were from popular genres. These heuristics were also applicable to early game prototypes to help identify problems before releasing final versions. Pinelle et al. (2008) proposed heuristics that mainly focused on usability problems based on a structured analysis. They divided usability problems into twelve categories of common classes. They then developed ten usability heuristics based on problem categories and described how common game usability problems could best be avoided. By focusing on usability issues, these heuristic differed from those proposed by Desurvire et al. (2004) to such an extent that previously known heuristics focusing on elements of fun, engagement and many usability problems remain unidentified. These heuristics were validated by using a demo version of the game and authors claimed they were useful in the evaluation of video game usability.

Table 2.5: Heuristics proposed by Pinelle et al. (2008)

	Heuristics
1	Provide consistent responses to the user's actions.
2	Allow users to customize video and audio settings, difficulty and game speed.
3	Provide predictable and reasonable behavior for computer controlled units.
4	Provide unobstructed views that are appropriate for the user's current actions
5	Allow users to skip non-playable and frequently repeated content.

Table 2.5 : Heuristics proposed by Pinelle et al. (2008) – cont'd

	Heuristics
6	Provide intuitive and customizable input mappings.
7	Provide controls that are easy to manage, and that have an appropriate level of sensitivity and responsiveness.
8	Provide users with information on game status.
9	Provide instructions, training, and help.
10	Provide visual representations that are easy to interpret and that minimize the need for micromanagement.

The heuristics proposed by Pinelle et al. (2008) did not perfectly evaluate every video games and were not without problems. The authors stated that the proposed heuristics only addressed usability issues. Nevertheless, evaluators need a different set of heuristics to evaluate other aspects like fun and engagement. The validation of their heuristics was also questionable as the authors used game reviews as a main data source. Using games reviews as a data collection source may be interesting but it is also flawed because game reviewers are not usability experts and may not discuss every usability problem. Although, authors evaluated one demo version of a game by five evaluators, it remained questionable as to how heuristics are validated through the evaluation of only one demo game from one genre. These problems were also reported by Paavilainen (2010).

Despite this lack of validation, their heuristics were defined and clearly presented and explained. Unlike many other authors, they followed the approach of Nielsen (2005b), with each heuristic having a heading and descriptive paragraph. The number of their heuristics was lower than others heuristics and only covered video game usability issues.

Pinelle et al. (2009) proposed another new set of usability heuristics to evaluate multiplayer games as shown in Table 2.6. These were similar to Pinelle et al. (2008), and were presented after a total of 382 reviews from Gamespot and Gamespy websites. These multiplayer heuristics were validated by evaluating two multiplayer games with two groups. One group used usability multiplayer heuristics as proposed by Pinelle et al. (2009), while the other used groupware heuristics

proposed by Baker, Greenberg, & Gutwin (2002). The authors claimed their newly proposed heuristics were more effective in identifying multiplayer usability problems. They further reported that multiplayer usability heuristics were more effective than groupware heuristics when identifying game usability problems.

Table 2.6: Usability Heuristics for Networked Multiplayer Games proposed by Pinelle et al. (2009)

	Heuristics
1	Simple session management: provide session management support that allows players to start new games, and that allows them to find and join appropriate games.
2	Flexible matchmaking: provide matchmaking features to help people find players with similar interests.
3	Appropriate communication tools: provide communication features that accommodate the demands of game play.
4	Support coordination: provide features that allow players to coordinate their actions during cooperative game play.
5	Meaningful awareness information: provide meaningful information about players, including information about action, location, and status.
6	Identifiable avatars: use noticeable and distinct avatars that have intuitive information mappings.
7	Training for beginners: provide training opportunities where novice players are not subject to pressures from experts.
8	Support social interaction: provide support for planned and opportunistic social interactions.
9	Reduce game-based delays: minimize interaction delays by reducing temporal dependencies between players.
10	Manage bad behaviour: provide technical and social solutions for managing cheating and unsavory behavior.

2.3.1.2 Mobile Games Heuristics

Mobile games have an important role in digital gaming. The advancement of technology is overtaking other gaming platforms due to the ease of mobile phone availability. Mobile games have also never been played at rates played nowadays (Comviva, 2009). Hence, mobile games remain immature compared to other

gaming platforms and users face playability problems such as: (i) user interface is inconvenient; (ii) interface navigation is complex; (iii) mobile screen layout problems; (iv) games cannot handle unexpected interruptions; (v) game pace and difficulty are not balanced; (vi) game objectives/goals are unclear; (vii) game terminology is unclear (Paavilainen, 2010). These issues needed/need solutions in order to produce good quality mobile games.

To evaluate playability of mobile games, heuristics are required. It is observed that computer games heuristics do not qualify as they are not effective in mobile game evaluation because mobile phones have different usability qualifications. It is also important to evaluate Mobility aspects which computer games' heuristics do not support. The very first playability heuristics for mobile games were proposed by Korhonen (2006) as shown in Table 2.7. Authors divided these heuristics into three modules: Gameplay, Usability and Mobility. Game usability highlighted both the control(s) and interface technology through which a player interacts with both the game world and other players. Gameplay describes the 'structure of interaction', while Mobility refers to issues that affect game mobility or how easily users enter the game world and how it behaves in uncertain conditions. Korhonen's playability heuristics comprised three Mobility heuristics, fourteen gameplay heuristics and twelve usability heuristics. These heuristics were validated by evaluating five different mobile games from developing companies employing usability experts, game designers and playability experts. The author reported 235 playability problems identified in all five mobile games, and also noted that there were unidentified playability problems, not covered by these heuristics. Some of which were related to game multiplayer issues (Korhonen, 2006).

Table 2.7: Heuristics for Mobile Games proposed by Korhonen (2006)

Category	Heuristics
Gameplay	The game provides clear goals or support player-created goals
	The player sees the progress in the game and can compare the results
	The players are rewarded and rewards are meaningful
	The players in in control
	Challenge, strategy, and pace are in balance

Table 2.7: Heuristics for Mobile Games proposed by Korhonen (2006) – cont'd

Category	Heuristics
Gameplay	The first-time experience is encouraging
	The game story supports the gameplay and is meaningful
	There are no repetitive or boring tasks
	The players can express themselves
	The game supports different playing styles
	The game does not stagnate
	The game is consistent
	The game uses orthogonal unit differentiation
	The player does not lose any hard-won possessions
Usabilty	Audio-visual representation supports the game
	Screen layout is efficient and visually pleasing
	Device UI and game UI are used for their own purposes
	Indicators are visible
	The player understands the terminology
	Navigation is consistent, logical, and minimalist
	Control keys are consistent and follow standard conventions
	Game controls are convenient and flexible
	The game gives feedback on the player's actions
	The player cannot make irreversible errors
	The player does not have to memorize things unnecessarily
	The game contains help
Mobility	The game and play sessions can be started quickly
	The game accommodates with the surroundings
	Interruptions are handled responsibly

Despite of some unidentified playability problems, these heuristics covered core aspects of games and identified severe playability problems. Due to vigorous testing, most of these heuristics were readily understood by simply reading their headings. Furthermore, the authors stated that the heuristic model was sensibly

segmented so that each module could be evaluated separately.

Paavilainen (2010) highlighted major issues and reported that some heuristics can be merged. For example, Game Usability heuristics: "*Control keys are consistent and follow standard conventions*" and "*Game controls are convenient and flexible*". These two heuristics can be merged as they reflect each other. Another example is "*There are no repetitive or boring Tasks*" and "*The game does not stagnate*". These also can be merged.

Later, Korhonen & Koivisto (2007) proposed Playability Heuristics for Multiplayer Mobile games as shown in Table 2.8. This set of heuristics covered expected playability problems in a multiplayer game such as player-to-player interaction, player-to-player communication, and other 'network' issues. The network latency issue also affected gameplay.

Table 2.8: Multiplayer Mobile Games Heuristics proposed by Korhonen & Koivisto (2007)

Category	Heuristics
Multiplayer	The game supports communication
	There are reasons to communicate
	The game helps the player to find other players and game instances
	The game supports groups and communities
	The design minimizes deviant behavior
	The design hides the effects of the network

Later, in 2009, Korhonen et al. conducted a comparative study on two playability heuristic sets proposed by Desurvire et al. (2001) and Korhonen (2006). Their results indicated that evaluators faced problems when browsing heuristics because the number of heuristics in a set was too large in both sets of heuristics. They recommended that playability heuristics needed further development before they could be practically utilized as the heuristics lacked comprehensiveness and clarity (Korhonen, 2009). Furthermore, important playability problems were unidentified as they lacked the ability to identify playability problems related to

gameplay, game usability, game mechanics, game mobility and multiplayer issues. Some heuristics were similar and the redundancy created confusion for evaluators. The number of heuristics in this model was also too large causing browsing difficulties for evaluators. Despite these significant issues, this heuristic set was still considered effective because no other heuristics were extant for mobile games.

The literature cites numerous researchers who proposed heuristics for video game evaluation from 1982 to 2012. Some sets of heuristics covered only general usability issues; others covered fun and engagement issues. Each researcher focused on a specific aspect of games while neglecting others. Hence, no general set of heuristics to evaluate video games for multiple platforms were forthcoming. The heuristics that were proposed were effective to some extent, but they did not cover all aspects of games.

Furthermore, the size of heuristics set is also important factor to consider. Federoff (2002) proposed forty heuristics and Desurvire et al. (2001) proposed forty-three heuristics; but large list of heuristics were considered as problematic for evaluators, because user face difficulty to browse large list of heuristics as cited by Korhonen (2009). However, the literature also reported small heuristic lists with problematic redundancies (Pinelle et al., 2008), as some identified problems were associated with more than one heuristic and evaluators were not able to allocate identified problems.

2.3.2 Usability Evaluation on Application Software

Generally, each software product has been evaluated for functionality and significance through different techniques (e.g. expert and end-user evaluation). Software usability consisted of learnability, efficiency, effectiveness, memorability, ease of use and satisfaction. Normally, experts evaluate a software product against general usability heuristics to discover usability problems for design and development (Korhonen, 2009). It was reported that expert evaluation is cost-effective and efficient and that usability experts identify software problems during their early stages of development (Desurvire et al., 2004).

2.3.3 Usability Evaluation on Games

Several methods have been designed and proposed for games evaluation by adopting evaluation techniques from the usability field. Two common methods are Playtesting and Heuristic evaluation. Each is described in the following sub-section.

2.3.3.1 Playtesting

Playtesting is the most common method for evaluating games. The literature reports it is the primary evaluation method used by game designers (Korhonen, 2010; Rouse & Ogden, 2005; Fullerton, Swain, & Hoffman, 2004), and has been extensively used by most game developing companies. In this approach, primary users spend much time playing a game and need to learn the game, and finally, can only then identify problems occurring during game-playing. Hence, play-testing consumes more time compared to heuristic evaluation. The main purpose of using playtesting is to gather data on problems facing users during play, and how users prioritize game objectives accordingly (Molich & Dumas, 2008). Once the major problems have been identified through user feedback and attended to, the full version of the game can be released to the market (Korhonen, 2010; Tan, Liu, & Bishu, 2009; Omar & Jaafar, 2008; Desurvire et al., 2001; Richard, 2001; Gray & Salzman, 1998).

2.3.3.2 Heuristic evaluation with Game Heuristics

Heuristic evaluation is the most popular method of usability inspection developed by Nielen and Molich. Heuristic evaluation does not usually include the targeted market group but is conducted by usability experts who evaluate the interface of an application (Desurvire et al., 2004).

Generally, the heuristic evaluation method can be used to evaluate games with a set of playability heuristics. Usability heuristics cannot be directly applied to games because games differ from application software, meaning usability heuristics do not cover all aspects such as game story, game play, mobility and multiplayer features. Design objectives for games and utility software are different in nature (Korhonen, 2009).

Thomas W. Malone introduced the first heuristics for game evaluation. These mainly focused on the educational aspects of a game. Several researchers proposed heuristics for game evaluation, most of these are briefly discussed in sections 2.3.2 and 2.3.3. Their key benefit is that experts can evaluate a game within a few hours. This method applies to functional prototypes, low-fidelity prototypes, and even concept and interactive designs (Korhonen, 2010).

2.3.4 Usability Evaluation with software tools

Over the last two decades heuristics evaluation played an important role in measuring the usability of software, games and websites as reported by Rosenbaum, Rohn, & Humburg (2000), but were also criticized as non-effective by Cockton, Lavery, & Woolrych (2002); E. L.-C. Law & Hvannberg (2002); Blandford, Vanderdonckt, & Gray (2001); Connell & Hammond (1999); Cuomo & Bowen (1994). Several attempts were made to improve their effectiveness but a non-biased measurement was not yet available (E. L. Law & Hvannberg, 2004). A major attempt was the automation of the process, it is reported that *Automation* is the use of machines, control devices and information technologies to reduce the need for human work in the production of goods and services, (Systems & Platform, 2013). E. L. Law & Hvannberg (2004) reported that Usability Practitioners considered problems with paper reporting time consuming giving rise to the development of usability assessment tools. Several of these tools are available in the market; for example: Tobbi (Tobii, 2010); URANUS (Sivaji, 2012); Loop (Loop11, 2012); and Usefeel (Userfeel, 2012). However, it was also difficult to determine which of these tools was most effective as the literature reports that each tool has pros and cons. Hence, simply purchasing a tool did not guarantee accurate results (Sivaji, 2012). Sivaji (2012) wrote that eight out of ten usability practitioners complained of difficulties when justifying which tool was better along with their costs. Comparisons of several tools are listed in Table 2.9.

Table 2.9: Comparison of Usability Assessment Tools

S. No.	Features	Morea	Tobii	Userfeel	Loop11	Uranus
1	Software or website testing	✓	✓	✓	✓	✓
2	Mobile device testing	✓	✓	×	×	×
3	Game testing	×	×	×	×	×
4	Protocol setup (task, questions)	✓	✓	✓	✓	✓
5	User recruitment	×	×	✓	×	×
6	Subject Ratings	✓	✓	✓	✓	✓
7	Voice and screen recording	✓	✓	✓	✓	✓
8	Face recording	✓	✓	×	×	×
9	Eye tracking analysis	×	✓	×	×	×
10	Task time measure	✓	✓	✓	✓	✓
11	Results exporting	✓	✓	×	✓	✓
12	Reporting and analysis	✓	✓	✓	✓	✓
13	Moderators rating	✓	×	×	×	✓
14	Open Source Support	×	×	×	×	✓

Despite the existence of several usability assessment tools that were especially designed to evaluate the usability of a software product, existing tools had either never been used to evaluate games or, if done, results were not published. Thus, motivation remained to developed web-based software systems to automate the process of heuristics evaluation for games.

However, a web-based software system has been developed to automate the process of heuristic evaluation. Its methodology is discussed in section 3.5 and results are discussed in section 4.7.

2.4 Summary

The first section of this chapter briefly introduced video and mobile games and the importance and use of mobile games in daily life. The production of good quality mobile games remains challenging as does their commercialization based on the evaluation quality of mobile game playability.

In the second section, it presented an extensive literature review of various heuristics for computer and mobile games. Each heuristic set had pros and cons and were valid only for specific domains. Benefits and limitations were pointed out for each heuristic set. Among various sets, a playability heuristic set was selected for the evaluation of games.

In the third section, methods for evaluating the playability of mobile games were discussed along with a review of automated processes for heuristics evaluation. Several usability assessments tools were presented to evaluate the usability of application software and web-pages.

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter presents all methods applied in this research. These have been divided into five phases as shown in Figure 3.1. Section 3.2 demonstrates the analysis carried out on mobile games which fall into three sub-sections as follows: preliminary study-I, preliminary study-II and experiments. Section 3.2.1 describes a preliminary study-I undertaken on mobile games to validate the problems (existing heuristics lacks in identifying playability problems in mobile games) reported in literature. Section 3.2.2 demonstrate the preliminary study-II to investigate that at what extended existing playability heuristics supports to evaluate mobile games of various genre. A total of two experimental studies were conducted. Section 3.3 describes experimental Study-I, in which heuristic evaluation was conducted on mobile games with existing playability heuristics. Section 3.4 describes experimental Study-II, in which heuristic evaluation was conducted on mobile games with proposed set of playability heuristics. Section 3.5 describes the development of a Playability Heuristic Evaluation System (PHES) as a web-based software system to automate the process of conducting heuristic evaluation for mobile games. Section 3.6 describes the evaluation of mobile games using the newly developed Playability Heuristic Evaluation System (PHES).

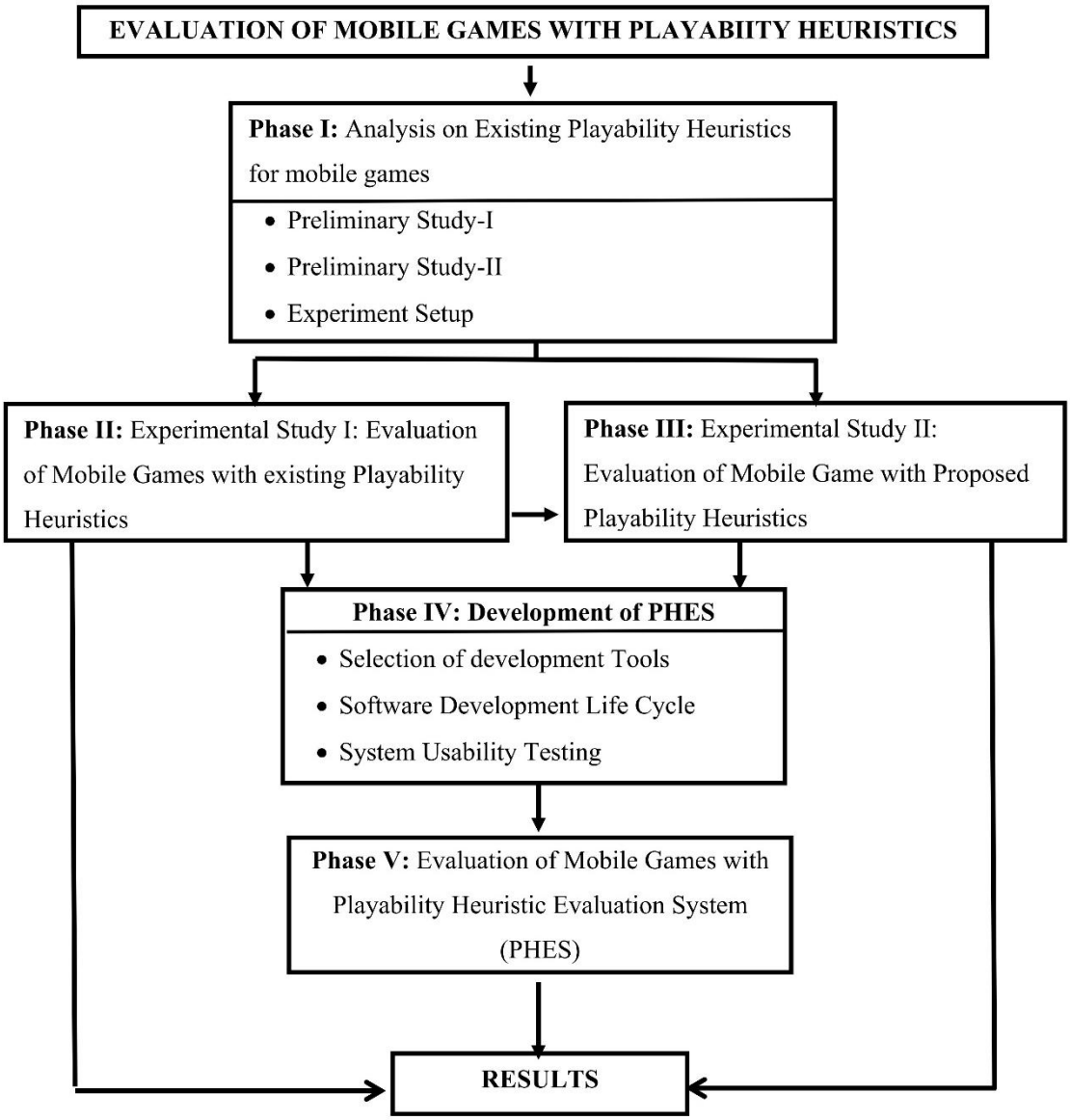

Figure 3.1: Overall view of methodology

3.2 Analysis on existing Playability Heuristics for Mobile Games

The first phase of this study comprised three studies as shown in Figure 3.2. The first study was a preliminary study-I to validate that the problems reported in literature review are valid. The second study was a preliminary study-II to see at what extend that existing playability heuristics supports to evaluate various game genre. The third study was experiments design to conduct an evaluation of mobile games with playability heuristics. Each section is discussed further below.

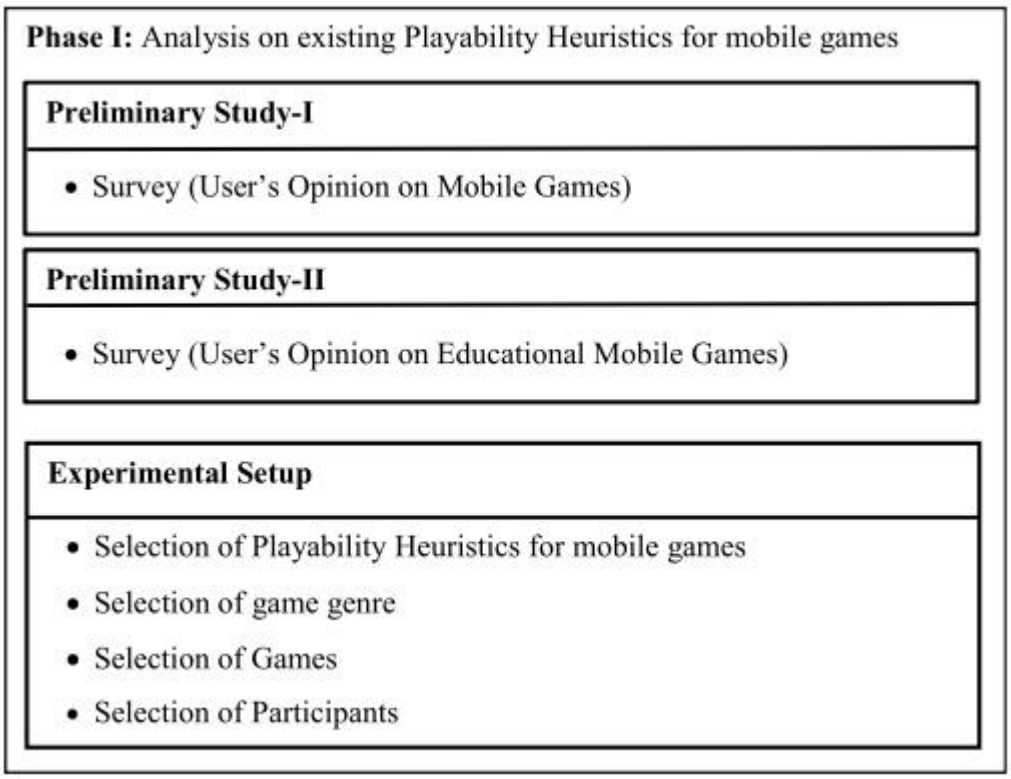

Figure 3.2: Overview of analysis on existing playability heuristics

3.2.1 Preliminary Study-I

It is reviewed from literature that existing playability heuristics lacked an ability to identify problems in mobile games. To validate the problem as reported in the literature, a preliminary study was designed and conducted. An analysis was done on various computer and mobile game heuristics to mark the absence of playability heuristics for mobile games. A questionnaire was formulated from existing sets playability heuristics as proposed by Korhonen (2006) and Korhonen & Koivisto (2007). Data has been collected via questionnaire and interview with the questionnaire as the primary tool and interview as secondary. The questionnaire contained twenty questions divided into three sections. Section 'A' covered user demographics; Section 'B' contained of eight questions based on Likert scale of (1-5, from strongly disagree to strongly agree); and section 'C' contained four open-ended questions. Random sampling was used and the questionnaire was distributed among university students from different disciplines, programs and age groups. One hundred questionnaires were distributed, of which all were returned with positive

responses.

Date collected from interviews and section C of questionnaire has been analyzed and compiled that validated the problems reported in literature. Furthermore, several new problems were identified from these sections that were not properly covered by the chosen heuristic models. These are presented below.

- The level of game difficulty and game speed
- Interruptions (internal & external)
- Lack of user control in game setting
- Multiplayer games are difficult to play
- Multiplayer games do not support multiple ways of connecting with other users.
- Multiplayer games do not support the multiple communication mediums.
- Game genre issues

Based on the analysis of identified problems from questionnaire, survey and literature search, a new set of ten playability heuristics for mobile games were proposed and divided into four categories as follows: Usability, Gameplay, Mobility and Multiplayer. These ten playability heuristic attempted to compensate for the heuristic vacuum left by Korhonen & Koivisto (2007) and Korhonen (2006). These heuristics are new and do not overlaps any heuristics proposed by Korhonen & Koivisto (2007) and Korhonen (2006). Each heuristic is further defined in section 4.2.1 of chapter 4.

Additionally, it is observed from literature review and this preliminary study that existing set of playability heuristics did not support evaluation of touchscreen mobile games. Existing sets of heuristics do not contain module that evaluate touchscreen usability of mobile games. Therefore, there was need to develop a new set playability heuristics that supports touchscreen mobile games.

3.2.2 Preliminary Study-II

In preliminary study-I major lacks were identified of existing playability heuristics for mobile games. It is also identified from literature that existing playability heuristics lacks to evaluate educational mobile games. The existing sets of playability heuristics do not cover pedagogical features of educational games. However, Mohamed and Jaafar (2010) proposed a set of heuristics for evaluating computer educational games. This preliminary study aims to investigate the extent to which current heuristics for educational computer games efficiently evaluate educational mobile games. Mohamed and Jaafar (2010) addressed some of the challenges and mentioned the need to consider the following factors: evaluation criteria, the evaluator, and the evaluation process, and then presented five evaluation criteria in combination: Playability Heuristics for Educational Games (PHEG). These heuristics were divided into five categories: Interface, Pedagogical, Content, Playability and Multimedia. Several methods were used to evaluate games, such as questionnaires, observations, interviews and log files (Papastergiou 2009; Barr, Noble and Biddle 2007). It is also noted that earlier researchers used questionnaires as a primary data source (Mohamed and Jaafar 2010).

In the study, a questionnaire approach was adopted. Questionnaire was formulated based on PHEG proposed by Mohamed and Jaafar (2010). Questionnaire was divided into two sections; Section one concerned participant demographics. Section two contained Likert scale questions from strongly disagree to strongly agree, related to Usability, Pedagogical, Content, and Playability. Random sampling technique was used and a total number of thirty questionnaires were distributed: among university students pursing undergraduate and postgraduate studies.

In this preliminary study four android educational games from different curricula are considered for evaluation to investigate that at what extend existing heuristics for educational games supports games of different curricula. Selected games are shown in Table 3.1. These games are available for android as downloads from the online Google play store.

Table 3.1: Games Characteristics (Preliminary Study-II)

Games	Genre	Subject	Player Mode
Spell It	Educational	English	Single Player
Animal Idioms	Educational	English	Single Player
Comic Maths	Educational	Math	Single Player
Chase Me	Educational	Math	Single Player

Descriptions of each game are presented as follows:

- Spell It!!

Spell It!! is a mobile game for learning basic English. The game is designed for children age ranging between 5 to 7 years old. However, the children still need assistance from teachers or parents. Game is focused on "Self-Kingdom" and "Life Kingdom" using flash card. This game is based on very common subject for teaching children, especially for the introduction of foreign language, (utp-project, 2012a). Screenshot of game is shown in Figure 3.3.

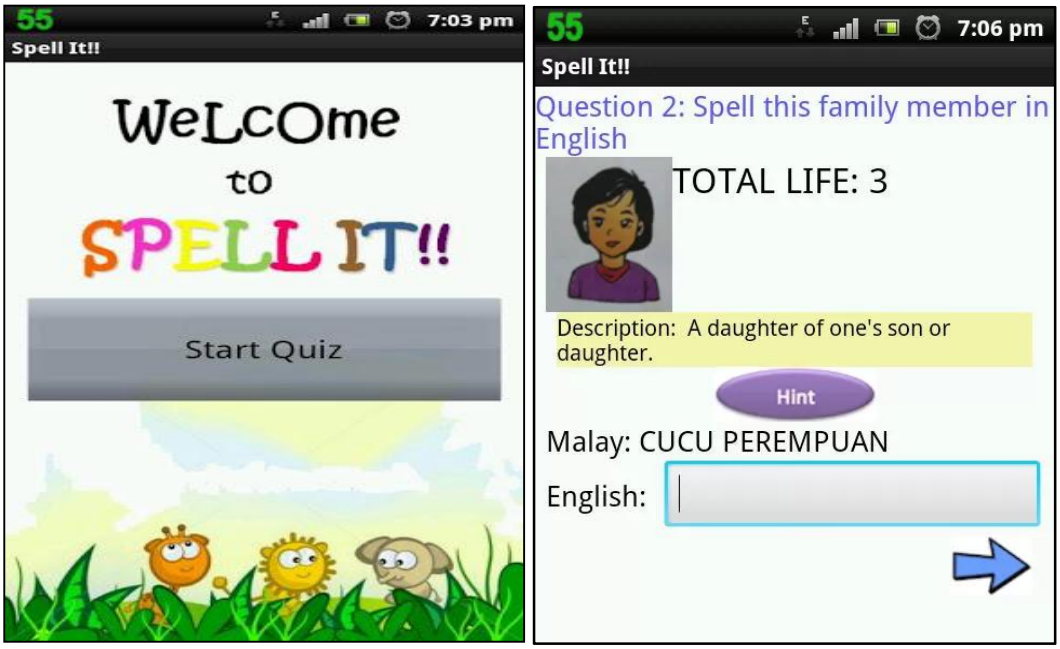

Figure 3.3: Spell It Screenshot (Source: utp-project, 2012d)

- Animal Idioms

Animal Idioms is a mobile educational game subjects to learn English idioms. Game is designed for primary school children. Game provides hint in a form of image of the word related to idiom that children require to complete. Children need to achieve the objective within time constraint in order to process to next level. Game is easily available to download from android google play store, (utp-project, 2012b). Screenshot of game is shown in Figure 3.4.

Figure 3.4: Animal Idioms Screenshot (Source: utp-project, 2012a)

- Comic Maths

"Comic Maths" is educational mobile games focused on math curriculum. Game allows children to learn basic mathematic in an interactive way with a storyline. Game contains two basic math operations; addition and subtraction for primary school children. Game is easily available to download from android google play store, (utp-project, 2012c). Screenshot of game is shown in Figure 3.5.

Figure 3.5: Comic Maths Screenshot (Source: utp-project, 2012c)

- Chase me

Chase Me is a mobile game, which aimed to help kids to learn mathematics in an interesting and fun way. It is focused on multiplication and division operation, (utp-project, 2012d). Screenshot of game is shown in Figure 3.6.

Figure 3.6: Chase Me Screenshot (Source: utp-project, 2012b)

In this study a total number of 3 smart phones were used for evaluation on which the games were installed. Due to limitation in Parallel sessions were. Each student was provided with a smart phone. They were allowed to play the game freely but were not taught to achieve any objectives. At the end of each 'play' session, each student was asked to fill in the questionnaire regarding their experience. They were free to ask any question regarding difficulties while answering questions.

The results of Preliminary Study-II endorsed the selected Playability Heuristics (PHEG) are applicable for evaluating educational games. However, it is observed that existing Playability Heuristics for Educational Games (PHEG) do not cover the mobility features of the mobile phone. Detailed statistical results were compiled and are presented in section 4.3 of chapter 4.

3.2.3 Experimental Setup

The preliminary studies examined existing playability heuristics for mobile games and indicated that different mobile games required evaluation with playability heuristics. Hence, this study conducted two experimental studies of existing playability heuristics for mobile games for various game genres. Experimental Study-I is evaluation of mobile games with existing sets of Playability heuristics for mobile games. Experimental Study-II is evaluation of mobile games with new proposed set of playability heuristics for mobile games.

In order to perform experiment, a setup is required. To fulfill necessities for experiments, various studies has been conducted on analysis of 1) a set existing playability heuristics for mobile games, 2) various game genre and games and 3) game platform and mobile phones to be used. Each study is further described in following sections.

3.2.3.1 Selection of Playability Heuristics for Mobile Games

Two sets of playability heuristics were selected based on the analysis on existing computer and mobile game heuristics as proposed by Korhonen & Koivisto, (2007) and

Korhonen (2006). Selected sets of heuristics are shown in Table 3.2. These sets of heuristics were chosen because of their appropriate match for mobile games with respect to the mobile context as they were specifically designed for the evaluation of mobile games and were classified according to mobile context.

In Table 3.2, keywords represent abbreviated names for heuristic as per category. For instance, GP represents Gameplay followed by a heuristic number, i.e. GP1. Similarly, GU represents Game Usability, MO represents Mobility and MP represents Multiplayer.

Table 3.2: Playability Heuristics proposed by Korhonen (2006) and Korhonen & Koivisto (2007)

Category	Keyword	Heuristic
GAMEPLAY (Korhonen, 2006)	GP1	The game provides clear goals or support player-created goals
	GP2	The player sees the progress in the game and can compare the results
	GP3	The players are rewarded and rewards are meaningful
	GP4	The players in in control
	GP5	Challenge, strategy, and pace are in balance
	GP6	The first-time experience is encouraging
	GP7	The game story supports the gameplay and is meaningful
	GP8	There are no repetitive or boring tasks
	GP9	The players can express themselves
	GP10	The game supports different playing styles
	GP11	The game does not stagnate
	GP12	The game is consistent
	GP13	The game uses orthogonal unit differentiation
	GP14	The player does not lose any hard-won possessions
USABILITY (Korhonen, 2006)	GU1	Audio-visual representation supports the game
	GU2	Screen layout is efficient and visually pleasing
	GU3	Device UI and game UI are used for their own purposes

Table 3.2: Playability Heuristics proposed by Korhonen (2006) and Korhonen & Koivisto (2007) - Cont'd

Category	Keyword	Heuristic
USABILITY (Korhonen, 2006)	GU4	Indicators are visible
	GU5	The player understands the terminology
	GU6	Navigation is consistent, logical, and minimalist
	GU7	Control keys are consistent and follow standard conventions
	GU8	Game controls are convenient and flexible
	GU9	The game gives feedback on the player's actions
	GU10	The player cannot make irreversible errors
	GU11	The player does not have to memorize things unnecessarily
	GU12	The game contains help
MOBILITY (Korhonen, 2006)	MO1	The game and play sessions can be started quickly
	MO2	The game accommodates with the surroundings
	MO3	Interruptions are handled responsibly
MULTIPLAYER (Korhonen & Koivisto, 2007)	MP1	The game supports communication
	MP2	There are reasons to communicate
	MP3	The game helps the player to find other players and game instances
	MP4	The game supports groups and communities
	MP5	The design minimizes deviant behavior
	MP6	The design hides the effects of the network

3.2.3.2 Selection of Game Genres

Once the heuristics were selected, game genres were chosen prior to game selection. There are many games available of different genre in commercial market, but some were more popular and widely played. Hence, eight popular mobile game genres were selected based on their Internet cited rankings. The reason for this selection was to

ensure that existing playability heuristics supported different genres. Selected genres has already been described in section 2.2.2.1 of chapter two.

3.2.3.3 Selection of Platform, Mobile Phones & Games

Mobile phone technologies have matured and are capable of fast processing. They are available with a variety of operating systems such as Android, iOS, Symbian OS, Windows Phone, BlackBerry OS and Bada OS. This study focused on Android OS games because Android is the most common and holds maximal market share (68.8%) as shown in Table 3.3.

Table 3.3: Top Mobile Operating Systems, 2012 (IDC Report, 2012)

Operating Systems	**2012 Market Share**
Android	68.8%
iOS	18.8%
Blackberry	4.5%
Symbian	3.3%
Windows Phone/ Mobile	2.5%
Others	2.1%
Total	**100.0%**

The Android operating system is available for different mobile brands. Two mobile phones, Sony Xperia S and Samsung Galaxy S3, were selected for this study as shown in Figure 3.7. These mobile phones were the latest release with the best hardware and software specifications.

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Figure 3.7: Selected mobile phones used in evaluation

There were a number of games available from the Android OS market called Google Playstore. Six games of different genre were considered for the evaluation based on the highest internet ratings. Four single player games and two multiplayer games were selected. Multiplayer games have additional features such as social interactions and connectivity functions. Characteristics of the selected games are presented in Table 3.4 and a detailed description of each game is presented in Section 2.2.2.1 of chapter 2.

Table 3.4: Games Characteristic

Games	**Game Genre**	**Playing Mode**	**Platform**
Temple Run	Action/Adventure	Single Player	Android
Train Crisis	Puzzle/Strategy	Single Player	Android
Cafeteria Nopponica	Simulation	Single Player	Android
Block Breaker 3	Arcade/Puzzle	Single Player	Android
Asphalt 6	Racing/Multiplayer	Multiplayer	Android
Modern Combat 3	Shooter/Multiplayer	Multiplayer	Android

3.2.3.4 Selection of Participants

Traditionally, usability evaluations are generally conducted by usability experts. However, the literature on heuristic evaluation for mobile games indicated that normal users with experience of gaming were sufficient (Korhonen, 2011, 2010).

In heuristic evaluation of utility software, 1–6 evaluators evaluate the applications and wrote a report on findings that violated heuristics (Korhonen, 2006). In this study, fourteen participants were recruited from the university to participate. In general, participants had good computer experience and mobile games and also attended usability evaluation courses during their studies. Table 3.5 shows participant demographics.

Table 3.5: Participant's details for evaluation

Group	**No. of Participants**	**Age Ranging**
Male	8	18-22
Female	6	18-22

3.3 Experimental Study-I: Evaluation of Mobile Games with existing Playability Heuristics

The selection of game genre, mobile platform, games and participants were carried out in Phase I of this study. The second phase was the evaluation of mobile games with existing playability heuristics as shown in Figure 3.8. The setting of this experiment is defined in section 3.2.3.

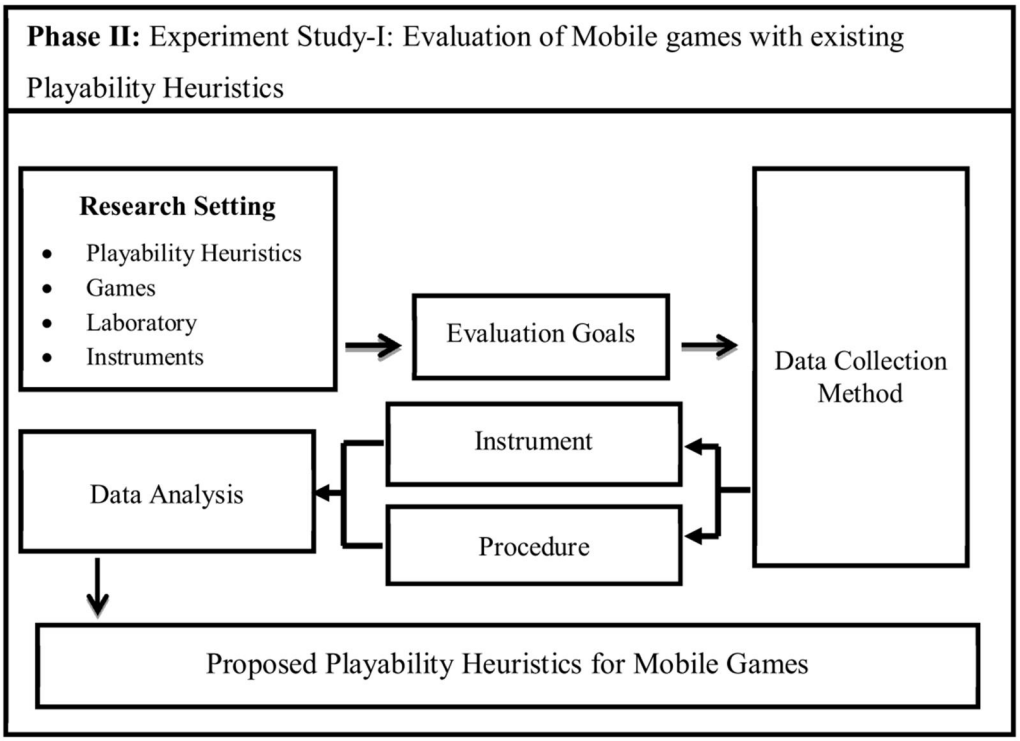


Figure 3.8: Overview flow of Evaluation on Existing Playability Heuristics

3.3.1 Research Settings

Evaluations were conducted in the Usability Laboratory at Department of Computer & Information Sciences, Universiti Teknologi PETRONAS Malaysia; a well-established and suitable lab for conducting evaluations in an undisturbed environment.

Evaluation was conducted over three days. Days one and two were divided into two sessions each and single sessions was held on day three. Participants involved in evaluations are shown in Table 3.6

Table 3.6: Participants Involved in Experimental Studies

Session	Participant	Game(s) Evaluated
Day 1, 1st Session	A	Temple Run
	B	Temple Run
	C	Temple Run
	D	Temple Run
Day 1, 2nd Session	A	Train Crises
	B	Train Crises
	E	Train Crises
	F	Train Crises
Day 2, 1st Session	E	Cafeteria Nipponica
	F	Cafeteria Nipponica
	G	Cafeteria Nipponica
	H	Cafeteria Nipponica
Day 2, 2nd Session	G	Block Breaker 3
	H	Block Breaker 3
	I	Block Breaker 3
	J	Block Breaker 3
Day 3	C	Asphalt 6, Modern Combat 3
	D	Asphalt 6, Modern Combat 3
	I	Asphalt 6, Modern Combat 3
	K	Asphalt 6, Modern Combat 3

3.3.2 Evaluation Goals

It is shown from literature review and preliminary studies that existing playability heuristics lack the ability to identify the playability problems in mobile games. The goal of this evaluation was to investigate extensively that at what extend existing playability heuristics lacks. Six android mobile games were evaluated to ensure that problems reported regarding playability heuristics were accurate. After conducting the

evaluation, this study then proposed a new set of playability heuristics for mobile games to compensate for the limitations of the existing heuristics. At the beginning of each session, participants were briefly presented with the objectives. Participants were also briefed on the playability heuristics and methods for conducting heuristic evaluation.

3.3.3 Data Collection Method

Heuristic evaluation is a common process employed to evaluate the usability of software applications and video game playability, particularly in Usability Laboratories. Data collection for this study was divided into two parts comprising a data collection instrument and data collection procedure.

3.3.3.1 Instrument

Mobile phones were used as the primary tool to evaluate mobile games and essential data were collected. A mobile phone on which games were installed, plus two sets of playability heuristics (presented in Tables 2.7 and 2.8), and evaluation sheets for reporting problems were given to each participant as shown in Figure 3.9. They were also provided with an evaluation guideline sheet as described in Figure 3.10. The guidelines instructed participants on the reporting of problems that violated heuristics and defined severity ratings for identified problems.

Evaluator Name: _____

Game: _____

S. No	Problem	Severity	Violated Heuristics

Figure 3.9: Evaluation sheet (a)

Problem

Write down a short description of the problem or specific issue found. The found problem or issues are features that affect the playability of the game.

Violated Heuristics: _____ (e.g. 5 or GP5)

Severity of the Problem: _____ (Low, Medium, Critical)

Low: Noticeable, but it does not prevent the player to achieve the objectives.

Medium: Annoying, but the player can live with it. The player can easily recover from the problem quite easily or can ovoid it.

Critical: Occurs everytime and it is unavoidable. It affects greatly to gaming experience.

Figure 3.10: Evaluation sheet (b)

3.3.3.2 Procedure

Participants started playing newly installed games they never played before on this mobile phones. This technique provided a realistic image for participants to facilitate

'first-time' experience of games, meaning participants created their own virtual profiles (avatar). Participants were not asked to achieve specific task and were free to play as they liked. However, they were familiar with the purpose of conducting the evaluation. Participants began playing and identified problems, assigned severity rankings, and then wrote comments on report sheets. They were asked not to discuss any identified problem with each other during the evaluation so that the data would be accurate and avoid biased results.

Additionally, researcher noted the time (manually) spent by each participant. This provided statistics for 'time spent' by each participant and the number of problems identified during that interval. At the end of each session, mobile phones and problem report sheets were collected from each participant. Participants were asked several questions regarding their experience and were given opportunity to suggest advances in the context of heuristics and the evaluation method.

3.3.4 Data Analysis

In order to examine the gathered data, each identified problem reported was checked and validated with the severity rating assigned by participants. Reported problems were compiled and identical problems discarded. The quantified data from all participants was organized using the Statistical Package for Social Sciences (SPSS) for further analysis. Mean, Standard Deviation and Variance were calculated for identified problems per heuristic. The mean for problems identified by each evaluator was calculated. Additionally, descriptive statistics were applied to calculate the frequency of identified problem with respect to the related violated heuristic.

3.3.4.1 Development of Playability Heuristics for Mobile Games

The development of new playability heuristics for mobile games started by defining what characteristics needed evaluation. Important factors that considered for development are general usability, usability of the touch screen, mobility, gameplay and multiplayer gaming. All of these bear importance and cannot be ignored. Existing

playability heuristics for mobile games did not cover touch screen interface issues. Other aspects were well covered and found satisfactory. However, the existing playability heuristics list was too large and caused difficulty for participants as some terms were ambiguous as also reported by other researchers (Korhonen 2010; and Paavilainen 2010).

General usability aspects are very important when evaluating games. When players concentrate on playing the game, they should not struggle with the game's interface. Control keys should be made convenient and instinctive. Current mobile technologies are quite mature and powerful enough to facilitate good-quality gaming with the touch interface. However, general usability heuristics do not apply to touch screen devices and this study focused on touch screen usability issues in mobile phones. 'Gameplay' is at the core of every game platform for which this study found issues not covered by existing playability heuristics. Hence, this study attempted to fill in the gaps of existing gameplay heuristics.

3.4 Experimental Study-II: Evaluation of Mobile Game with Proposed Playability Heuristics

In this phase of study, evaluation were carried out on mobile games with a proposed set of playability heuristic. The study was conducted to validate the proposed playability heuristics in order to see if they covered gaps in the existing playability heuristics proposed by Korhonen & Koivisto (2007) and Korhonen (2006). Figure 3.11 shows the overview of Phase III.

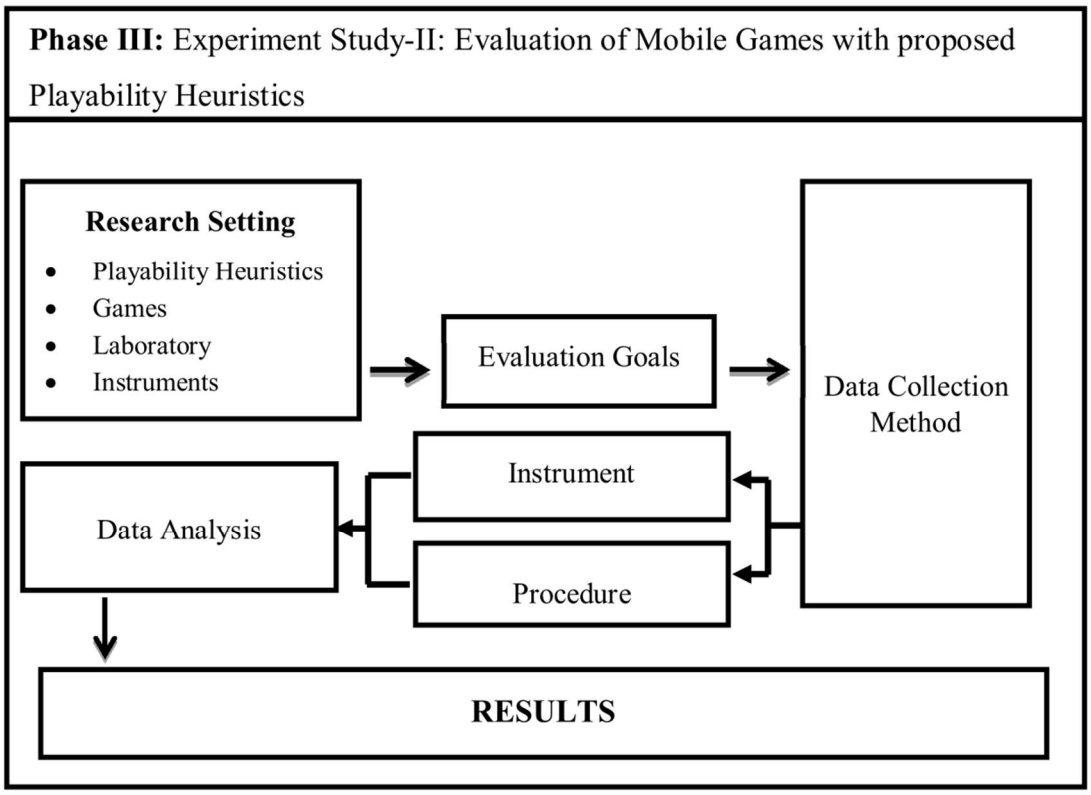


Figure 3.11: Overview of Evaluation on Proposed Playability Heuristics

3.4.1 Research Settings

The research settings and procedures were the same as those described in section 3.3.1.

3.4.2 Evaluation Goals

This study has previously conducted an evaluation of existing playability heuristics for mobile games to ascertain whether or not they covered all core aspects of contemporary mobile games. The results demonstrated the lack in existing playability heuristics to identify playability problems and other new issues were found. This study then proposed a new set of playability heuristics for mobile games to overcome the cited limitations in existing playability heuristics.

In this section, an experiment was conducted on the same games used in Phase-II using the proposed set of playability heuristics. The objective was to ensure that the proposed heuristics were valid and could identify playability issues in mobile games.

3.4.3 Data Collection Method

Data collection used the same protocol as Experimental Study-I as described in section 3.3.3.

3.4.3.1 Instrument

Instruments were the same as in Experimental Study-I (Refer to section 3.3.3.1). However, a new list containing the proposed Playability Heuristics was provided for participants. The proposed Playability Heuristics are presented in section 4.5.

3.4.3.2 Procedure

Same protocols are used as in Experimental Study-I, as presented in section 3.3.3.2.

3.4.4 Data Analysis

Data analysis was also the same as in Experimental Study-I, as presented in section 3.3.4.

3.5 Development of Playability Heuristic Evaluation System

The need to develop a new Playability Heuristic Evaluation System (PHES) was discussed in section 2.3.4 of chapter 2. This section covers the methodology applied to develop PHES and is divided into sub-sections as shown in Figure 3.12.

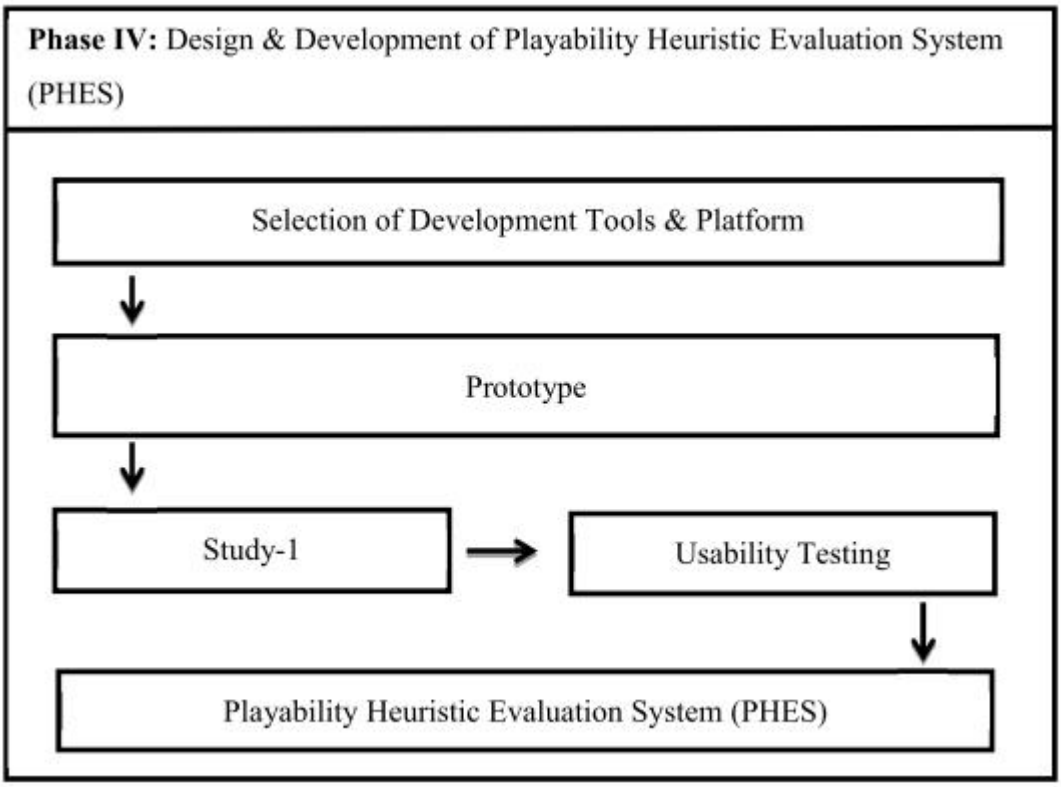


Figure 3.12: Overall view of Development of PHES

3.5.1 Development Tools & Platform

Before the development of PHES, several usability assessment tools were reviewed as a framework for the PHES design. Replicating existing usability assessment tools in PHES was crucial to the intended web-based software system for games' evaluations using playability heuristics. For this purpose, open source web development tools such as HTML and Pre-processor Hypertext (PHP) were selected as primary programming languages. JavaScript and Ajax Script were selected as scripting tools. Adobe Photoshop was selected to design the interface, and the web-based PHES. XAMPP MySQL was used as a primary database tool to store necessary evaluation data for

future use. All design and development processes were carried out by the Windows operating system.

3.5.2 Software Prototyping

A software prototyping model, as shown in Figure 3.13, was adopted as the development life cycle for PHES. The prototyping life cycle was divided into four phases, with each phase as its reverse iteration.

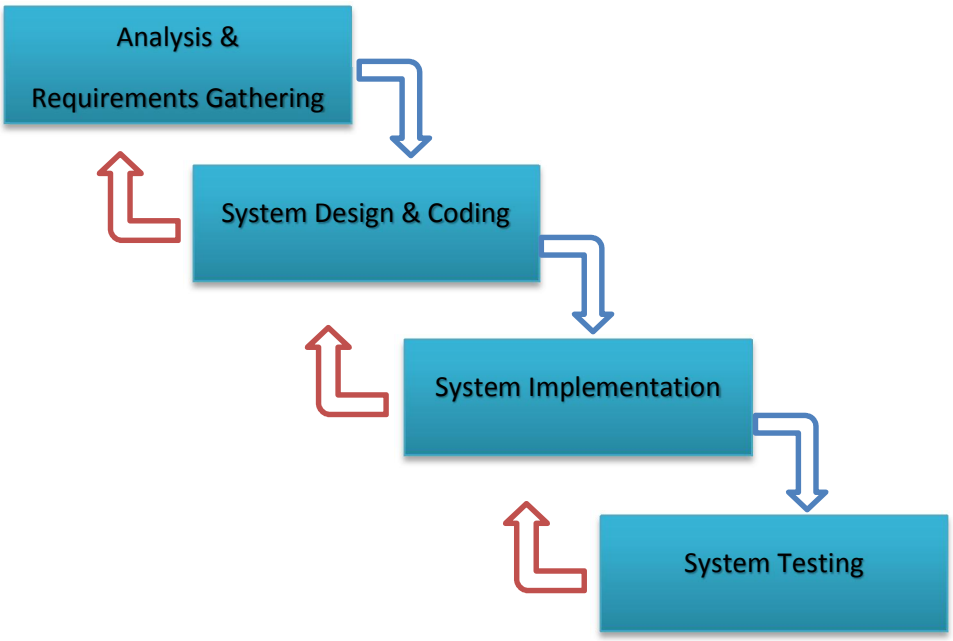


Figure 3.13: Software Prototyping

3.5.2.1 Analysis & Requirements Gathering

Before developing the Playability Heuristic Evaluation System, related words and other requirements were gathered in terms of software and hardware. All the data was gathered and analyzed accordingly with respect to the system's functionality. This approach helped us in the systematic development of PHES.

A majority of requirements were gathered from literature review to replicate the process of conducting a traditional heuristic evaluation method. Suggestions given by

participants during Phase-I of this study were also analyzed and considered, and then implemented in the development of PHES.

3.5.2.2 System Design & Coding

Every software system has an architectural framework for the implementation of gathered requirements. Similarly, system architecture was proposed for the development of PHES, which, in turn, aided the understanding of the work and the system's data flow.

Entity relations for the database were developed as shown in Figure 3.14. Three main entities were instilled: (i) Author of proposed heuristics; (ii) Game to evaluate; (iii) and Problems identified that violated heuristics. 'HE' represents the relationship between these entities. Each has attributes with specific functions. The entity, 'Author', was created to store heuristics in the system with respect to author who proposed the cited heuristic. It holds three main attributes: name, origination and heuristics. Each stored heuristic in the system has information; hence, the attribute, 'Heuristic', was further divided into five attributes as follows: description, category, sub-category, year proposed and keyword. The entity 'Game' was created to store details for games evaluated by the system. Each game had information assigned to five attributes as follows: name, platform, genre, mode and description. The third entity, 'Problem', was created to store problems violating heuristics in the system as reported by evaluators and was subdivided into the following attributes: description, violated heuristic, severity, time, game, and user.

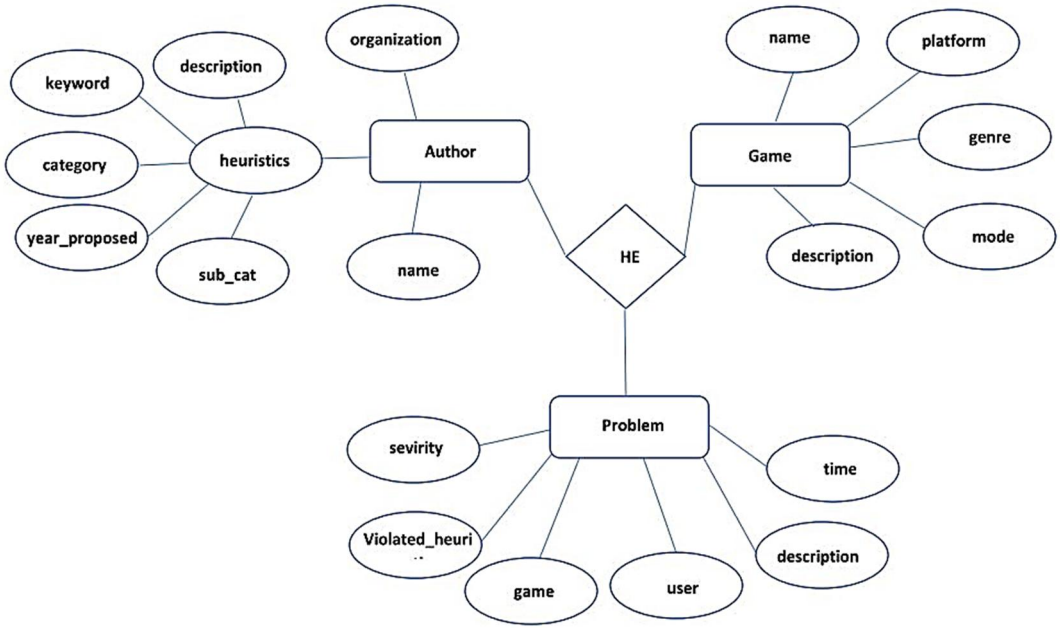


Figure 3.14: ER Diagram of PHES

The Web Interface of PHES was designed in Adobe Photoshop CS6 and developed using the Cascading Style Sheet (CSS). The Developer attempted to make the interface very simple so that participants would not struggle with PHES while evaluating a game. If the interface of a system is messy, it negatively affects evaluation results as participants lose focus on main objectives while struggling with the interface. A static interface was designed and no animations were used.

3.5.2.3 System Implementation

To check functionality and test PHES, it was implemented in the Usability Laboratory Department of Computer & Information Science, Malaysia. The system was web based and accessed by other computers in the usability lab via the local area network (LAN) IP address.

3.5.2.4 System Testing

Usability tests were conducted to check the system's functionality. Five participants took part, all of whom also worked in software developing companies and had expertise in conducting usability testing.

3.6 Evaluation of Mobile Games with Playability Heuristic Evaluation System PHES

The objective of this study evaluate games with PHES in order to validate the efficiency and effectives of PHES. Proposed playability heuristics were incorporated in PHES to evaluate mobile games. An overview of this phase is shown in Figure 3.15.

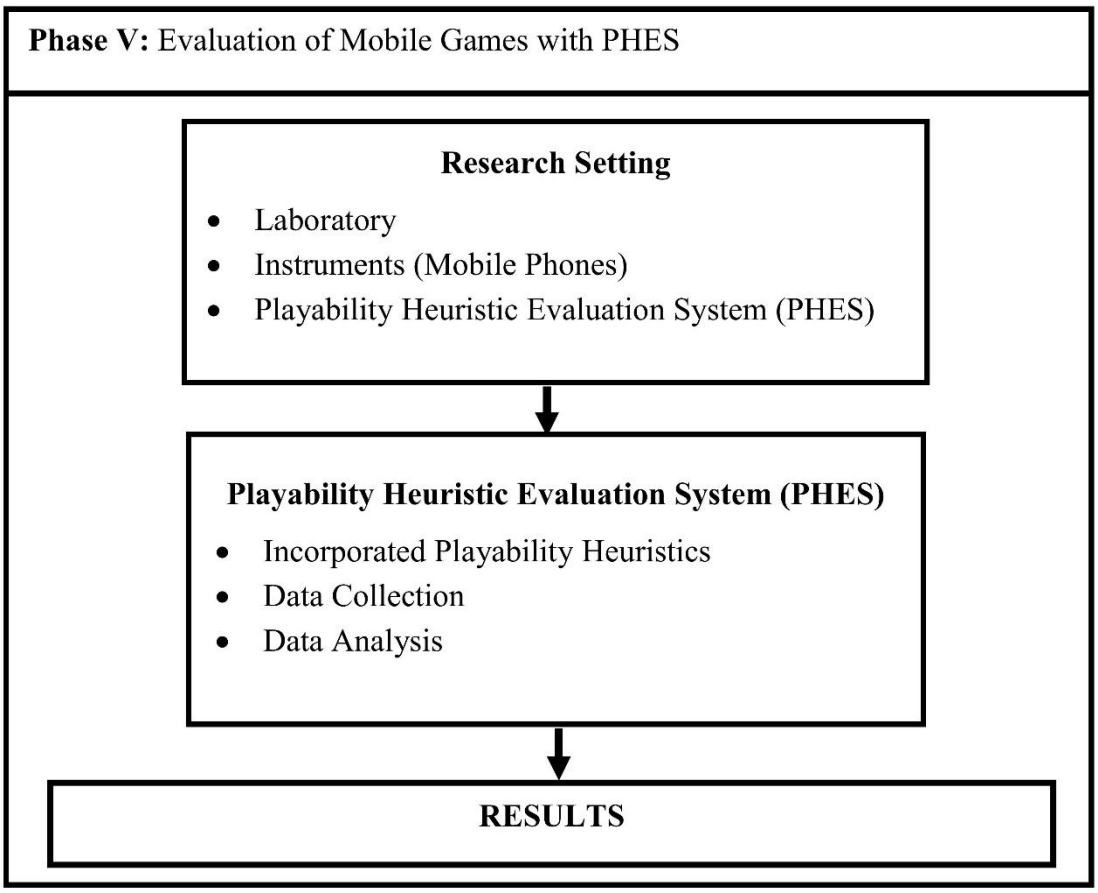


Figure 3.15: Overview of evaluation of mobile games using PHES

The evaluation was conducted over two days. Day one was further sub-divided by two participants who evaluated two different games. In the second session of day

one, one participant evaluated two games. On day two, two participants evaluated two games.

3.6.1 Research Settings

The evaluations were conducted in the Usability Laboratory at Department of Computer & Information Sciences, Universiti Teknologi PETRONAS Malaysia. This lab accommodates evaluation confidentiality and privacy in an undisturbed environment.

Mobile phones were given to each participant with games already installed. A computer system was provided for each participant on which PHES was installed. Before beginning each session, each participant was briefed on purpose of the evaluation.

3.6.2 Evaluation Goals

In prior evaluation trials, mobile games were evaluated with manual heuristic evaluation approach. Literature review indicated that manual heuristic evaluation was time consuming and that usability tools were needed to automate the process of heuristic evaluation. Hence, a playability heuristic evaluation system was developed to automate the process of heuristic evaluation. The evaluation's goal was to validate (measure) the efficiency and effectiveness of PHES compared to manual heuristic evaluation.

3.6.3 Data Collection

The literature review suggested that time could be saved by an automated process for heuristic evaluation. A web-based software named Playability Heuristic Evaluation System has been developed for evaluating mobile games. In Phases II and III of this study, evaluations were carried out manually. In this phase, an evaluations were conducted by using the PHES. Problem reports sheets and guidelines were not provided

for this phase. Identified Problems were directly reported and recorded in PHES by all participants.

3.6.4 Results Validation

A comparative study has been conducted of manual heuristic evaluations vs. the automated PHES system. Time spent by each manual evaluator was compared to time spent with PHES evaluators to measure the efficiency of PHES. Problems identified with manual heuristics evaluation and with PHES were also compared to measure PHES effectiveness. In addition, a descriptive statistical test was applied to results, also for comparison. Results are presented in Chapter 4.

3.7 Summary

In this chapter, methodologies were presented regarding the objectives of this study. Two preliminary studies were conducted, study-I was to validate the problems reported in literature. Study-II was to see at what extend the existing playability heuristics supports to evaluate various mobile games genre. An analysis was then completed for various heuristics, mobile game genres, and mobile games. Two experimental studies were conducted: (i) an experimental study to evaluate mobile games using existing playability heuristics from which results indicated a need to propose a new set of playability heuristics for mobile games. An experimental study was then conducted to validate proposed playability heuristics using the same mobile games that facilitated experiment one. A web-based software system named PHES was then developed in which proposed playability heuristics were incorporated. Evaluations were then conducted on mobile games to measure the efficiency of PHES vs. manual heuristic evaluation in terms of time and quality.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Overview

This chapter presents results and discussions from/of the analysis of existing playability heuristics for mobile games, proposing a new set of playability heuristics for mobile games and development of Playability Heuristic Evaluation System (PHES). There are two interrelated parts in this chapter: (1) the formulation of Playability Heuristics for mobile games; and (2) the design and development of the automated Playability Heuristic Evaluation System (PHES).

An evaluation was conducted on mobile game applications using existing sets of playability heuristics to validate the extent to which existing playability heuristics supported the identification of playability problems in mobile games. Based on these results, this study proposed a new set of playability heuristics for mobile games. In order to validate this new set, six mobile games were evaluated. A comparison was then made of results from evaluations utilizing existing and proposed playability heuristics.

To improve/propose the process of heuristic evaluation, a web-based software system named Playability Heuristic Evaluation System (PHES) was developed. In order to validate the efficiency and effectiveness of PHES, five mobile games were evaluated with PHES. The results have been compared from manual heuristic evaluation and automated heuristic evaluations.

4.2 Preliminary-I Results

A preliminary study was conducted to validate the problems reported in literature that existing playability heuristics lacked an ability to identify problems in mobile games. A questionnaire was formed from playability heuristics as proposed by Korhonen (2006) and Korhonen & Koivisto (2007). Demographic results from section 'A' of the questionnaire showed that participants belonged to different programs and different university disciplines. Most participants were regular game players and some played frequently. Participants preferred playing mobile games because of the "anytime-anywhere" availability of the mobile phone. Some participants stated they did not like mobile games because of their poor usability. Additionally, most participants played single and multiplayer games.

As heuristics are re-formed question patterns, in Section 'B' of the questionnaire, the Likert Scale were used from (1-5, from strongly disagree to strongly agree), to ask participants their views on the heuristics used, as shown in Table 4.1.

Table 4.1: Users opinion on game features (Preliminary Study-I)

Heuristics	Mean	Std. Deviation	Variance
Usefulness of introductory images and videos	3.92	.761	.579
Usefulness of game cheat codes	3.91	.767	.588
Usefulness of game help	3.73	1.090	1.189
Repetitions in games are enjoyable	3.82	.687	.472
Personalization of games settings	3.74	.597	.356
Ability to pause game at anytime	3.40	.651	.424
Ability to save game at anytime	3.66	.623	.388
Preference of single player over multiplayer games	3.99	.823	.677

Section 'C' of the questionnaire contained open-ended questions completed while collecting the questionnaires when researcher asked opinions from users on improving mobile games. Results were compiled and various major problems were reported by users as presented in Table 4.2.

Table 4.2: Problems Reported by Users

Label	Description	Example statement
The level of game difficulty and game speed	Users reported that mobile games were difficult to play with the available features of the mobile phone. Two participants reported: "*it is difficult to play games on the mobile because of small keys*", and "*our figures hide most of mobile screen when playing the game, so there should be other ways of controlling the game like voice*".	Control keys were not convenient for handling game characters when making quick decisions in order to respond with effective timing. Control keys should be made more convenient in order to play the game more effectively and effortlessly. Some participants stated that there should also be new methods to control game characters such as voice interaction.
Interruptions (internal & external)	Game users faced interruptions while playing mobile games; both internal and external. Users reported that "*incoming phone calls were very annoying, so the game should pause itself,*" and "*mobile games are not saveable like computer games*".	Internal interruptions were those occurring within the internal environment of the mobile phone, like incoming calls and text messages. External interruptions are those of the physical environment; for example, when someone asks you to do something while you are playing the game. For internal interruptions, games should auto-pause the game session. To handle external interruptions, the user should able be to pause the game any time during play without losing game progress.
Lack of user control in game setting	Users complained of limitations in game settings, reporting that "*graphics and sounds are not controllable and*	Users desired games that could be customizable in terms of controlling audio, visual and

	that they cannot customize game settings", and that "*mobile games are very fast and difficult to play on a touchscreen phone, so there should be game speed settings*".	speed effects. Sometimes, users wanted to skip introductory images and videos (non-playable contents) they did not consider them useful and suggested control for skipping non-playable contents.
Multiplayer games do not support multiple ways of connecting with other users	Another major problem reported by users was that multiplayer mobile games only supported a single medium to connect with game servers and other users. Users reported that "*I cannot use multiplayer games because the mobile data packages are expensive, and I prefer to play on wifi only*", and "*multiplayer games on mobile games are very difficult to play, it takes so much time to start one game and there is no guarantee how long you can stay in the game*".	There should be multiple approaches to connectivity in multiplayer mobile games such as Bluetooth, WLAN, 3G and the 4G network. It is noted also that 3G and 4G data plans are very costly and limited in volume. Hence, users may not want to spend money to play multiplayer mobile games. Therefore, games should have options to create multiplayer sessions with more than one connectivity medium.
Difficulty in playing multiplayer games	Users also reported that multiplayer games were difficult for players compared to single player games because: "*Multiplayer games start very slow and we need to wait too long*", and "*due to poor mobile data network, there is no guarantee how long you can stay in the game and you may need to restart from the beginning*".	Multiplayer game sessions should be created easily. Mobile phones have limited resources, users might not want to spend battery for just waiting for game to respond.
Multiplayer games do not support the multiple communication medium	There was also a lack of communication reported for multiplayer mobile games. Users suggested "*there should be a 'voice chat' facility to communicate with other player because we cannot*	In mobile games, users cannot text chat with other players while playing because of inconvenient control keys, smaller screen size, and also due to many items displayed on

	type so fast on a mobile phone while playing games".	the game screen. Hence, it is better to have voice communication between games players while playing a game. This feature might boost the charm of multiplayer mobile gaming among game users.
Game genre issues	Users also reported favourite genres for mobile games. Users reported: "*I prefer to play simulations games, they are very enjoyable and I can play for long times*", and "*old style games like puzzles are boring, there should be role playing games like counter strike and call of duty*".	Users preferred story based games rather than arcade and puzzle genres. They also preferred to play simulation games, role-playing games, strategy and action-adventure games. Mobile games should retain similar genres for games as do other gaming platforms.

Identified problems were compiled accordingly and then prepared an initial set of playability heuristics for mobile games. These proposed sets of playability heuristics attempted to fill in gaps left vacant by existing playability heuristics for mobile games. Each heuristics is now defined in the following sub sections.

4.2.1 Initial Proposed Playability Heuristics for Mobile Games

This study proposes a set of ten playability heuristics and categories, respectively, as shown in Table 4.3. This set of heuristics were proposed/derived from Section C of preliminary study. Each heuristic is further defined below.

Table 4.3: Initial Proposed Heuristics for Mobile Games

Gameplay	
1	Player able to save the game anytime
2	Game objectives are moderate (neither too easy not too difficult)
Usability	
3	Player able to skip movies & images (non–playable content)
4	Game allow customization
Mobility	
5	Game can handle interruptions(internal)
6	Player able to pause the game anytime
Multiplayer	
7	Multiplayer sessions can be easily created
8	Game sessions can be saved & restored in loss of connectivity
9	Game supports multiple connectivity medium
10	Game supports multiple ways of communications(voice & text)

Each heuristic is further defined below:

1. **Player is able to save the game anytime**
   (Derived from results of preliminary study "*internal interruptions*")

A player should be able to save the game anytime and at any stage of gameplay. Due to limited resources on the mobile phone, the player should be able to save the game whenever he/she wants to save it, and later continue from the saved position.

2. **Game objectives are moderate (not to be easy-nor too difficult)**
   (Derived from results of preliminary study "*lack of user control in game setting*")

Game objectives should not be too easy to achieve without effort and not too difficult as to make the game impossible.

3. **Player is able to skip movies & images (non–playable)**
   (Derived from results of preliminary study "*lack of user control in game setting*")

A player is able to skip non-playable content such as introductory movies and images.

4. **Game allows customization**
   (Derived from results of preliminary study "*lack of user control in game setting*")

Game should allow users to customize game settings so users can play the game at their desired level of difficulty and desired game speed.

5. **Game can handle interruptions (internal)**
   (Derived from results of preliminary study "*internal interruptions*")

Games should be able to handle internal interruptions from incoming calls, text messages, and emails, etc. Game should auto-pause when such interruptions occur so players can continue afterwards.

6. **Player is able to pause in the game anytime**
   (Derived from results of preliminary study "*interruptions*")

To handle external interruptions from the immediate environment, the player should be able to pause the game and continue later if so desired.

7. **Multiplayer sessions can be easily created.**
   (Derived from results of preliminary study "*Multiplayer games are difficult to play*")

Games should be able to create multiplayer game sessions easily with little effort. If a player needs to wait for a prolonged time, they consider it a useless waste of time and resources.

8. **Game sessions can be saved & restored in loss of connectivity.**
   (Derived from results of preliminary study "*Multiplayer games are difficult to play*")

In cases of lost connectivity during multiplayer gaming, games should be able to save the game session when interruptions occur and restore the session when both players re-connect. Usually this will have time limitations.

9. **Game supports multiple connectivity medium**
   (Derived from results of preliminary study "*Multiplayer games do not support multiple ways of connecting with other users*")

Games should support multiple connectivity options such as Bluetooth, Wifi and 3G. It should be in the control of players which medium they prefer for convenience.

10. **Game supports multiple ways of communications**
    (Derived from results of preliminary study "*Multiplayer games do not support the multiple communication medium*")

In multiplayer mobile games, games should support multiple ways of communicating with each other, due to the small-screen size of the mobile phone and inconvenient control keys. Players do not prefer to text chat, if the game supports voice communication, players prefer voice chat and it will also increase the player's social circle.

4.2.1.1 Discussion

From the results of preliminary study and literature review, it is learned that existing playability heuristics for mobile games lacked the ability to identify major issues for smartphone games, i.e. phones with a touchscreen interface. An extensive literature review on playability heuristics showed that none of the playability heuristic sets supported the evaluation of touchscreen mobile games. Therefore, the need for new playability heuristic sets to evaluate touchscreen mobile games was made clear.

Additionally, it is observed that a review of literature and/or survey were not appropriate approaches to extensively analyze existing playability heuristics and to propose a new set of heuristics. An extensive analysis was required to find the gaps

in existing sets of heuristics. Therefore, this study conducted heuristic evaluation on six touchscreen Android mobile games of different genres. The selection of games and game genres are discussed in Section 2.2.2.2. Results of evaluation are discussed in section 4.4.

4.3 Preliminary-II Results

This preliminary study was conducted to investigate the extent to which current heuristics for educational computer games efficiently evaluate educational mobile games. Section one of questionnaire was on demographic of participants that shows 71% of participants played mobile games regularly and preferred to play mobile games more than computer games because of the mobility feature of the mobile phone. Fifty-three percent (53%) of participants agreed that playing games on mobile phones was more interesting as they can be played anytime, anywhere. Participants responded very positively and showed interest in mobile learning games. They stated that mobile learning games were very helpful and enjoyable, and that skills improved quickly when playing mobile games. Participants also agreed that learning through games was creative and interesting as educational games provided both fun and knowledge. However, some participants contradicted this sentiment, arguing that educational games did not provide sufficient knowledge and preferred traditional teaching methods. They also thought that games were meant to provide fun, not knowledge.

The second section of the questionnaire consisted of questions regarding usability, pedagogical content, and playability factors. A total of eighteen questions were presented that highlighted important factors of educational games. A total of fifty-eight questionnaires were returned with positive responses, and two questionnaires were returned unfilled.

Cronbach's α was computed for the eighteen questions for each game individually to check whether or not the questionnaire was a reliable measuring tool. (George & Mallery, 2002) defined a rule of thumb for Cronbach's α stating that, >0.9 is Excellent, >0.8 is Good, >0.7 is Acceptable, >0.6 is Questionable and >0.5 is Poor. As shown in Table 4.4, Cronbach's α was >0.9 for each game, indicating reliability was

excellent. Cronbach's α was computed individually for each game to validate reliable questions for games from different curricula.

Table 4.4: Reliability Statistics: Cronbach's α (Preliminary Study-II)

Game	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
Animal Kingdom	.963	.965	18
Chase Me	.850	.837	18
Comic Maths	.971	.975	18
Spell It	.953	.956	18

Results for all four games were analysed, as shown in Table 4.5. Each factor for the game was assessed individually to perceive that how existing educational games heuristics are applicable on mobile games.

Table 4.5: Scale Statistic of Games (Preliminary Study-II)

Games	Factors	Mean
"Animal Kingdom"	Usability	20.70
	Playability	18.80
	Pedagogical	15.60
	Content	16.60
"Chase Me"	Usability	18.63
	Playability	16.13
	Pedagogical	12.38
	Content	13.00
"Comic Maths"	Usability	20.00
	Playability	19.83
	Pedagogical	16.33
	Content	16.00
"Spell IT"	Usability	19.67
	Playability	19.67
	Pedagogical	16.33
	Content	16.17

Tables 4.5 shows statistical results for pedagogical, content, usability and playability factors. Most participants were satisfied with game features. However, pedagogical and content scored low in every game, indicating that game usability and playability heuristics are much appropriate and understandable by participants. The games used for evaluation were all first release versions. Game development teams suggested improvements in the usability of games in order to release new versions with better efficiency and effectiveness.

The results demonstrated that the use of educational games in school and college are applicable. Participants from school were happy to play and became deeply engaged in achieving objectives. PHEG, as proposed by Mohamed & Jaafar (2010) was found satisfactory for evaluating educational games. PHEG was proposed for computer games but these heuristics were also applicable to mobile games. However, PHEG did not cover some mobility features for mobile phones. It was therefore recommended that to formulate specific heuristics for the evaluation of educational mobile phone games.

4.4 Results of Experimental Study I: Evaluation of Mobile Games using existing Playability Heuristics

The objective of this Experimental Study-I was to investigate at what extend existing playability heuristics lacked the ability to identify playability problems in mobile games. This study concerned two sets of playability heuristics, as shown in Table 4.6 for evaluating mobile games as proposed by Korhonen & Koivisto (2007) and Korhonen (2006). The first set evaluated gameplay, usability and mobility features. The second set evaluated multiplayer mobile gaming.

The procedure followed for these evaluations is explained section 3.3.3.2. During evaluation, participants reported a total of 121 problems, listed in Table 4.6, according to defined heuristic categories. Most identified problems were related to Gameplay. Although, evaluating Gameplay is the most difficult part of game evaluation because of its dynamic feature, participants managed to identify (N = 47 or 38.88%) of problems violating gameplay heuristics. The games assessed also violated

Usability, Mobility and Multiplayer heuristics as well, with participants reporting (N = 39, 32.23%) of the 121 problems with Usability; (N=17, 14.04%) for Mobility; and (N =18, 14.87%) for Multiplayer heuristics. Each heuristic category was violated and the identified problems are discussed in the following sub-section.

Table 4.6: Number of problems identified in Evaluation

Heuristics Category	Problems Identified	Weightage %
Gameplay	47	38.84%
Usability	39	32.23%
Mobility	17	14.04%
Multiplayer	18	14.87%
Total	**121**	**100%**

4.4.1.1 Problems Violating the Gameplay Heuristics

Gameplay is the core of any game and is a very critical phase in evaluation protocols due to its dynamic nature. Gameplay for each and every game is different depending on the genre as players experience interactions with the mechanics of the game. The evaluation revealed that the largest number of identifiable problems was related to gameplay issues, as shown in Figure 4.1. Heuristic GP1: "the game provides clear goals or supports player-created goals" was violated (N = 6, 12.77%); GP5: "challenge, strategy and pace are in balance" was violated (N = 6, 12.77%); GP6: "the first-time experience is encouraging" was violated (N = 7, 14.89%); and GP7: "the game story supports the gameplay and is meaningful" was violated (N = 6, 12.77%). Overall, the problems that violated these heuristics stated that the games did not provide clear goals and the pace of the game was not balanced. Each of thirteen heuristics was violated except for one, GP9: "the player can express themselves". However, four (8.51%) new gameplay problems were identified that did not have proper heuristics.

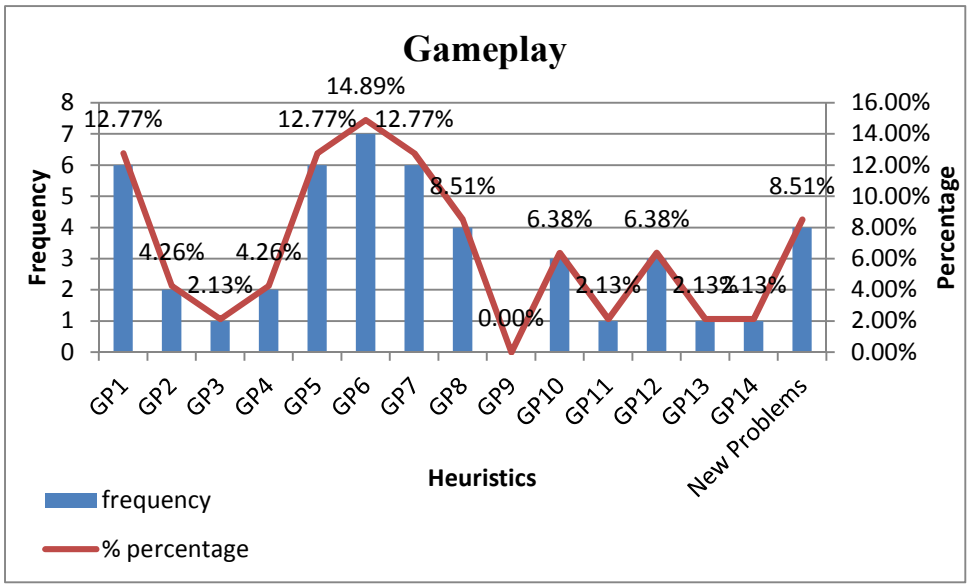


Figure 4.1: Playability problems violating Gameplay Heuristics

4.4.1.2 Problems Violating the Game Usability Heuristics

Participants reported that game usability (GU) heuristics were much easier to understand and that they did not face the same problems faced during the evaluation of gameplay heuristics. A total number of thirty-nine problems were reported by participants that violated game usability heuristics, as shown in Figure 4.2. Nine new usability issues were identified and reported showing that the maximum number of problems identified for usability were new problems: (N = 9, 23.08%), not supported by existing usability heuristics. Most of these problems were related to the touch screen interface.

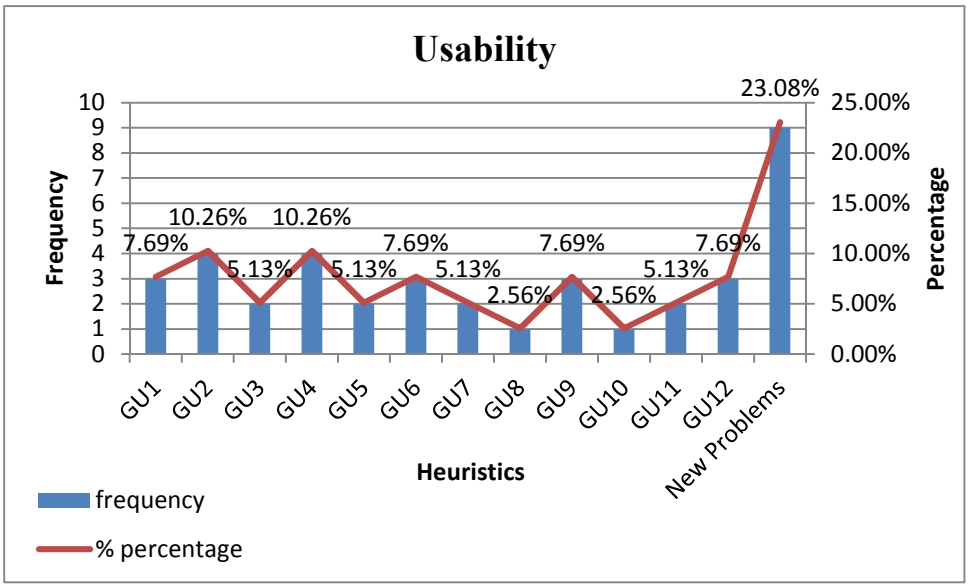


Figure 4.2: Playability problems violating Usability Heuristics

4.4.1.3 Problems Violating the Mobility Heuristics

Seventeen (N =17) game mobility problems were reported by participants as shown in Figure 4.3. Each identified problem violated existing mobility heuristics. However, three (N = 3, 17.65%) of the new problems identified did not have a proper heuristic. These latter problems were related with interruptions players faced while playing. Participants reported that games were not able to handle internal interruptions during playing, such as email, messaging and call alerts. They also reported that touch screen mobile phones were difficult to handle when playing while walking.

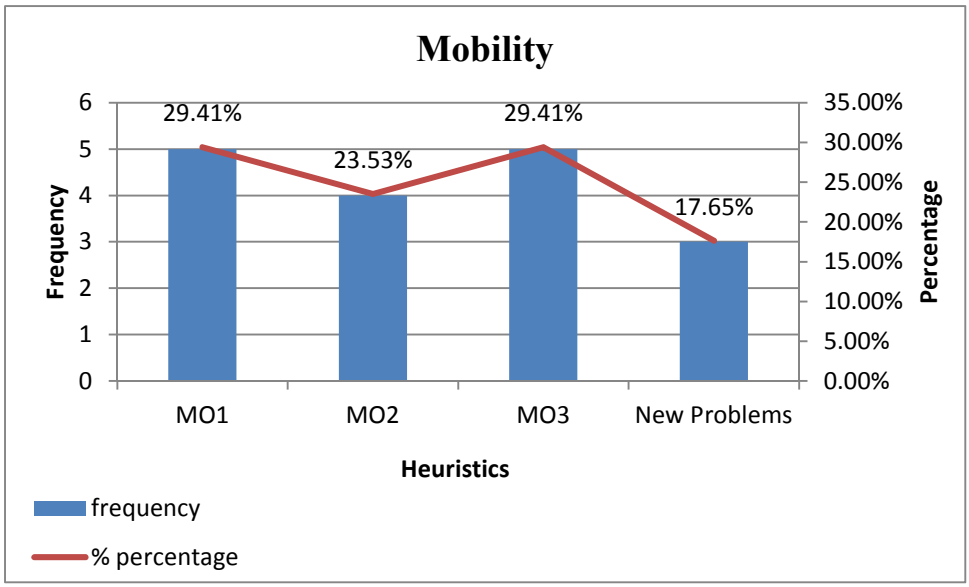


Figure 4.3: Playability problems violating Mobility Heuristics

4.4.1.4 Problems Violating the Multiplayer Heuristics

Four participants reported eighteen (18) problems that violated mobile multiplayer heuristics as shown in Figure 4.4. Eleven of these violated existing multiplayer heuristics and seven (N = 7, 38.89%) were new problems identified during the evaluation. The new problems were related to communication and the medium of connectivity between players. Participants reported it was very difficult to communicate with other players while playing because the games only supported the chat feature. Moreover, participants also reported that the game was supported only by the Wi-Fi medium for connectivity with other players which restricted multiplayer gaming boundaries to local wireless gaming.

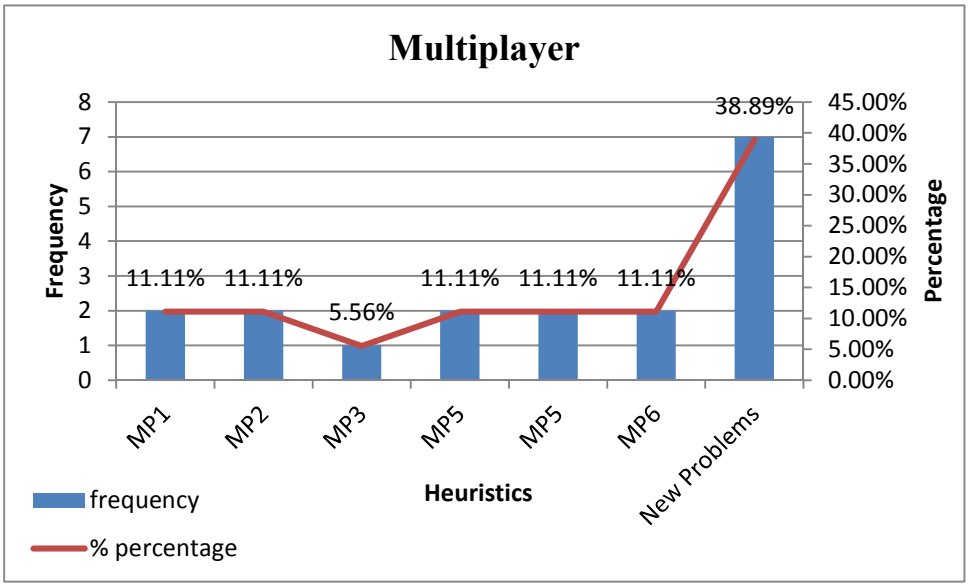


Figure 4.4: Playability problems violating Multiplayer Heuristics

Based on these findings from the use of existing playability heuristics as proposed by (Korhonen, 2006) and (Korhonen & Koivisto, 2007), a new set of playability heuristics for mobile games were proposed. These proposed heuristics were classified into five categories as follows: Usability, Touch Screen Usability, Mobility, Gameplay and Multiplayer and were not only applicable to touch screen interface games but can also to various mobile devices, games and platforms. These heuristics were further sub-divided to facilitate usability practitioners to choose each module separately for evaluation, one module at a time. This approach proved very useful for evaluating early version of games. The Proposed Playability Heuristics for mobile game are presented in section 4.5.

4.5 The Proposed Playability Heuristics for Mobile Games

This study proposed an initial set of ten heuristics based on the findings of preliminary study-I. It was also observed from preliminary studies that survey is not an appropriate approach to analyse game extensively and to propose a new set of heuristics. Therefore, this six android games were evaluated using heuristic evaluation with two sets of heuristics as discussed in section 3.2.3.

Based on findings from evaluation of existing playability heuristics, a new set of playability heuristics was developed and proposed for the evaluation of single player and multiplayer mobile games as shown in table 4.7.

Table 4.7: Proposed Playability Heuristics for Mobile Games

Category	Heuristic	Derived from
USABILITY	Game provides immediate feedback on player's action	(Desurvire et al., 2004), (Korhonen, 2006), and (Desurvire & Wiberg, 2009)
	Game provides help & hints	(Desurvire et al., 2004) and (Korhonen, 2006)
	Audio & Visuals demonstration supports the games	(Korhonen, 2006)
	Player experience game menu as part of game	(Desurvire et al., 2004)
	Player does not need to memorize unnecessary things	(Korhonen, 2006)
	Navigation is consistent, logical & minimalist	(Desurvire et al., 2004) and (Korhonen, 2006)
	Game allows customization	Preliminary Study-I
	Game allows to skip Non-playable content	Preliminary Study-I
	Game controls are convenient & flexible	Preliminary Study-I
	Device UI & Game UI are used for their own purpose	(Korhonen, 2006)
TOUCHSCREEN USABILITY	Game UI does not overlaps device resources status bar	Experiment Study I
	Device provide ergonomics	Experiment Study I
	Game control keys do not collapse with device control keys	Experiment Study I

	Game use gyroscope and accelerometer	Experiment Study I
	Device allows game to use screen precisely and responsively	Experiment Study I
GAMEPLAY	Game provides clear objectives	(Desurvire et al., 2004) and (Korhonen, 2006)
	Game progress is visible to player	(Desurvire et al., 2004) and (Korhonen, 2006)
	Game is easy to play & difficult to master	(Desurvire et al., 2004)
	First time experience is inspiring, is re-playable and does not contain repetitive tasks	(Desurvire et al., 2004) and (Korhonen, 2006)
	Game pace, challenge & strategy are in balance	(Korhonen, 2006)
	Game story is part of gameplay	(Desurvire et al., 2004)
	Game supports different playing styles	Experimental Study I
	Game engages player in personal involvement (i.e. happiness, scare, threat, thrill, reward & punishment)	(Desurvire et al., 2004)
	Player reflects in game character	(Korhonen, 2006)
	Player does not lose any hard-won possess	(Desurvire et al., 2004)
MOBILITY	Interruptions (internal & external) are handled responsively	Preliminary Study I and (Korhonen, 2006)
	Game sessions started quickly	Experimental Study I and (Korhonen, 2006)
	Game sessions are pause and resume able	Experimental Study I
	Game suits the surrounding of player	Experimental Study I
MULTIPLAYER	Game session are easily created	Preliminary Study I and Experimental Study I
	Game sessions can be saved and restored in case of connectivity loss	Preliminary Study I and Experimental Study I
	Game supports multiple ways of communication	Preliminary Study I and Experimental Study I
	Game supports multiple medium of connectivity	Preliminary Study I and Experimental Study I
	Other online players are visible & able to connect	(Korhonen & Koivisto, 2007)

	Game supports social groups & communities	(Korhonen & Koivisto, 2007)

Each category and corresponding heuristics are described in the following sub-sections.

4.5.1 Usability Heuristics

The Usability Heuristics shown in Table 4.8 were used to evaluate aspects of a game's control mechanisms and interface. The game's interface is the first thing users will encounter. In general, the game's interface allows users to interact smoothly as it displays necessary data. A game with good usability ensures that the user will have enjoyable gaming sessions.

Table 4.8: Heuristics for evaluating Game Usability

Category	Keyword	Heuristic
Game Usability Heuristics	GU1	Game provides immediate feedback on player's action
	GU2	Game provides help & hints
	GU3	Audio & Visuals demonstration supports the games
	GU4	Player experience game menu as part of game
	GU5	Player does not need to memorize unnecessary things
	GU6	Navigation is consistent, logical & minimalist
	GU7	Game allows customization
	GU8	Game allows to skip Non-playable content
	GU9	Game controls are convenient & flexible
	GU10	Device UI & Game UI are used for their own purpose

Heuristics shown in Table 4.7 derive from problems reported in section 4.4 (existing playability heuristics for computer and mobile games). Each heuristic demonstrated in Table 4.7 is defined below.

- **GU1 - Game provides immediate feedback on player's action**
  (Derived from (Desurvire et al., 2004), (Korhonen, 2006), and (Desurvire & Wiberg, 2009))

A good user interface provides immediate feedback for the player's action(s). An action can be one or more inputs to the game. Players should see that the game has responded to their action(s). A good game provides feedback by two means, graphic and auditory.

- **GU2- Game provides help & hints**
  (Derived from (Desurvire et al., 2004) and (Korhonen, 2006))

The game teaches the player how and where to begin. There are two possible methods for providing help; manuals and tutorials but mobile games do not provide printed manuals for most games, so this is not acceptable. Tutorials are useful at the beginning of a game to teach players about game control keys and interactions with game characters. However, a full tutorial at the beginning of game is also not acceptable as sometimes player do not want to learn the full game at once.

Game hints provide clues for users when the player is stuck on objectives. At some stages of the game, players may not understand the objective or the game stagnates. In these cases, games should contain hints to clear the obstacle. It is also recommended that the number of hints should be limited throughout the game; otherwise players complete the game using infinite hints.

- **GU3 - Audio & Visuals demonstration supports the games**
  (Derived from (Korhonen, 2006))

Current GPUs (Graphics Processing Unit) for Mobile phones are powerful and capable of providing appealing visuals (players expect good visuals). However, game graphics should support the game story and be educational. In Addition, mobile game graphics should be good enough to be played either in outdoor or indoor environments under different lighting conditions—high colour and contrast levels are preferable.

Audio features are used to evoke feelings and increase player involvement in the game. These can be in forms of music and sound effects. Both have their own importance in creating a 'sound' environment for interactive play. Music and sound

effects should be used to enhance the player's engagement rather than disturb the player's focus on the game.

- **GU4- Player experience game's menu as part of game**
  (Derived from (Desurvire et al., 2004))

The game's menu provides access to different components of the game. Mobile games provide a menu only at the beginning of game which is not acceptable. The Game's menu should be accessible at any stage of game to facilitate player navigation to other modules of the game such as visual and audio settings.

- **GU5 - Player does not need to memorize unnecessary things**
  (Derived from (Korhonen, 2006))

Games should not overstress the player's with unnecessary items. The games objectives and challenges should be concise and simple enough to be adopted by the player without memorization or need to refer to written prompts.

- **GU6 - Navigation is consistent, logical & minimalist**
  (Derived from (Desurvire et al., 2004) and (Korhonen, 2006))

The player navigates the game menu to access different modules of the game such as settings and/or the selection of desired game sessions. In the game user interface, modules should be organized reasonably and, if possible, on different screens. While playing, players should have access to different modules of the game. Game navigation should be short paths that provide clarity and are easy to remember. Long navigation paths are not acceptable and are difficult to memorize.

Mobile devices have two types of navigation controls; permanent and temporary. Permanent navigation keys are used for interaction with the interface of the mobile device. Temporary navigation keys are often related to specific applications. Since games do not need to follow the device's navigation keys, games should have their own navigation keys.

- **GU7 - Game allows customization**
  (Derived from "Initial Proposed Playability Heuristics, Section 4.2.1")

It is difficult to play games on mobile phones as they are not as convenient as other gaming platforms. Mobile phones are also not as effective because of incontinent control keys. Games should therefore allow users to adjust the desired pace and game settings as preferred by the player. They should have settings that adjust the game's level of difficulty and pace.

Moreover, games should allow players to customize graphics and sound setting as well. Recent mobile games have very pleasing and attractive graphics but sometimes games also lag when the mobile phone does not meet the game's requirements. Mobile games should have graphic settings that adjust the graphics to low, medium and high modes.

- **GU8 - Game allows to skip non-playable content**
  (Derived from "Initial Proposed Playability Heuristics, Section 4.2.1")

Games may have introductory videos and images (non-playable content). Most non-playable content derives from the game developing company's introduction and/or game story line. Sometime it may feel good to see this content but continual replay of the content for every game launch causes frustration in players.

Games should allow players to skip non-playable content when desired. Moreover, mobile phones have limited battery resources, and continuous running of such content reduces battery life.

- **GU9 - Game controls are adjustable**
  (Derived from "Initial Proposed Playability Heuristics, Section 4.2.1")

Beginning game players usually require only the standard set of keys to play the game. On the other hand, experienced players may want to adjust control keys according to preference. Control keys should be adjustable to meet the desires of the player.

Currently, mobile phones are not flexible enough to provide such a facility compared to other games. Game developers should design control keys according to device compatibility.

- **GU10 - Device UI & Game UI are used for their own purpose**
  (Derived from (Korhonen, 2006))

It should always be obvious when a player interacts either with the device's interface or the game's interface. The game's interface should not display either the mobile phone's or other device's interface during the game. In mobile phones, features like network connections, messages, call logs and email status should not be visible on the game's interface. The most impressive immersion is achieved when the game's display this information using user interface widgets that are consistent with other elements.

4.5.2 Touchscreen Usability Heuristics

In recent years, touch screen mobile devices have become more popular. Mobile devices with touch screen capability increase the ratio of mobile games users. The evaluation results showed that existing usability heuristics were unable to identify touchscreen usability issues. Hence, a set of Touchscreen Usability Heuristics has been proposed that should cover usability issues regarding mobile touchscreen usability. These heuristics are listed in Table 4.9 and defined below.

Table 4.9: Heuristics for Evaluating Touchscreen Usability

Category	Keyword	Heuristic
Touchscreen Usability Heuristics	TSU1	Game UI does not overlaps device resources status bar
	TSU2	Device provide ergonomics
	TSU3	Game control keys do not collapse with device control keys
	TSU4	Game use gyroscope and accelerometer
	TSU5	Device allows game to use screen precisely and responsively

- **TSU1 - Game UI does not overlaps device status bar**
  (Derived from problems reported in "Experiment Study I")

In current mobile phone operating systems, Apple's iOS and Google's Android have a status bar at the top of the screen. A status bar shows necessary information on battery resources, network information, emails, messenger, call logs and other notifications. Players generally want to know the current status of these notifications, most importantly, the battery indicator. Mobile games should cover the balance of the phone's screen, but should not overlap the status bar. It would be a unique approach if mobile games made this information visible in the game's interface if the game generally hides the device's status bar.

- **TSU2 - Device provide ergonomics**
  (Derived from problems reported in "Experiment Study I")

Controlling a game character on a touchscreen mobile phone is not as easy as in other gaming platforms. Controls keys for the game should be placed in recognizable positions and should naturally fit normal hand posture.

- **TSU3 - Game control keys do not collapse with device control keys**
  (Derived from problems reported in "Experiment Study I")

Recent touchscreen mobile devices come without physical control keys. Mobile phones use a small part of the screen for the placement of device control keys, mostly at the bottom of the screen. The game interface should not collapse with the device's control keys. Games should have separate control keys for game navigation.

- **TSU4 - Game use gyroscope and accelerometer**
  (Derived from problems reported in "Experiment Study I")

Currently, mobile phones come with gyroscope and accelerometer capabilities. Placing two thumbs or figures on a mobile screen to control game characters hides most of the screen, which is not conducive for game playing. Games should use both the gyroscope and accelerometer as control keys for game interaction. By using these features, the game's screen should become more visible and provide necessary information for the player.

- **TSU5 - Game uses screen precisely and responsively**
  (Derived from problems reported in "Experiment Study I"))

The mobile game interface contains much information for its small screen. This information, in addition to control keys as shown on the interface, should be managed responsively by the game. Hence, the game interface should use the mobile phone screen more precisely and responsively to facilitate better usability.

4.5.3 Mobile Gameplay Heuristics

Since Usability heuristics evaluate the game's interface, mobile Gameplay Heuristics evaluate gameplay. Gameplay is the core of every game and is difficult to evaluate. It is also difficult to ensure successful player expertise when evaluating gameplay. Gameplay is dynamic and occurs when the player interacts with the game's mechanics. Game mechanics consist of instructions that define the game actions. The Mobile Gameplay Heuristics listed in Table 4.10 are valid for every game regardless of platform. Each heuristic is defined below.

Table 4.10: Heuristics for evaluating Mobile Gameplay

Category	Keyword	Heuristic
Mobile Gameplay Heuristics	MGP1	Game provides clear objectives
	MGP2	Game progress is visible to player
	MGP3	Game is not easy play & not difficult to master
	MGP4	First time experience is inspiring, is re-playable and does not contain repetitive tasks
	MGP5	Game pace, challenge & strategy are in balance
	MGP6	Game story is part of gameplay
	MGP7	Game supports different playing styles
	MGP8	Game engages player in personal involvement (i.e. happiness, scare, threat, thrill, reward & punishment)
	MGP9	Player reflects in game character
	MGP10	Player does not lose any hard-won possess

- **MGP1 - Game provides clear objectives**
  (Derived from (Desurvire et al., 2004) and (Korhonen, 2006))

A game without clear objectives cannot be considered a successful game. The player should be able to understand the game's objectives. A player with a clear objective in mind has a most enjoyable experience. Game objectives can be divided into two categories: some games inspire players to create their own objectives, and some allow the player to choose pre-defined objectives.

Objectives can be either primary or secondary. Primary objectives are long-term goals that remain active throughout the game. Secondary objectives are short-term goals the player must achieve in order to attain primary objectives. Short-term objectives usually work as pre-requisites for long-term objectives and can be repeated several times.

- **MGP2 - Game progress is visible to player**
  (Derived from (Desurvire et al., 2004) and (Korhonen, 2006))

The player should have knowledge of their current game status. Players should have information about their progress towards attaining objectives achieved as well as those remaining. According to (Korhonen, 2006), game progress can be shown explicitly and implicitly. It is encouraging for players when they compare this progress to previous results and to the progress of other players. Without showing progress to a player, performance can become insignificant and the player will disengage.

- **MGP3 - Game is not easy is play and not difficult to master**
  (Derived from (Desurvire et al., 2004))

The objectives of a game should be moderate for novices and experienced players. However, games should allow users to change the level of difficulty according to preference. Games should not be made too easy for objective achievement without effort, otherwise it loses its charm and players will disengage.

Game should not be so difficult that players consider its goals unachievable. The player should have the feeling that objectives and goals are achievable and that the

game permits them to make progress. Players have been noted to use cheat codes in order to achieve objectives when a game stagnates.

- **MGP4 - First time experience is Inspiring, is re-playable & does not contain repetitive task**
  (Derived from (Desurvire et al., 2004) and (Korhonen, 2006))

First time game experiences create a lasting impression on the player. If the first experience is uninspiring, the player may never play the game again. Not only is the initial experience of importance, but the game should also be continually enjoyable throughout the game. Players should feel they have achieved something and thus become inspired to play continuously. The game should not contain repetitive tasks without changing conditions. Repeating a task again and again is called grinding, and it usually ends up killing the game. Players quit playing a game if it does not offer more excitement (fun).

- **MGP5 - Game pace, challenge & strategy are in balance**
  (Derived from (Korhonen, 2006))

The game should be designed equally so that players do not become frustrated or bored. Game pace, challenge and strategy should be balanced considering the ability of moderate player skills. Single player games should allow for 'level of difficulty' choices.

- **MGP6 - Game story is part of gameplay**
  (Derived from (Desurvire et al., 2004))

Game story is an important component of many games and has an important role. Yet some games do not have a theme or story as gameplay alone creates a win or lose venue. For example, games like *Chess & Checker*, in which players make their own decision and the story follows the player's choice. Even in complex Multiplayer games, players create their own stories base on a background theme.

- **MGP7 - Game supports different playing styles**
  (Derived from problems reported in "Experimental Study I")

Players gaming styles vary in terms of expertise and style preferences. Games should support different gaming styles for players in multifaceted games such as elaborately designed multiplayer online venues with role play. This heuristic is limited to certain types of games and is not applicable to every genre.

- **MGP8 - Game engages player in personal involvement (i.e. happiness, reward, scare, threat, thrill and punishment)**
  (Derived from (Desurvire et al., 2004))

Games should engender a player's personal involvement. Players should feel involved personally and experience joy on achieving objectives with reward, or fear the threat of losing an objective and thus suffer penalty. These features improve the player's engagement with the game's venue.

- **MGP9 - Player reflects in game character**
  (Derived from (Korhonen, 2006))

Games should provide facility for player's to project their own image onto game characters (identify with): for instance, acting in a certain way within the game's venue, or customizing game characters, or modifying the game according to their own personality traits. This enables the player to increasingly become immersed in the game's activities as it reflects aspects of the player's personal identity. *Sims 3* is a good example with this feature.

- **MGP10 - Player does not lose any hard-won possessions**
  (Derived from (Desurvire et al., 2004))

Players become frustrated if they lose something important for which they have worked hard to achieve. Perhaps a player has developed a game character for several weeks but after a single mistake they lose the character completely as a penalty. Games should be flexible enough to avoid such penalties and make allowances for the hard work of players.

4.5.4 Mobile Mobility Heuristics

Since mobile devices are flexible and allow gaming in different environments, game design should integrate this autonomy with game experience. Mobile mobility heuristics, as shown in Table 4.11, cover issues concerning game mobility.

Table 4.11: Heuristics for evaluating Mobile Mobility

Category	Keyword	Heuristic
Mobile Mobility Heuristics	MM1	Interruptions (internal & external) are handled responsively
	MM2	Game sessions started quickly
	MM3	Game sessions are pause and resume able
	MM4	Game suits the surrounding of player

- **MM1- Interruptions (internal & external) are handled responsively**
  (Derived from "*Initial Proposed Heuristics*" and (Korhonen, 2006))

Mobile devices are generally multipurpose devices capable of multitasking. When playing game on a multipurpose, multitasking device, interruptions are expected. Interruptions are internal or external interferences with the game's progress. Internet interruptions occur with incoming calls, messages, email alerts, alarms and other notifications, some of which can be ignored such as messages and emails. Since incoming calls are generally attended immediately, games should be able to pause the current session and then restore the session from the point of interruption. If games are not capable of this, players lose their objective(s) and become frustrated.

External interruptions occur while, for instance, playing when waiting for a train and the train arrives. Players then want to save or pause and restore for continued play later.

- **MM2- Game sessions started quickly**
  (Derived from Problems reported in "Experimental Study I" and (Korhonen, 2006))

Mobile phones have limited battery resources and it is common for games to have introductory movies and/or company advertisements at start-up. In mobile games,

players prefer not to drain the battery for these contents. Hence, players should be able to start game sessions easily and quickly.

Navigation should also be minimal to quickly initiate sessions instead of roaming around the game menu. Games usually contain multiple settings for the interface to allow customization of control keys settings. Games should also store any changes made by the player which will help initiate game sessions quickly for the next play. Otherwise, at every game start-up, players need to reset again and again, which is time-consuming.

- **MM3 - Game sessions are pause and resume able**
  (Derived from Problems reported in "Experimental Study I")

Game sessions on mobile devices normally are not as lengthy as computer and console games and people generally play mobile games for short intervals. Players should be able to save game sessions as an option, and resume from the last saved state. This will allow players to continue their game from wherever and whenever they paused.

- **MM4- Game suits to surrounding of player**
  (Derived from Problems reported in "Experimental Study I" and (Korhonen, 2006))

Mobile devices are portable and can be used "anytime-anywhere". Playing mobile games in a different environment may disturb other people in the immediate surroundings. The most typical disturbance derives from music and other sounds. Game settings should conveniently adjust volume levels whenever the player wishes. Although volume can be decreased or increased via device settings, this is not preferable. Games should have their own volume controls.

4.5.5 Mobile Multiplayer Gaming Heuristics

Multiplayer gaming is commonly considered more interesting compared to single player games because of 'player to player' interactions. The latest mobile devices are capable of facilitating multiplayer gaming. The Mobile Multiplayer Heuristics list in Table 4.12, evaluates multiplayer issues for mobile devices.

Table 4.12: Mobile Multiplayer Heuristics

Category	Keyword	Heuristic
Mobile Multiplayer Heuristics	MMP1	Game session are easily created
	MMP2	Game sessions can be saved and restored in case of connectivity loss
	MMP3	Game supports multiple ways of communication
	MMP4	Game supports multiple medium of connectivity
	MMP5	Other online players are visible & able to connect
	MMP6	Game supports social groups & communities

- **MMP1 - Game session are easily created**
  (Derived from "*Initial Proposed Heuristics*" and Problems reported in "*Experimental Study I*"

Mobile multiplayer games are recent developments and not as stable as computer games. Playing a multiplayer game on a mobile game is noticeably more difficult; for instance, Massive Multiplayer Online Role Playing Games (MMORPG). The reasons are limited battery resources, network accessibility and inconvenient game control keys. Creating and starting a multiplayer session on mobile games is also not easy and takes time. Generally speaking, players do not want to wait two to five minutes to initiate a session and the success rate is currently low. Mobile games should have a minimalist approach with quickly accessible options that create sessions promptly.

- **MMP2 - Game sessions can be saved and restored in case of connectivity loss**
  (Derived from "*Initial Proposed Heuristics*" and Problems reported in "*Experimental Study I*")

As discussed in Heuristics MMG1, multiplayer mobile sessions are not readily initiated. Players become frustrated when sessions abruptly terminate after spending time to establish the connections. Multiplayer game sessions are often terminated due to disturbances in network connectivity. The most apparent issue is delay in response time between player and server. Games should be able to restore sessions if loss of connectivity occurs during a multiplayer session. Some limitations are applicable on restoration time.

- **MMP3 - Game supports multiple ways of communication**
  (Derived from "*Initial Proposed Heuristics*" and Problems reported in "*Experimental Study I*")

With multiplayer games, players communicate with other players, most often of via text and voice chat. Computer games support both avenues making it easy to communicate. But mobile phones are smaller and it is difficult to type when playing or to communicate with other players. Texting is just not convenient or feasible. However, voice communication is a most impressive medium for multiplayer mobile games. Games should have multiple modalities for communication, most preferably, vocal. Such a feature in multiplayer mobile games will increase their charm of mobile gaming for gamers.

- **MMP4 - Game supports multiple medium of connectivity**
  (Derived from "*Initial Proposed Heuristics*" and Problems reported in "*Experimental Study I*")

Creating multiplayer game sessions needs a connectivity medium. In mobile devices this can be Bluetooth, Wi-Fi, or a mobile network (GPRS/EDGE/3G/4G). Mobile network data plans are very expensive and have limited volume quotas. Players may not prefer to play online multiplayer games using a mobile data package. Bluetooth can be used to create a local game group within a room, and Wi-Fi can also be used within large premises such as home, college, university or office. Games should have a feature to create multiplayer gaming sessions with different network options.

- **MMP5 - Other online players are visible & able to connect**
  (Derived from (Korhonen & Koivisto, 2007))

Multiplayer games usually involve other players and players should sense their partner player's presence online. In online multiplayer games, players should also be enabled to search for other online players. Search features allow players to specify characteristic properties or titles that locate compatible players. This is an approach that readily enables joint sessions in a timely manner.

- **MMP6 - Game supports groups & communities**
  (Derived from (Korhonen & Koivisto, 2007))

Players belonging to a 'player community' are more likely to play games. A Multiplayer game should support player groups and communities. This enables players to establish and/or find communities, organize them (ranks, stats and roles), and provide private channels for each community.

The proposed playability heuristics for touchscreen mobile game are applicable to different game genres and modalities. Each heuristics category can be evaluated separately and individually. Game Usability and Touchscreen Usability heuristics are presented separately to facilitate the evaluation of non-touchscreen mobile phones.

4.6 Results of Experimental Study-II: Evaluation on games using the Proposed Playability Heuristics for Mobile Games

In order to validate the proposed playability heuristics for mobile devices, an evaluation of mobile games was conducted. All games evaluated were assessed previously with existing playability heuristics as discussed in section 4.4. Fourteen participants took part in this trial, all participants had evaluated these games in the cited study with existing playability heuristics for mobile games, as proposed by Korhonen & Koivisto (2007) and Korhonen (2006).

4.6.1 Data Analysis

The proposed playability heuristics have a module that evaluates touchscreen usability, which was lacking in the prior listing. Results from this evaluation revealed a total number of 169 playability problems identified in total for all six games, as shown in Table 4.13. Usability heuristics comprised 33.13% (N = 56) of violations; 13.01% were touchscreen usability heuristics violations (N = 22); 31.95% violated gameplay heuristics (N = 54); 10.06% of identified problems violated mobility heuristics (N = 17); and 11.83% of identified problems violated mobile multiplayer heuristics (N = 20).

The maximum numbers of problems identified concerned mobile usability gameplay issues identified by the newly proposed, respective modules. Nevertheless, each and every heuristic module was violated by the games under review. Problems identified by each module are discussed in the following sub-sections.

Table 4.13: Problems identified in evaluation using proposed Playability Heuristics

Heuristics Category	Problems Identified	Weightage %
Usability	56	33.13%
Touchscreen Usability	22	13.01%
Gameplay	54	31.95%
Mobility	17	10.06%
Multiplayer	20	11.83%
Total	**169**	**100%**

4.6.1.1 Problems Violating the Game Usability Heuristics

Figure 4.5 shows problems that violated each heuristic. Participants reported that it was easy to assign heuristics for each identified problem compared to the previous evaluation. They reported that the previous evaluation did not contain appropriate heuristics for the newly identified problems; remarking that the prior lists created confusion when they attempted to assign problems to a particular heuristics.

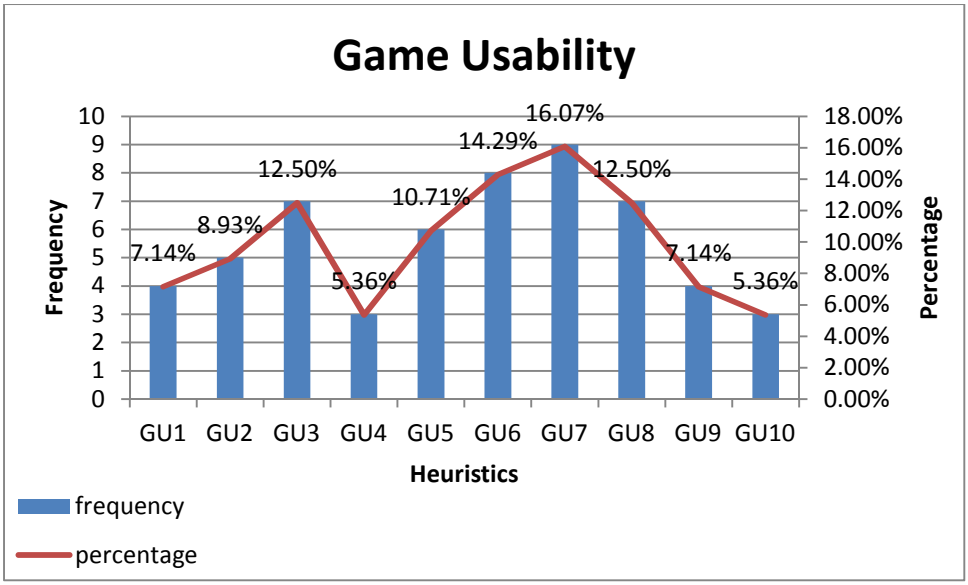


Figure 4.5: Playability problems violating Mobile Game Usability Heuristics

Problems reported that violated Game Usability Heuristics GU8 ("Game allows customization") numbered seven (12.50%). Participants observed that the game lacked customization settings such as game pace and balance, as well as sound and video settings. Participants also reported that game navigation was not convenient although they managed game menus easily. Eight problems (14.29%) violated heuristic GU6 ("Navigation is consistent, logical and minimalist"). Participants also reported that in multiplayer game sessions it was difficult to navigate even the menus (time consuming), especially because players were required to go through each and every menu when starting a new session. Heuristic GU3 ("Audio and Visual demonstrations support the games") was violated seven times (12.50%) by each game. Participants reported that game visuals were not clearly visible in daylight and that colour combinations were also not effective. As a result, important information such as game indicators was not made visible under different lighting conditions. Heuristic GU7 ("Game allows customization") was violated nine times (16.07%). The games studied did not permit customization, meaning that participants were unable to change game settings, pace and level of difficulty.

4.6.1.2 Problems Violating Touchscreen Game Usability Heuristics

Existing playability heuristics lacked the ability to assess problems with mobility game touchscreens. Participants, using the new set of touchscreen usability heuristics reported that the new heuristics were very similar to game usability heuristics and found them easy to comprehend. Figure 4.6 shows the problems violated by each heuristic.

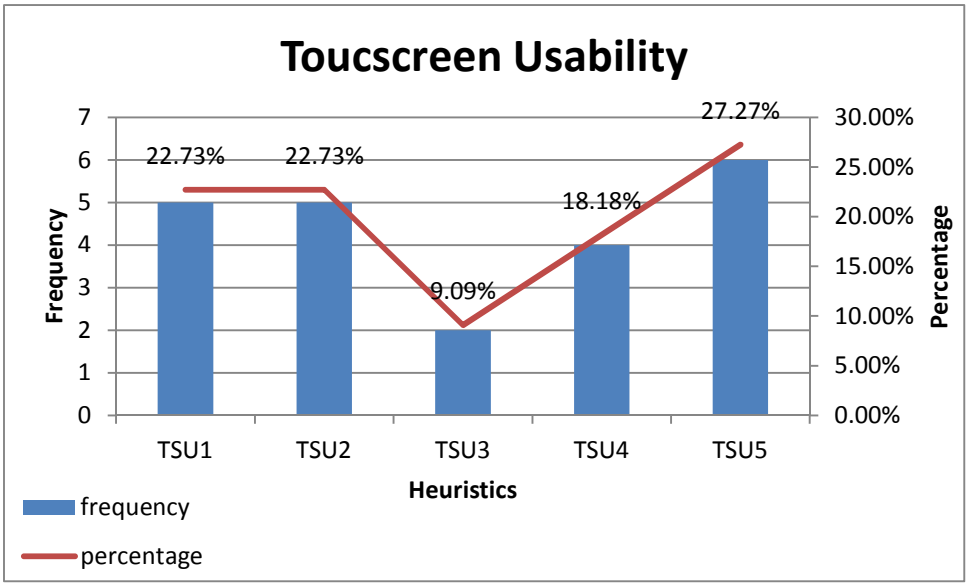


Figure 4.6: Playability problems violating Touchscreen Game Usability Heuristics

Participants reported that the game's interface overlapped with important data from the device such as signal strength and battery life. This violated heuristic TSU1 (Game UI does not overlap device resources status bar) five times (22.73%). Heuristic TSU2 ("Game supports ergonomics") was also violated by five reported problems (22.73%). Participants reported difficulty handling the device while playing multiplayer games. Game control keys were not positioned in a suitable area for easy manipulation. Participants also reported that the game's interface was imprecise and poorly responsive, violating heuristic TSU5 ("Game uses screen precisely and responsively") six times (27.27%). Participants also reported that some game controls keys were much too small, ineffective and poorly responsive, making it too difficult to manage pace and game balance.

4.6.1.3 Problems Violating Mobile Gameplay Heuristics

Gameplay is essential for every game and very critical to evaluate but participants noted it was more difficult to evaluate compared to other aspects of game. Gameplay also varied from game to game because of the dynamic features of some games. A player can only evaluate gameplay during interaction with game mechanics. Participants evaluated gameplay with the proposed gameplay heuristics and reported a total of fifty-four playability problems shown in Figure 4.7. Every gameplay heuristic was violated by a minimum of four problems.

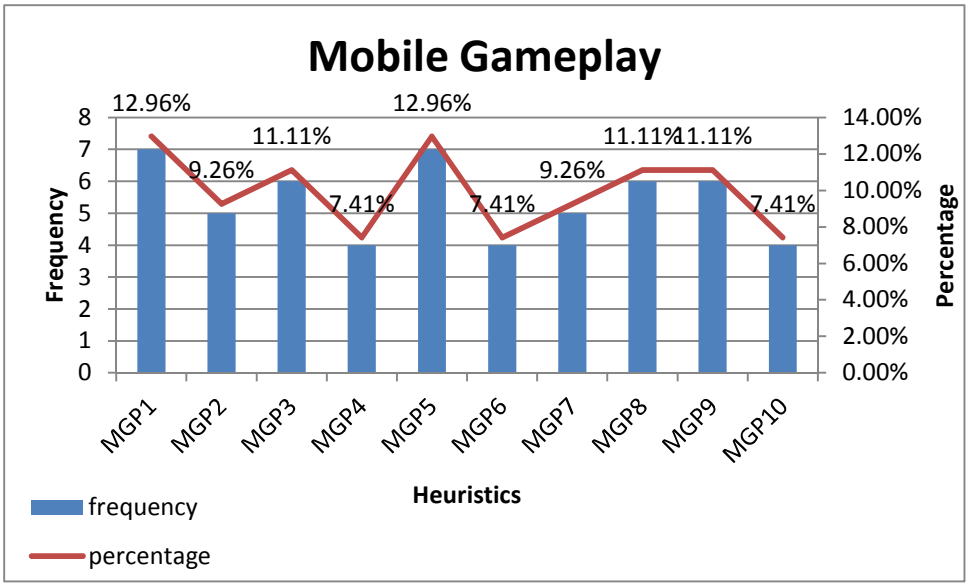


Figure 4.7: Playability problems violating Mobile Gameplay Heuristics

Heuristics MGP1 and MGP5 were violated the most. Participants reported that game objectives were not well defined on initial play. They also reported that in Multiplayer games they had no idea what to do on certain occasions and found themselves roaming around in the game's virtual world because objectives were not clearly presented. These problems violated heuristic MGP1 ("Game provides clear objectives") seven times (12.96%). Participants also reported problems that violated Heuristic MGP5 "Game pace, challenge & strategy are in balance" (N = 7, 12.96%). As reported previously, game pace, challenge & strategy were equally sorted. Game pace was too fast to handle making it very difficult to complete the challenge. Pace, challenge and game strategy should be more suitably designed for mobile devices. Participants noted that most single player games did not support different styles of play,

thus, violating heuristic MGP7 ("Game supports different playing styles"). Another major problem violated heuristic MGP10 (Player does not lose any hard-won progress). Participants reported that this was very discouraging after struggling to reach important goals.

4.6.1.4 Problems Violating Mobility Heuristics

When evaluating mobile games, it is important to consider mobility features. Participants evaluated games against the proposed Mobility Heuristics and identified seventeen problems shown in Figure 4.8.

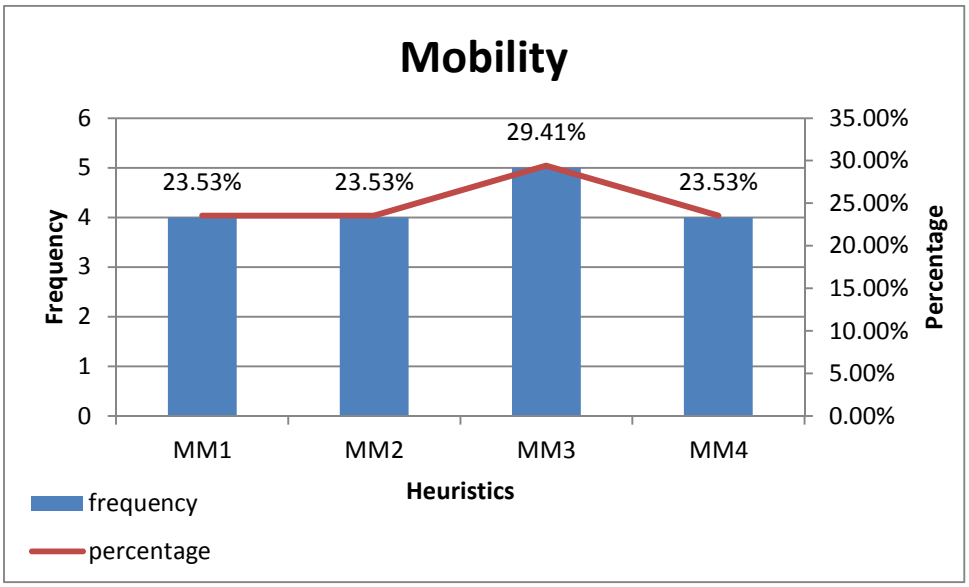


Figure 4.8: Playability problems violating Mobility Heuristics

They reported that the games could not handle notifications and calls responsively. Games should automatically pause when any interruptions occur during play. These problems violated Mobility Heuristic MM1 ("*Interruptions—internal & external—are handled responsively*") on four reports (23.53%). Participants also noted that initiating a game session was slow and that players were required to sort multiple menus before starting. This caused wastage as players prefer not to spend time and resources struggling through game menus. These problems violated heuristic MM2 ("*Game session started quickly*") four times (23.53%).

Mobile games are intended for play in different environments due to mobility feature of mobile devices. Players play for short time periods rather than the usual long sessions attending other gaming platforms. Games should permit players to save game sessions and restore them from the saved position at will. Participants reported this problem for five violations (29.41%) of heuristic MM3 ("Game sessions are pause and resume able"). Lastly, four problems (23.53%) violating heuristic MM4 ("Game suits the surroundings of the player") were also reported. Games did not permit customizable settings to facilitate users while playing in public environments.

4.6.1.5 Problems Violating Multiplayer Gaming Heuristics

Multiplayer gaming for mobile devices is still young compared to other gaming platforms. The reasons are various limitations in communication technology. Mobile data plans are expensive and limited. Players may prefer not to spend money on multiplayer mobile games and play at home on other platform instead. To identify playability problems users face during multiplayer mobile games, two multiplayer games have been evaluated as detailed in Chapter Three. Participants reported twenty multiplayer problems shown in Figure 4.9, which violated the proposed multiplayer heuristics.

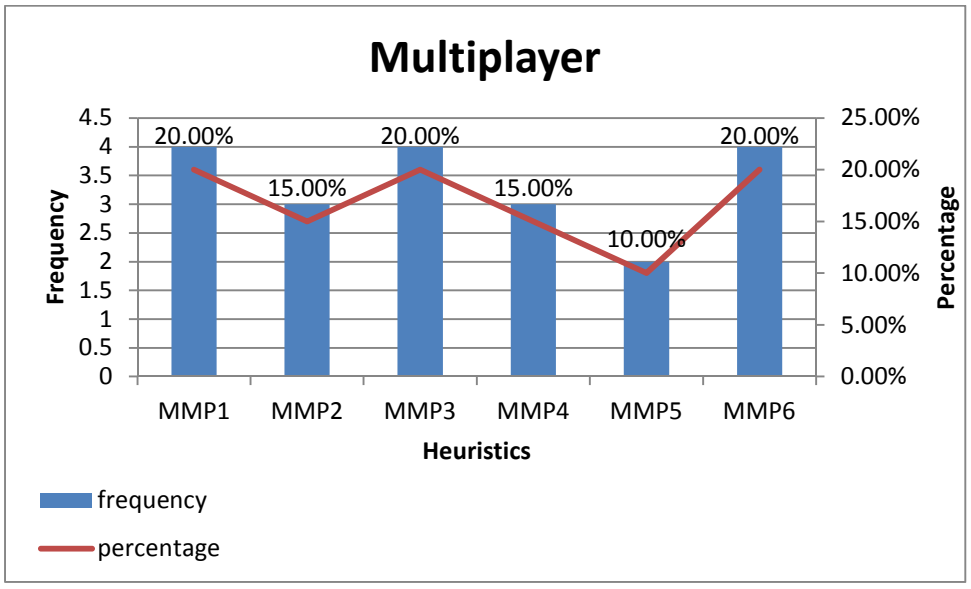


Figure 4.9: Playability problems violating Multiplayer Heuristics

Participants reported much difficulty when starting multiplayer game sessions on mobile devices. First they needed to navigate many game menus and even then the possibility of success was low: only three successes out of eight attempts. This problem violated heuristic MMP1 ("Game sessions are easily created"). While playing multiplayer games, the game was unable to handle network delays causing connection loss and terminated sessions. This was very frustrating for players who did not wish re-start a new session. These problems violated heuristics MM2 ("Game sessions can be saved and restored in case of connectivity loss").

Games should also be able to initiate multiplayer sessions with a number of connectivity options (Network, Wi-Fi and Bluetooth). Participants reported that the games did not have this feature, which violated heuristic MM3. Hence, each Multiplayer heuristic was violated by the games that inspected.

4.6.2 Comparative Results of Evaluation using Existing and Proposed Heuristic

Six android games were evaluated twice employing existing playability and proposed playability heuristics. Comparative results from both evaluations are shown in Table 4.14. Existing sets of playability heuristics contained fourteen *gameplay* heuristics and the proposed set of heuristics contained ten gameplay heuristics. Forty-seven problems were identified with the existing set of playability heuristics vs. fifty-four problems with the proposed playability heuristics.

Table 4.14: Identified Problems violating the Gameplay Heuristics (heuristics wise)

Existing Gameplay Heuristics			**Proposed Gameplay Heuristics**		
Heuristics ID	Problems Identified	Severity Mean	Heuristic ID	Problems Identified	Average Severity
GP1	6	2.00	MGP1	7	2.48
GP2	2	3.00	MGP2	5	2.60
GP3	1	3.00	MGP3	6	3.00
GP4	2	2.00	MGP4	4	3.00
GP5	6	3.00	MGP5	7	3.29
GP6	7	2.57	MGP6	4	2.50
GP7	6	3.16	MGP7	5	2.60
GP8	4	2.00	MGP8	6	2.33

GP9	0	0.00	MGP9	6	2.67
GP10	3	1.00	MGP10	4	3.00
GP11	1	3.00			
GP12	3	2.00			
GP13	1	5.00			
GP14	1	1.00			
New Problems	4	3.50			
Total	**47**		**Total**	**54**	
Problem Mean per Heuristic	**3.133333**		**Problem Mean per Heuristic**	**5.4**	
Mean		**2.42**	**Mean**		**2.75**
Standard Deviation		**1.1642**	**Standard Deviation**		**0.2902**
Variance		**1.3555**	**Variance**		**0.0842**

Participants identified more gameplay problems with this study's proposed heuristics than with the heuristics proposed by (Korhonen, 2006). The severity of each identified gameplay problem was calculated on a scale of 1–3–5, with '5' as most severe. Problems identified with the proposed heuristics were more severe (M = 2.75, SD = 0.2902); while problems identified with (Korhonen, 2006) were less so (M = 2.42, SD = 1.1642). Moreover, the number of gameplay problems identified with proposed heuristics was M = 5.4 per heuristic; while the problems identified by (Korhonen, 2006) were M = 3.1333 per heuristic.

Results were compiled and computed 'group wise' as shown in Table 4.15. The mean index of problems identified for all games via existing *gameplay* heuristics was M = 7.833 (SD = 1.9507). For the proposed gameplay heuristics they were M = 9 (SD = 1.2909). In addition, seven new gameplay problems were identified with the proposed gameplay heuristics, each one related directly to a well-defined heuristic. Hence, the comparison clearly demonstrates that the proposed gameplay heuristics as more appropriate and have identified more gameplay problems.

Table 4.15: Identified Problems violating the Gameplay Heuristics (group wise)

	Existing Gameplay Heuristics	**Proposed Gameplay Heuristics**
Games	**Problems Identified**	**Problems Identified**
Cafeteria Nipponica	9	9
Temple Run	7	8
Train Crisis	10	10
Block Breaker 3	4	7

Asphalt 6	8	9
Modern Combat 3	9	11
Total	**47**	**54**
Mean	**7.8333**	**9**
Standard Deviation	**1.9507**	**1.2909**
Variance	**3.8055**	**1.6666**

Table 4.16 shows the number of problems identified violating *usability* heuristics for six mobile games. A total of thirty-nine *usability* problems were identified with the existing set of heuristics, and fifty-six problems were identified with the proposed usability heuristics.

Table 4.16: Identified Problems violating the Usability Heuristics (heuristics wise)

Existing Usability Heuristics			**Proposed Usability Heuristics**		
Heuristics ID	**Problems Identified**	**Severity Mean**	**Heuristic ID**	**Problems Identified**	**Severity Mean**
GU1	3	3.00	MGU1	4	2.50
GU2	4	2.50	MGU2	5	3.40
GU3	2	2.00	MGU3	7	2.71
GU4	4	2.50	MGU4	3	3.00
GU5	2	3.00	MGU5	6	2.33
GU6	3	3.00	MGU6	8	3.00
GU7	2	3.00	MGU7	9	2.33
GU8	1	3.00	MGU8	7	2.43
GU9	3	2.33	MGU9	4	2.50
GU10	1	3.00	MGU10	3	3.00
GU11	2	2.00			
GU12	3	3.00			
New Problems	9	3.00			
Total	**39**		**Total**	**56**	
Problem Mean per Heuristic	**3**		**Problem Mean per Heuristic**	**5.6**	
Mean		**2.72**	**Mean**		**2.74**
Standard Deviation		**0.3835**	**Standard Deviation**		**0.3439**
Variance		**0.1471**	**Variance**		**0.1182**

Similarly, participants identified more usability problems with the proposed *usability* heuristics than with those proposed by (Korhonen, 2006). The severity of each identified problem was calculated on a scale of (1–3–5). Severity of identified problems via proposed usability heuristics was M = 2.74 (SD = 0.3439); and problems identified (Korhonen, 2006) was M = 2.72 (SD = 0.3835). In addition, nine new

usability problems were identified with the proposed usability heuristics, which were acknowledged by participants as 'well defined'.

The mean for identified usability problems via proposed heuristics was (M = 5.6) per heuristic; while the mean of problems identified with (Korhonen, 2006) heuristics was (M = 3.00). Hence, the comparison suggests that the proposed usability heuristics for mobile games are more suitable for identifying usability problems.

Results were also compiled and computed for 'group wise' problems that violated usability heuristics shown in Table 4.17. These identified usability problems were compiled for each game, respectively. The Mean index for all games via existing usability heuristics was M = 6.5 (SD = 1.3844), and the mean for proposed usability heuristics was M = 9.3333 (SD = 1.3743). The comparison again demonstrates that the proposed usability heuristics were more appropriate than those proposed by (Korhonen, 2006).

Table 4.17: Identified Problems violating the Usability Heuristics (group wise)

	Existing Usability Heuristics	**Proposed Usability Heuristics**
Games	**Problems Identified**	**Problems Identified**
Cafeteria Nipponica	7	10
Temple Run	7	8
Train Crisis	5	8
Block Breaker 3	9	11
Asphalt 6	5	8
Modern Combat 3	6	11
Total	**39**	**56**
Mean	**6.5**	**9.3333**
Standard Deviation	**1.3844**	**1.3743**
Variance	**1.9166**	**1.8888**

Comparison for *mobility* heuristics was also done. Table 4.17=8 shows results for both sets of mobility heuristics. Participants identified a total of seventeen mobility problems for six mobile games using both heuristic sets.

Table 4.18: Identified Problems violating the Mobility Heuristics (heuristics wise)

Existing Mobility Heuristics			**Proposed Mobility Heuristics**		
Heuristics ID	Problems Identified	Average Severity	Heuristic ID	Problems Identified	Average Severity
MO1	5	3.00	MM1	4	3.00
MO2	4	2.50	MM2	4	2.50
MO3	5	2.60	MM3	5	2.60
New Problems	3	3.67	MM4	4	3.50
Total	**17**		**Total**	**17**	
Problem Mean per Heuristic	**4.25**		**Problem Mean per Heuristic**	**4.25**	
Mean		**2.94**	**Mean**		**2.90**
Standard Deviation		**0.4598**	**Standard Deviation**		**0.3937**
Variance		**0.2114**	**Variance**		**0.155**

Severity for each identified mobility problem was calculated on a scale of (1–3–5). The severity mean for problems identified with (Korhonen, 2006)mobility heuristics was M = 2.94 (SD = 0.4598); while that for the proposed mobility heuristics was M = 2.90 (SD = 0.3937) which was slightly lower. The mean index of identified mobility problems for both mobility heuristics sets equalled M = 4.25 per heuristic.

Results were also complied and computed 'group wise' for problems violating mobility heuristics as shown in Table 4.19, for each game, respectively. The mean index for all games via existing mobility heuristics was M = 2.8333 (SD = 1.0671); and for proposed mobility heuristics was M = 2.8333 (SD = 0.6871). However, three new problems were identified with the proposed heuristics set. The comparison thus demonstrated that the proposed mobility heuristics as more appropriate than those proposed by (Korhonen, 2006).

Table 4.19: Identified Problems violating the Mobility Heuristics (group wise)

	Existing Mobility Heuristics	**Proposed Mobility Heuristics**
Games	**Problems Identified**	**Problems Identified**
Cafeteria Nipponica	4	3
Temple Run	2	2
Train Crisis	4	3
Block Breaker 3	1	2
Asphalt 6	3	3
Modern Combat 3	4	4

Total	**17**	**17**
Mean	**2.8333**	**2.8333**
Standard Deviation	**1.0671**	**0.6871**
Variance	**1.1388**	**0.4722**

Table 4.20 shows problems identified that violated *multiplayer* heuristics. A total of eighteen problems were identified with the heuristics proposed by (Korhonen & Koivisto, 2007); while a total of twenty problems were identified via proposed multiplayer heuristics. The proposed multiplayer heuristics uncovered two more problems as well as seven entirely new problems compared to (Korhonen & Koivisto, 2007) heuristics which did not have the properly defined heuristics.

Table 4.20: Identified Problems violating the Multiplayer Heuristics (heuristics wise)

Existing Multiplayer Heuristics			**Proposed Multiplayer Heuristics**		
Heuristics ID	**Problems Identified**	**Average Severity**	**Heuristic ID**	**Problems Identified**	**Average Severity**
MP1	2	3.00	MMP1	4	3.00
MP2	2	2.00	MMP2	3	3.00
MP3	1	3.00	MMP3	4	3.00
MP5	2	3.00	MMP4	3	3.00
MP5	2	3.00	MMP5	2	3.00
MP6	2	3.00	MMP6	4	3.50
New Problems	7	3.57			
Total	**18**		Total	**20**	
Problem Mean per Heuristic	**2.57142857**		**Problem Mean per Heuristic**	**3.33333333**	
Mean		**2.94**	**Mean**		**3.08**
Standard Deviation		**0.4306**	**Standard Deviation**		**0.1863**
Variance		**0.1854**	**Variance**		**0.0347**

The severity of each identified multiplayer problem was calculated on a scale of (1–3 –5). The severity's mean for problems identified via (Korhonen & Koivisto, 2007)was M = 2.94 (SD = 0.4306); while that for problems identified with the proposed set of heuristics was M = 3.08 (SD = 0.1863)—slightly higher. The mean for problems identified with the proposed heuristics was M = 3.3333 per heuristic, and the mean for problems identified with via (Korhonen & Koivisto, 2007) is M = 2.5714.

Group wise (game) compiled results for multiplayer heuristics are shown in Table 4.21. Games E and F supported multiplayer features whereas Game A, B, C and D were

single player games where multiplayer heuristics were not applicable. Identified multiplayer problems were compiled for each game, respectively. The mean index for all games via existing multiplayer heuristics was M = 9 (SD = 2); and for the proposed multiplayer heuristics it was M = 10 (SD = 1). This comparison once again demonstrated that our proposed multiplayer heuristics were more appropriate and better defined than multiplayer heuristics as proposed by (Korhonen & Koivisto, 2007).

Table 4.21: Identified Problems violating the Multiplayer Heuristics (group wise)

	Existing Multiplayer Heuristics	**Proposed Multiplayer Heuristics**
Games	**Problems Identified**	**Problems Identified**
Asphalt 6	7	9
Modern Combat 3	11	11
Total	**18**	**20**
Mean	**9**	**10**
Standard Deviation	**2**	**1**
Variance	**4**	**1**

The newly proposed heuristics contained a novel set of touchscreen usability heuristics. Participants evaluated six mobile games and identified twenty-two problems that violated the new touchscreen usability heuristics. Table 4.22 shows the identified problems along with the severity for each violated heuristic. The severity mean for these identified touchscreen usability problems was M = 2.78 (SD = 0.4331). The mean for these problems was M = 4.4 per heuristic.

Table 4.22: Identified Problems violating the Touchscreen Usability Heuristics (heuristics wise)

Existing Touchscreen Heuristics			**Proposed Touchscreen Heuristics**		
Heuristics ID	**Problems Identified**	**Average Severity**	**Heuristic ID**	**Problems Identified**	**Average Severity**
			TSU1	5	3.25
			TSU2	5	3.00
			TSU3	2	3.00
			TSU4	4	2.00

			TSU5	6	2.67
Total			**Total**	**22**	
Problem Mean per Heuristic			**Problem Mean per Heuristic**	**4.4**	
Mean			**Mean**		**2.78**
Standard Deviation			**Standard Deviation**		**0.4331**
Variance			**Variance**		**0.1876**

Similarly, severity of each problem is calculated (on a scale of 1, 3, and 5). Severity mean of identified touchscreen usability problem is computer which is (M=2.78; SD=0.4331). The mean problems identified with proposed touchscreen usability heuristics is (M=4.4) per heuristics.

Results were also complied and computed group wise for problems violating touchscreen heuristics, shown in Table 4.23 for each game, respectively. The mean index for all games via the proposed mobility heuristics was M = 3.6666 (SD = 1.1055).

Table 4.23: Identified Problems violating the Touchscreen Usability Heuristics (group wise)

	Existing Touchscreen Heuristics	**Proposed Touchscreen Heuristics**
Games	**Problems Identified**	**Problems Identified**
Cafeteria Nipponica		4
Temple Run		3
Train Crisis		2
Block Breaker 3		5
Asphalt 6		3
Modern Combat 3		5
Total		**22**
Mean		**3.6666**
Standard Deviation		**1.1055**
Variance		**1.2222**

Table 4.24 shows all problems identified via the playability heuristics proposed by (Korhonen, 2006) as well as by (Korhonen & Koivisto, 2007). Table 4.25 shows the all problems identified with the newly proposed playability heuristics. The overall mean for each heuristic category was calculated for both sets, respectively. Problems identified with the proposed set of playability heuristics were more severe M = 2.85 (SD = 0.3294); whereas problems identified with playability heuristics as proposed by (Korhonen, 2006) and (Korhonen & Koivisto, 2007)was M = 2.75 (SD = 0.6095).

The total number of problems identified with the newly proposed playability heuristics was 169, whereas the total number for existing heuristics was 121. Hence, forty-eight new problems were identified with the proposed playability heuristics. Moreover, twenty-three new problems were identified during the evaluation with existing playability heuristics which did not have any proper heuristic; whereas, all problems identified with the proposed set of playability heuristics were properly defined by each cited heuristic.

Table 4.24: Overall playability problems identified with the existing Playability Heuristics

Evaluation Results with Existing Playability Heuristics				
Heuristics Category	**Problems Identified**	**Severity Mean**	**Standard Deviation**	**Variance**
Gameplay	47	2.42	1.1642	1.3555
Usability	39	2.72	0.3835	0.1471
Mobility	17	2.94	0.4598	0.2114
Multiplayer	18	2.94	0.4306	0.1854
Touchscreen Usability				
Total Problems	**121**			
Overall Severity Mean		**2.75**		
Overall Standard Deviation			**0.6095**	
Overall Variance				**0.4748**

Table 4.25: Overall playability problems identified with the proposed Playability Heuristics

Evaluation Results with Proposed Playability Heuristics				
Heuristics Category	**Problems Identified**	**Severity Mean**	**Standard Deviation**	**Variance**
Gameplay	54	2.75	0.2902	0.0842
Usability	56	2.72	0.3439	0.1182
Mobility	17	2.90	0.3937	0.1182
Multiplayer	20	3.08	0.1863	0.0347
Touchscreen Usability	22	2.78	0.4331	0.1876
Total Problems	**169**			
Overall Severity Mean		**2.85**		
Overall Standard Deviation			**0.3294**	
Overall Variance				**0.1086**

The comparative study, therefore, vigorously suggests that the new set of proposed playability heuristics were more appropriate to pre-existing playability heuristics. In addition, proposed playability heuristics were also applicable to touchscreen mobile games where existent playability heuristics did not venture.

4.7 Playability Heuristic Evaluation System

The 'Playability Heuristic Evaluation System' (PHES) was developed to enhance the process of heuristic evaluation by improving efficiency and effectiveness in less time compared to manual heuristic evaluation. The idea of automating the process of heuristic evaluation was adopted from the literature and from suggestions made by usability inspectors.

During Heuristic Evaluation with PHES, participants stored each identified problem and assigned it a severity value. This system proved itself flexible enough to allow participants to review reported problems and modify problems as needed; but they could only review and modify problems they reported personally. The purpose of integrating this security technique was to avoid bias. If this system permitted others to

review all reported problems, the chances of artificial duplication would increase. Such duplication could lead to identical problems to the exclusion of those yet to be identified, thereby minimizing rather than maximizing valid results.

The system's design was not limited to the evaluation of mobile games with only one set of heuristics. To the contrary, it was flexible enough to include different sets of heuristics depending on the requirements of the pending evaluation. Several researchers proposed heuristics for different types of games; hence, multiple or single sets of heuristics could be used with this system. Additionally, PHES was also made capable of storing evaluation heuristic records, as well as the games so analysed for future use. The several advantages of PHES are further discussed in Section 4.7.3.

4.7.1 User Interface of Playability Heuristic Evaluation System (PHES)

PHES is a web based software system made accessible by various web-browsers. PHES is secured with login and password authentication. Users need to login with their current username and password, as shown in Figure 4.10. Login authentication is required for everyone, whether admin or participant.

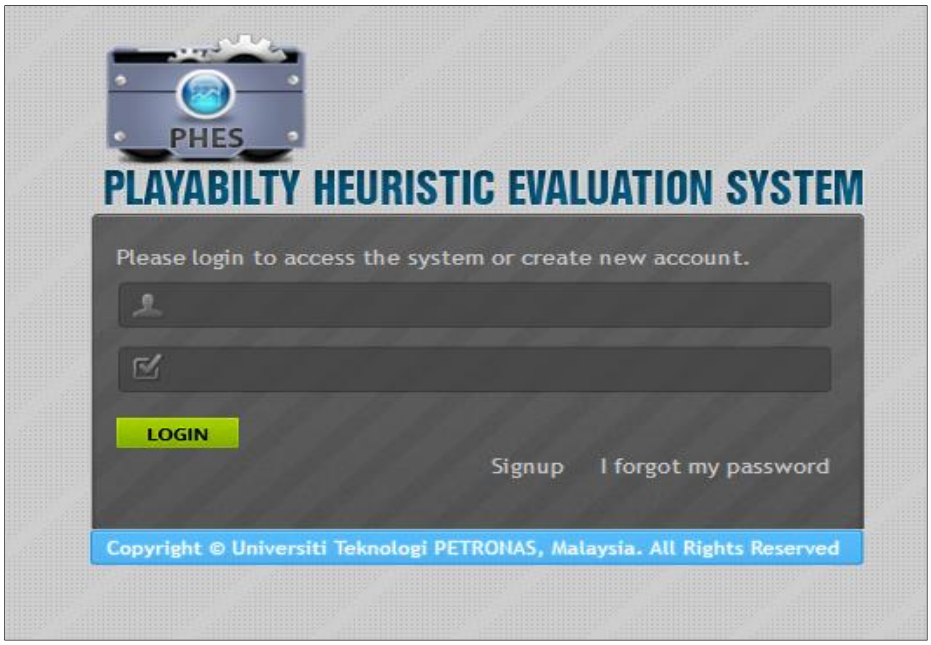


Figure 4.10: Login page of PHES

A new user can be registered by an existing registered user, within their account, or by creating a new account. Figure 4.11 shows the necessary data required. All required information in the signup form is mandatory and must be completed by each new user. This is to track the user's job title, organization, and contact numbers for demographic purposes when evaluating user participation.

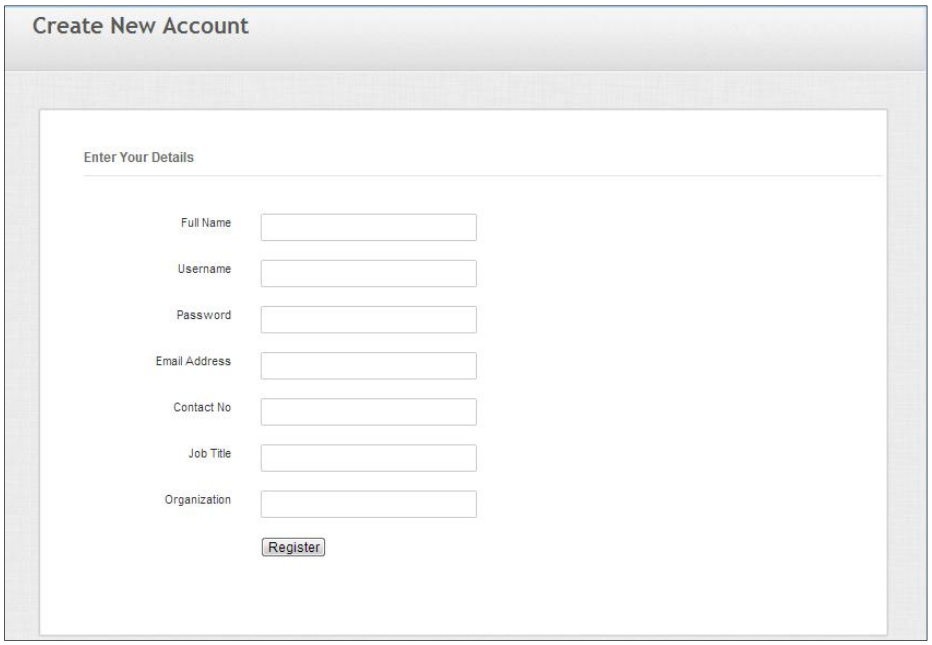


Figure 4.11: Signup page of PHES

Figure 4.12 shows the main page for the PHES website where a brief introduction is presented on the system. Navigation menus are placed in a bar located at the top of the page. The main navigations buttons are: Home, Heuristic Evaluation, Heuristic Database, Game Database and Results. Each component is described below.

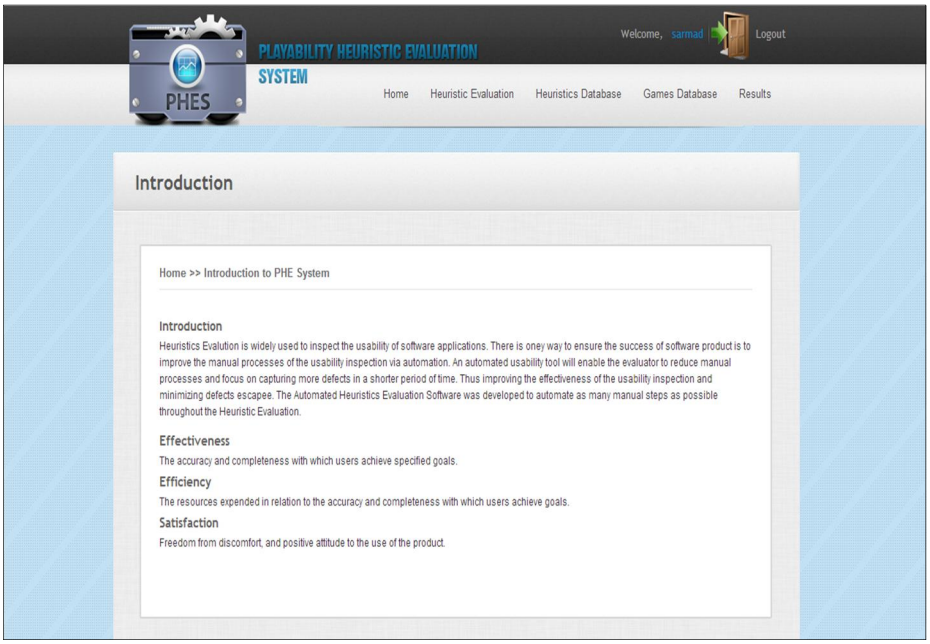


Figure 4.12: Main page of PHES

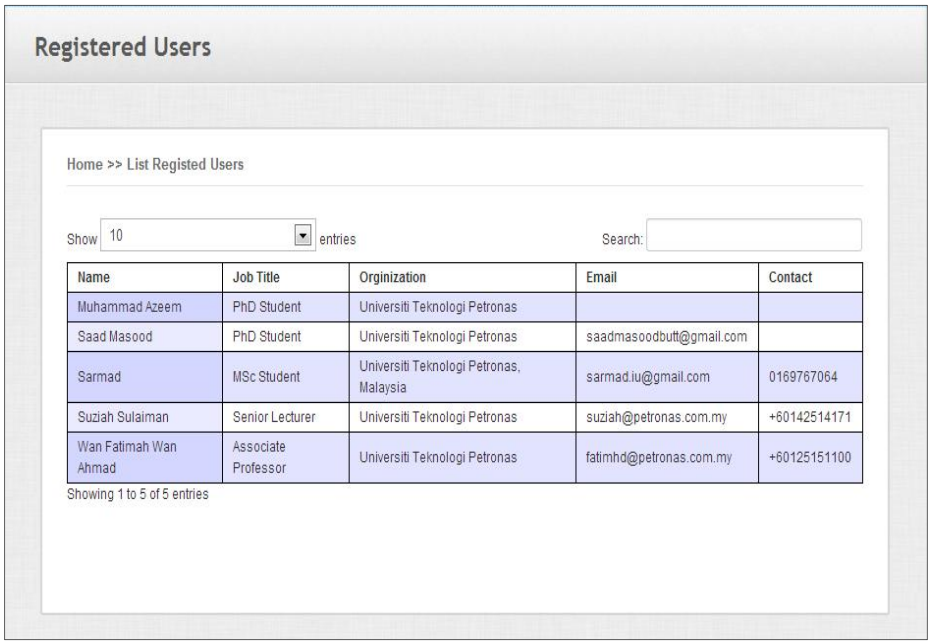


Figure 4.13: List of Registered users in PHES

Logged in users can update their data via the User Profile page as shown in Figure 4.14. Users can update details such as job title, contact number, email address and password, but the account's username cannot be changed.

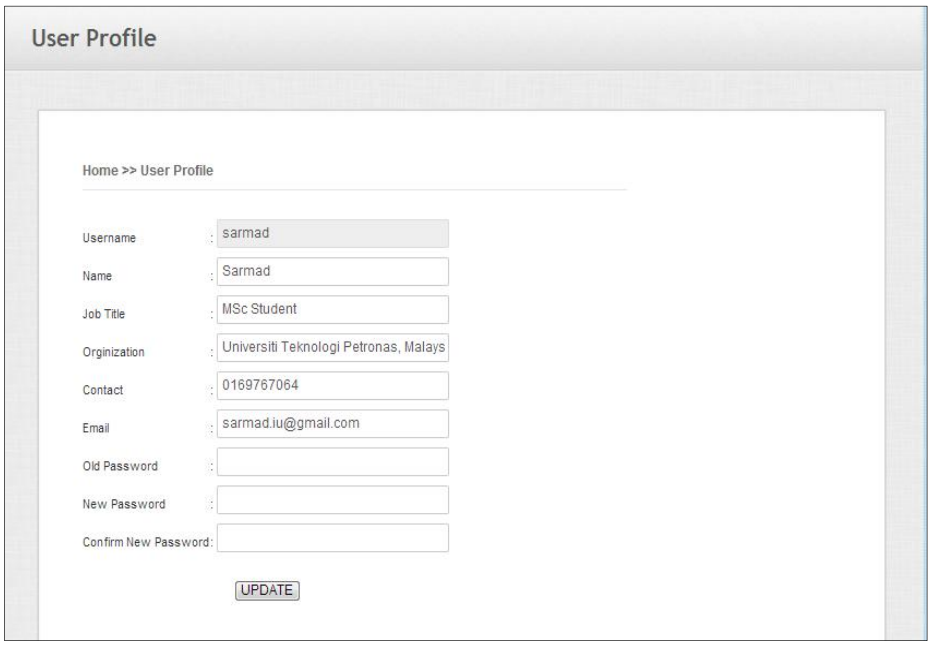


Figure 4.14: User profile page of PHES

Game database menu is reserved for the storage of information regarding the game used for evaluation. In the Game Database component there are four sub-sections; *add new game*, *modify game*, *delete game* and *list stored game*. On the *add game* page, a new game can be added to the database with required information such as game name, genre, game mode, game platform and game description, as shown in Figure 4.15.

Figure 4.15: Add new game page

The games stored in the database can be viewed by the user from the "List Games" menu. Figure 4.16 shows games stored in the database with their complete information.

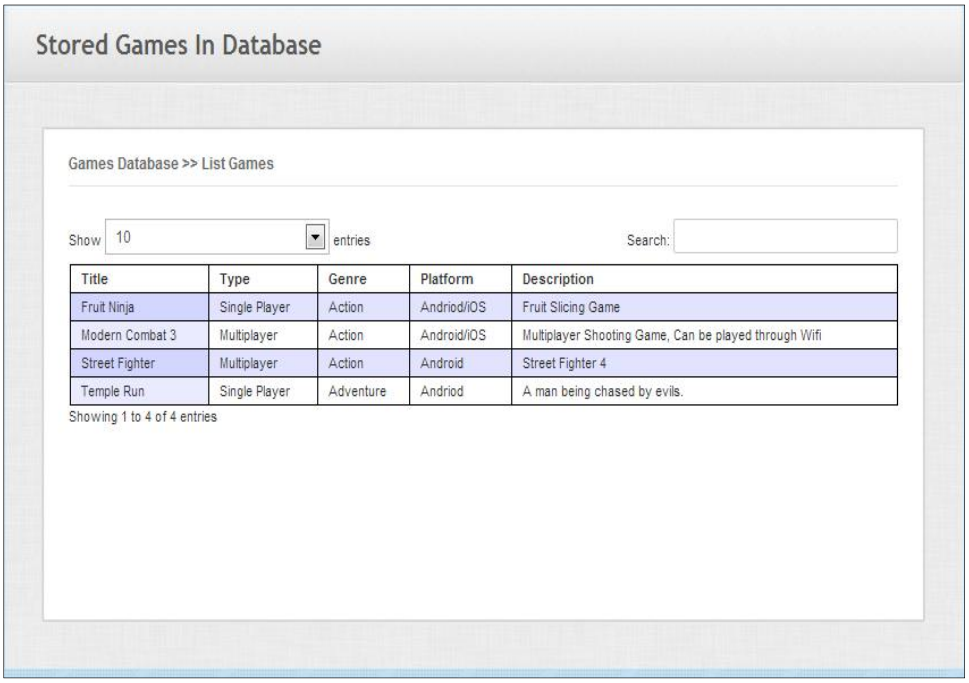


Figure 4.16: Games stored page in PHES

The Heuristic Database component was developed to store heuristics in the PHES database for use in evaluations. It contains four sub-sections: add new heuristics, modify heuristics, delete heuristics and list stored heuristics. Various types of heuristics can be stored in the system to evaluate computer, mobile and social games. The author proposed a unique identity for heuristics. For purposes of evaluation, participants select any heuristic set, as guided by usability practitioners, to evaluate games and then store identified problems in the system. All stored heuristics in the system can then be viewed by the "List Heuristic" menu as shown in Figure 4.17.

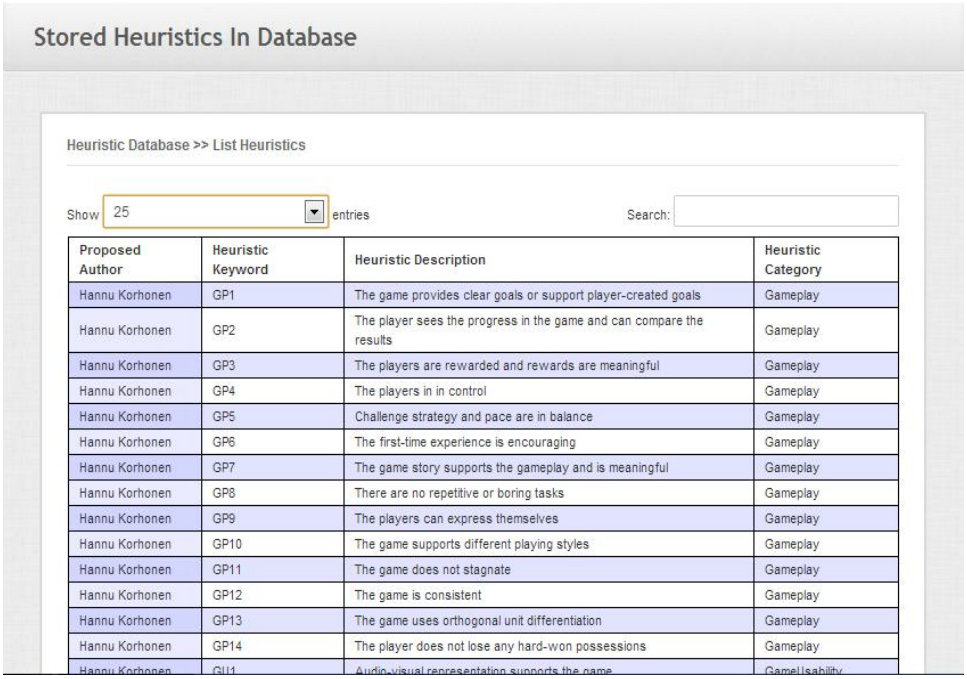


Figure 4.17: Heuristics stored page in PHES

Figure 4.18 demonstrate a display of problem report sheet, where user record the identified problem in PHES. User need to select few elements e.g. game, violated heuristic, problem severity from dropdown menu and problem description in textbox.

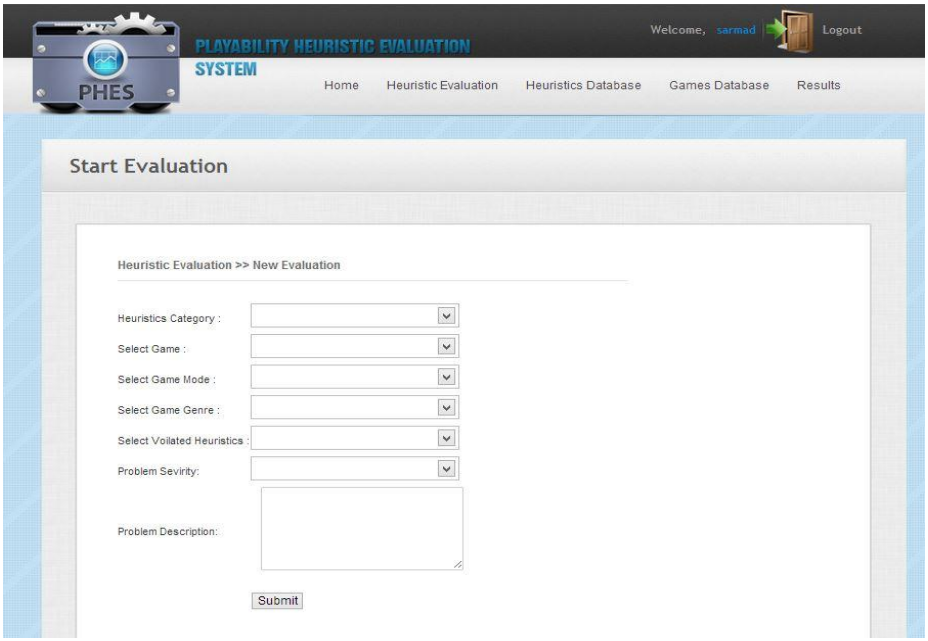


Figure 4.18: Problem Report Sheet

Two types of results can be viewed within PHES: demographic and heuristic evaluation results. Figure 4.19 demonstrates an example of demographic results with respect to a game. Demographic results are viewed by selecting any game from the current list of evaluated games. It shows frequency of participants with respect to gender and presents the age group of evaluators.

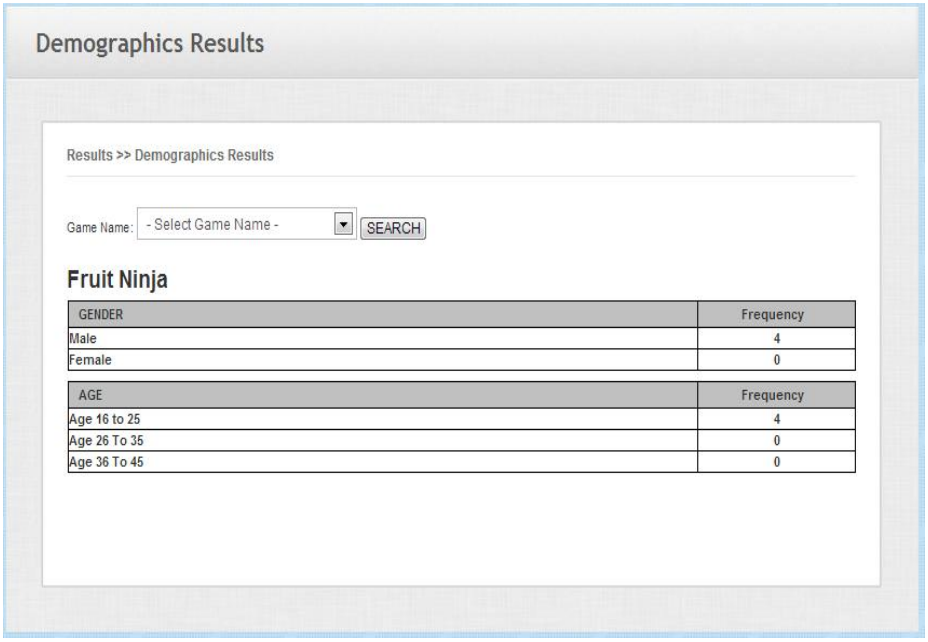
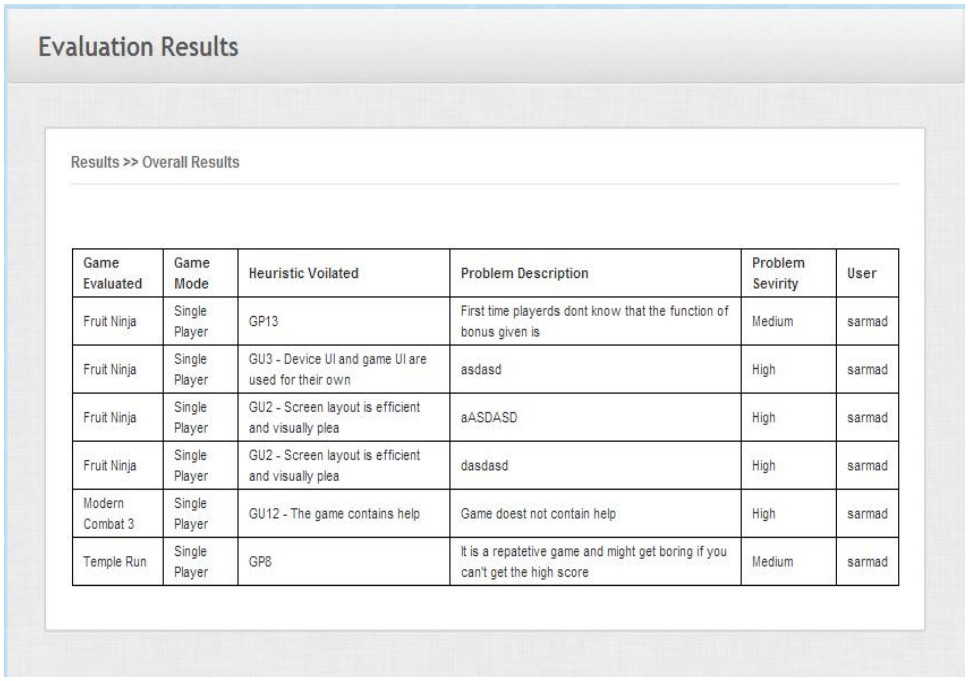


Figure 4.19: Demographics results page of PHES

Figure 4.20 demonstrates a display of evaluation results where, identified problems are viewed with respect to game, problem description, violated heuristic, severity of problem, and participants reporting the problem.



Game Evaluated	Game Mode	Heuristic Voilated	Problem Description	Problem Sevirity	User
Fruit Ninja	Single Player	GP13	First time playerds dont know that the function of bonus given is	Medium	sarmad
Fruit Ninja	Single Player	GU3 - Device UI and game UI are used for their own	asdasd	High	sarmad
Fruit Ninja	Single Player	GU2 - Screen layout is efficient and visually plea	aASDASD	High	sarmad
Fruit Ninja	Single Player	GU2 - Screen layout is efficient and visually plea	dasdasd	High	sarmad
Modern Combat 3	Single Player	GU12 - The game contains help	Game doest not contain help	High	sarmad
Temple Run	Single Player	GP8	It is a repatetive game and might get boring if you can't get the high score	Medium	sarmad

Figure 4.20: Evaluation results page of PHES

4.7.2 Usability Evaluation on Playability Heuristic Evaluation System (PHES)

A usability study was conducted on the playability heuristic evaluation system (PHES) in order to validate the system's functionality. At the beginning of the session, each participant was briefed on the purpose of developing this system and its importance in the context of this research. Each participant was asked to go through the system and uncover usability problems. They were advised to inspect the following factors, "*website navigation, accessibility, flexibility, ease of use, website design & layout, website functionality*". Participants reported and actually wrote a listing of each identified problem with respect to evaluation factors. At the end of the session, each participant was asked to suggest possible improvements in the system.

Evaluators generally liked the objectives and concept for developing PHES. They reported that navigation of the system was very simple and understandable and they did not face any difficulty. However, they suggested that navigation could be

improved with the placement of navigation tracking data. Moreover, they also admired the terminologies used, although some found that terms were too technical for novice users: i.e. "*Heuristic Evaluation*" and "*Playability"*.

Evaluators also reported that website aesthetics, layout and colours were well structured and even elegant, remarking that font size and tone were graceful and easily read without unpleasant visual effects. Additionally, the system was fully functional and ready to use for heuristics evaluation.

4.7.3 Benefits of Playability Heuristic Evaluation System (PHES)

Playability Heuristic Evaluations System has several benefits over manual heuristics evaluation as presented in Table 2.6.

Table 4.26: Benefits of PHES

Benefits	Description
Time saving	Participants reported an easy browsing experience and preferred storing heuristics online when reporting a problem compared to manual paperwork. Participants said that reporting and assigning severity to problems were far more comfortable as they preferred to type online rather than write on paper. In turn, this enabled PHES users to report more problems in a shorter space of time.
Flexibility	PHES is very flexible because it is not only designed for evaluating mobile games with one set of heuristics but has multiple set of heuristics stored for use at any time and even simultaneously. Moreover, the system can be used to evaluate other game formats and platforms such as computer and console games, etc.
Reporting	Usability practitioners do not need to compile and store results from their evaluations with any other software tool. PHES has its own database and data reporting form.

Remote Heuristic Evaluation	As the system is web based, it facilitates remote evaluation by users who may be located anywhere. This broadens the boundaries of heuristic evaluation far beyond a specific usability environment.

4.8 Results of Evaluation of Mobile Games with Playability Heuristic Evaluation System

Fifty-nine playability problems were identified for five games, as shown in Table 4.27. Each participant reported a mean of 11.8 problems per evaluator. The total time spent by five evaluator was 195 minutes (M = 39 m) per evaluator.

Table 4.27: Problems identified with PHES

Participant	Number of games	Problems Identified	Time spent(minutes)
A	2	14	43
B	2	11	39
C	2	13	33
D	2	10	32
E	2	11	48
Identified Problem Mean per Evaluator		**11.8**	**39**
Total		**59**	**195**

Fifty-six playability problems were identified for five games, as shown in Table 4.28. Each participant reported a mean of 11.2 problems per evaluator. The total time spent by five evaluator was 234 minutes (M = 468.8 m) per evaluator. Further detailed results are discussed in section 4.8.1.

Table 4.28: Problems identified with manual Heuristic Evaluation

Participant	Number of games	Problems Identified	Time spent(minutes)
A	2	14	51
B	2	10	41
C	2	12	39
D	2	9	44
E	2	11	59
Identified Problem Mean per Evaluator		**11.2**	**46.8**
Total		**56**	**234**

4.8.1 Comparative Results of Manual Heuristic Evaluation and Heuristic Evaluation with Playability Heuristic Evaluation System

This study included two evaluation sets of five mobile games for the purpose of comparing manual heuristic evaluation with the Playability Heuristic Evaluation System (PHES). The objective was to measure the effectiveness and efficiency of an automated heuristic evaluation process.

In Evaluation-I, five participants were recruited. Each participant evaluated two games, of their own choice. Participants were asked to use the manual heuristic evaluation method. The duration of evaluation time was noted without participant knowledge. Average time spent by each evaluator per number of identified problems was calculated.

In Evaluation-II, the same participants used PHES which has an inherent feature to calculate time spent on each evaluation. This timing feature was not visible to evaluators. Table 4.29 shows identified problems via Manual Heuristic Evaluation vs. PHES: these were fifty-six vs. fifty-nine. Participants spent 234 minutes to evaluate games manually and 192 minutes evaluating games with PHES, giving a mean index

of M = 46.8 m (SD = 7.3321) vs. M = 39 m (SD = 6.0332), respectively, per identified problem.

Table 4.29 shows the identified problems with Manual Heuristic Evaluation and PHES. The total number of problems identified with PHES is (N=59), while the problems identified with manual heuristic evaluation is (N=56). There is slightly difference in the number of identified problems; with PHES participants identified 3 more playability problems. Time duration of both evaluations was calculated. All the participants have spent total 192 minutes for evaluating games with PHES. The mean index of participants is (M=39; SD=6.0332). Similarly, Participants have spent 234 minutes for evaluating games with manual heuristics evaluation method where mean index is (M=46.8; SD=7.3321). It is noticeable that with PHES, participants spent less time and identified 3 more problems. The time difference of both evaluations is 39 minutes.

Table 4.29: Problems Identified with Manual HE and PHES

		Evaluation-I: PHES		**Evaluation-II: Manual Heuristic Evaluation**	
Participant	**Number of games**	**Problems Identified**	**Time spent(minutes)**	**Problems Identified**	**Time spent(minutes)**
A	2	14	43	14	51
B	2	11	39	10	41
C	2	13	33	12	39
D	2	10	32	9	44
E	2	11	48	11	59
Total		**59**		**56**	
Identified Problem Mean per Evaluator		**11.8**		**11.2**	
Total Time Spent (minutes)			**195**		**234**
Time Mean per Evaluator			**39**		**46.8**
Standard Deviation			**6.0332**		**7.3321**
Variance			**36.4**		**53.76**

Hence, the automated process for heuristic evaluation (PHES), demonstrated time efficiency, which is beneficial for large numbers of projects are ongoing with time constraints.

4.9 Summary

In this chapter results and discussions were presented associated to analysis on existing playability heuristics for mobile games and development of Playability Heuristic Evaluation System (PHES). All the objectives this study have been successfully achieved with following outcomes.

1) A new set of Playability Heuristics for Mobile Games has been proposed to evaluate mobile games. Proposed set playability heuristics are validated by evaluating six mobile games. A comparative study been carried on results of evaluation with existing Playability Heuristics for Mobile Games proposed by (Korhonen, 2006) and (Korhonen & Koivisto, 2007) and evaluation with proposed set of Playability Heuristics for Mobile Games. The results of comparative study state that, proposed set of playability heuristics are more appropriate in identifying playability problems in mobile games.

2) A web based software system has been developed named Playability Heuristic Evaluation (PHES) to automate the process of conducting heuristic evaluation. Developed PHES was validated by evaluating five mobile games. A comparative study has been conducted with manual method of conducting heuristic evaluation and heuristic evaluation with PHES. The outcome of comparative study states that, by automating the process of heuristic evaluation, more problems have been identified with in less time. PHES has been proved as time efficient system as compare to manual heuristic evaluation.

CHAPTER 5

CONCLUSIONS

5.1 Overview

This chapter presents conclusion of this research work along with contributions, study limitations and recommendations for future work. It helps in determining that whether the research objectives have been achieved. This study achieved the research objectives as outlined in Section 5.2. Section 5.3 presents the contributions of this work, and recommendations for future work are presented in section 5.4. Following that, future works are presented in Section 5.5. In addition, this chapter concludes with a summary as presented in Section 5.6.

5.2 Conclusion

Keeping in view the research problem this study aims to propose a new set of Playability Heuristic for mobile games and to develop a web-based software system (Playability Heuristic Evaluation System) to improve/enhance the process of heuristic evaluation. Three explicit objectives were identified at the completion of this study. The achievement of each objective are now summarized and presented as follows.

1. **To investigate existing playability heuristics for various mobile game genre**

In order to investigate existing playability heuristics for various mobile games genres, an extensive literature review was conducted on various playability heuristics for computer and mobile games. Two sets of playability heuristics were then selected from the literature review that best fit mobile games (Section 2.3.1.2 and 3.2.3.1). In order

to investigate the limitations of these existing playability heuristics for mobile games, an experimental setup was designed (Section 3.2.3) to evaluate mobile games with the selected sets of playability heuristics. Evaluations (Experimental Study-I) (Section 3.3) were conducted on six touchscreen android mobile games for different genres with the selected (extant) playability heuristics for mobile games. Fourteen participants have been involved in these evaluations. Results (Section 4.4) demonstrating that existing playability heuristics for mobile games clearly lacked facilities to identify playability problems in mobile games. Some new playability problems were also identified that lacked proper heuristics. Additionally, these findings indicated that existing playability heuristics did not support touchscreen mobile games.

2. To propose a new set of playability heuristics for mobile games

To propose a new set of playability heuristics for mobile games, all important aspects were considered such as general usability, usability of touch screen, mobility, gameplay and multiplayer gaming. All of these are important and cannot be ignored. The findings from Experimental Study-I demonstrated that existing playability heuristics did not cover the touch screen interface of mobile phone gaming.

Based on these findings, a new set of playability heuristics for mobile games were then proposed (Section 4.5). These heuristics were divided into five categorize as follows: Usability, Touchscreen Usability, Gameplay, Mobility and Multiplayer. The proposed set of playability heuristics attempted to full fill gaps left by existing playability heuristics and enrich the existing body of knowledge. In order to validate the proposed heuristics, Experimental Study-II (Section 4.6) was conducted in which six touchscreen mobile games with the proposed set of playability heuristics. The results demonstrated that proposed set of playability heuristics are more appropriate in identifying playability problems.

For further validation, a comparison study (Section 4.6.2) was carried out on results from Experimental Study-I against the proposed set of playability heuristics for mobile games (Experimental Study-II). These findings clearly showed that the proposed set of playability heuristics were much appropriate in identifying playability

problems. The total number of identified problems was not only higher but even more severe problems were revealed. Additionally, new problems were also identified by the existing set of playability heuristics that did not have proper heuristics. However, the newly identified problems revealed by the proposed playability heuristics were all identified with clearly defined heuristics.

3. To develop a web-based system that automates the process of heuristic evaluation and that incorporates the proposed set of playability heuristics

A web based application software system named "Playability Heuristic Evaluations System (PHES)" was then developed to automate the heuristic evaluation process for mobile games (Section 3.5). Two studies were conducted. In the first evaluation, five mobile games were evaluated with a proposed set of playability heuristics manually. In the second evaluation, same five mobile games were evaluated via the Playability Heuristic Evaluation System (PHES). A comparative study of these results was made to check the efficiency of PHES over manual Heuristic Evaluation (Section 4.8). This result clearly showed that heuristic evaluation with PHES was more efficient in terms of time compared to manual heuristic evaluation.

5.3 Contributions

The contributions of this study are divided into two main sections. The first is the proposed Playability Heuristics for Mobile Games and the second is development of Playability Heuristic Evaluation System.

1. Playability Heuristics for Mobile Games

This study has proposed a new set of playability heuristic for mobile games which attempts to fulfil the gaps of existing Playability Heuristics for mobile games. It was also experienced from literature review, preliminary studies and experimental study I that existing sets of Playability heuristics for mobile games do not support evaluation of touchscreen games. No heuristic module was observed from literature that support evaluation of touchscreen usability of games. In this regards, proposed set of Playability

Heuristics have a module that supports to evaluate touchscreen usability for mobile games.

The proposed set of Playability Heuristics are divided into five modules as follows: Usability, Touchscreen Usability, Mobility, Gameplay and Multiplayer. The reason for dividing the list of heuristics into modules is that, it allow Usability/Playability experts to use module individually. For example, if these heuristics are considered to evaluate non-touchscreen games, so researcher can skip touchscreen module so that other modules are applicable on non-touchscreen games. Similarly, for evaluation of single player mobile games, multiplayer heuristic module can be skipped.

2. Playability Heuristic Evaluation System (PHES)

It was reviewed from literature that manual heuristic evaluation is time consuming. Many attempts were made to improve the efficiency of heuristic evaluation. The major attempt was automation. Several usability assessment tools were commercialized in market for evaluation of desktop applications and websites. However, it is observed that those tools lack the attention to evaluate computer and mobile games, or might the results were not published.

In this regard, a web-based software system named "Playability Heuristic Evaluation System" was developed to evaluate computer and mobile games. This system attempts to enhance the process of heuristic evaluation by improving efficiency in terms of time compared to manual heuristic evaluation. PHES is very much flexible that it supports evaluation of different platforms (e.g. computer, console and mobile). PHES has a database that can store multiplayer sets of heuristics and can be used in one evaluation. Furthermore, it is web-based system so it can be accessed online remotely that allows to conduct heuristic evaluation from remote places. Moreover, results can be stored in PHES database for future use.

5.4 Recommendations

On the basis of the results and analysis observed in this study, some recommendations have been made in order to evaluate mobile game more efficiently.

- Evaluation experiences and results suggest that the proposed set of playability heuristics lack in addressing educational mobile games. Hence, a new heuristic module can be added that supports the pedagogical content of educational mobile games.

- The proposed set of playability heuristics have potential to evaluate interactive tabletop display games in single user perspective.

- The study findings and literature review suggest that there should be standardized size of heuristics for evaluating playability of games.

5.5 Future Work

Participants involved in this study were not game developers or game usability experts. Hence, the outcome of this study can be improved upon by recruiting game developers and game usability experts. The heuristic terminologies used in proposed set of Playability Heuristics were easily understandable by normal user and experts. Therefore, same set of heuristics can be used with usability/playability experts.

Proposed set of Playability Heuristics support the evaluation of touchscreen usability, there it can be used to evaluate touchscreen laptop games and interactive tabletop display games in single user perspective. This research can also be carried out to evaluate touchscreen laptop and tabletop games to investigate to what extent playability heuristics are applicable to other touchscreen gaming platforms. In addition, playability heuristics for mobile games can be used to evaluate educational mobile games if a new heuristic module is added in support of pedagogical content.

In current version of Playability Heuristics Evaluation System (PHES) there is lack of obtaining statistical results. PHES can be further improve with the incorporation

of statistical analysis. In this regards, usability practitioners might not need to use third party statistical software applications. Moreover, the PHES can be extended to conduct heuristic evaluations for computer games and web-based social games. Additionally, (PHES) can be improved with new module that covers the 'Evaluating User Experience' for games.

5.6 Summary

This chapter presented the overall conclusion of the whole thesis through the achievement of the research objectives by summarizing the research findings of the study. It concluded the research contributions and recommendations. The chapter ended with future work which presented the suggestions of the areas which the readers and other researchers could take into consideration for further research studies.

REFERENCES

Adams, E. (2009). *Fundamentals of Game Design (2nd Edition)* (p. 700). New Riders.

Baker, K., Greenberg, S., & Gutwin, C. (2002). Empirical development of a heuristic evaluation methodology for shared workspace groupware. *In Proceedings of the ACM Conference on Computer-Supported Cooperative Work*, 96–105. Retrieved from http://dl.acm.org/citation.cfm?id=587093

Barr, P., Noble, J., & Biddle, R. (2007). Video game values: Human–computer interaction and games. *Interacting with Computers*, *19*(2), 180–195. doi:10.1016/j.intcom.2006.08.008

Bevan, N. (1995). Measuring usability as quality of use. *Software Quality Journal*, *4*(2), 115–130. doi:10.1007/BF00402715

Blandford, A., Vanderdonckt, J., & Gray, P. (Eds.). (2001). *People and Computers XV—Interaction without Frontiers*. London: Springer London. doi:10.1007/978-1-4471-0353-0

Clanton, C. (1998). An Interpreted Demonstration of Computer Game Design. *Most*, (April), 7–8.

Cockton, G., Lavery, D., & Woolrych, A. (2002). Inspection-based evaluations, 1118–1138. Retrieved from http://dl.acm.org/citation.cfm?id=772072.772142

Comviva. (2009). Realizing Potential of Mobile Gaming White Paper December 2009. *Business*, (December).

Connell, I., & Hammond, N. (1999). Comparing usability evaluation principles with heuristics: problem instances vs. problem types. *Proceedings of INTERACT'99 - Human Computer Interaction*, 621 – 629.

Coriolis, E. (2012). Game Architecture and Design.

Cuomo, D. L., & Bowen, C. D. (1994). Understanding usability issues addressed by three user-system interface evaluation techniques. *Interacting with Computers*, *6*(1), 86–108. doi:10.1016/0953-5438(94)90006-X

Desurvire, H., Blvd, W., Rey, M., & Caplan, M. (2004). Using Heuristics to Evaluate the Playability of Games. *Defense*, 1509–1512.

Desurvire, H., & Wiberg, C. (2009). Game usability heuristics (play) for evaluating and designing better games: The next iteration. *Online Communities and Social Computing*. Retrieved from http://www.springerlink.com/index/CL1W17LP067K39Q1.pdf

Egenfeldt-Nielsen, S., Smith, J. H., & Tosca, S. P. (2008). *Understanding Video Games: The Essential Introduction* (p. 302). Routledge.

Eskelinen, M. (2001). Game Studies 0101:The Gaming Situation. *the international journal of computer game research*, *1*(1).

Evan, A. (2012). Nintendo NES. Retrieved September 24, 2012, from http://en.wikipedia.org/wiki/File:NES-Console-Set.jpg

Fabricatore, C., Nussbaum, M., & Rosas, R. (2002). Playability in Action Videogames: A Qualitative Design Model. *Human-Computer Interaction*, *17*(4), 311–368. doi:10.1207/S15327051HCI1704_1

Federoff, M. A. (2002). Heuristics and usability guidelines for the creation and evaluation of fun in video games. *FUN in Video Games Thesis University Graduate School of Indiana University Dec*, *Master of*(December), 52. doi:10.1.1.89.8294

Foundation, W. (2013). Heuristic. *Wikimedia Foundation*. Retrieved March 09, 2013, from http://en.wikipedia.org/wiki/Heuristic

Fullerton, T., Swain, C., & Hoffman, S. (2004). *Game Design Workshop: Designing, Prototyping, and Playtesting Games*. *Journal of veterinary internal medicine American College of Veterinary Internal Medicine* (p. 460). CMP Books.

Gameloft. (2012a). Block Breaker. Retrieved from 12-8-2012

Gameloft. (2012b). Asphalt 6: Adrenaline. Retrieved August 12, 2012, from https://play.google.com/store/apps/details?id=com.gameloft.android.ANMP.GloftA6HP

Gameloft. (2012c). Modern Combat 3: Fallen Nation. Retrieved August 12, 2012, from https://play.google.com/store/apps/details?id=com.gameloft.android.ANMP.GloftM3HM

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, Motivation, and Learning: A Research and Practice Model. *Simulation & Gaming*, *33*(4), 441–467. doi:10.1177/1046878102238607

George, D., & Mallery, P. (2002). *SPSS for Windows Step by Step: A Simple Guide and Reference, 11.0 Update* (4th Editio., p. 400). Allyn & Bacon.

Gray, W. D., & Salzman, M. C. (1998). Damaged Merchandise ? A Review of Experiments That Compare Usability Evaluation Methods, *13*, 203–261.

Guardian, T. (2013). PlayStation 2 manufacture ends after 12 years.

Hanna, P. (2012). Video Game Technologies. In *Java Games Programming*.

IDC Report. (2012). Retrieved April 24, 2013, from http://www.idc.com/getdoc.jsp?containerId=prUS23946013

Imangi Studios. (2012). Temple Run. Retrieved May 12, 2013, from https://play.google.com/store/apps/details?id=com.imangi.templerun

Janarthanan, V. (2012). Serious Video Games: Games for Education and Health. *2012 Ninth International Conference on Information Technology - New Generations*, 875–878. doi:10.1109/ITNG.2012.79

Johnson, D., & Wiles, J. (2003). Effective affective user interface design in games. *Ergonomics*, *46*.

Kairosoft, C. (2012). Cafeteria Nipponica. Retrieved August 12, 2012, from https://play.google.com/store/apps/details?id=net.kairosoft.android.restaurant_en

Koeffel, C., Hochleitner, W., & Leitner, J. (2010). Using heuristics to evaluate the overall user experience of video games and advanced interaction games. ... *Experience in Games*. Retrieved from http://link.springer.com/chapter/10.1007/978-1-84882-963-3_13

Koivisto, E. (2008). Mobile game playability heuristics. Forum Nokia, 1–28. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Mobile+Game+Playability+Heuristics#3

Korhonen, H. (2006). Playability Heuristics for Mobile Games. *Human Factors*, 9–16.

Korhonen, H. (2009). Expert Review Method in Game Evaluations – Comparison of Two Playability Heuristic Sets. *Development*, 74–81.

Korhonen, H. (2010). Comparison of playtesting and expert review methods in mobile game evaluation. *Proceedings of the 3rd International Conference on*, 18–27. Retrieved from http://dl.acm.org/citation.cfm?id=1823820

Korhonen, H. (2011). The explanatory power of playability heuristics. *Proceedings of the 8th International Conference on*, 1. doi:10.1145/2071423.2071473

Korhonen, H., & Koivisto, E. M. I. (2007). Playability heuristics for mobile multi-player games. In *Proceedings of the 2nd international conference on Digital interactive media in entertainment and arts* (pp. 28–35). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=1306828

Kunda, Z. (1999). *Social cognition: Making sense of people*. Cambridge, MA, MIT Press.

Law, E. L., & Hvannberg, E. T. (2004). Analysis of Strategies for Improving and Estimating the Effectiveness of Heuristic Evaluation. *Proceedings of the third*

Nordic conference on Human-computer interaction - NordiCHI '04, 241–250. doi:10.1145/1028014.1028051

Law, E. L.-C., & Hvannberg, E. T. (2002). Complementarity and convergence of heuristic evaluation and usability test. In *Proceedings of the second Nordic conference on Human-computer interaction - NordiCHI '02* (p. 71). New York, New York, USA: ACM Press. doi:10.1145/572020.572030

Loop11. (2012). Remote & online usability testing tool. Retrieved October 11, 2012, from http://www.loop11.com/

Mohamed, H., & Jaafar, A. (2010). Challenges in the evaluation of educational computer games. In *Information Technology (ITSim), 2010 International Symposium in* (Vol. 1, pp. 1–6). IEEE.

Molich, R., & Dumas, J. S. (2008). Comparative usability evaluation (CUE-4). *Behaviour Information Technology*, *27*(3), 263–281. doi:10.1080/01449290600959062

Nacke, L. E., de Kort, Y., Drachen, A., IJsselsteijn, W., Korhonen, H., Kuikkaniemi, K., … Kort, Y. A. W. De. (2009). Playability and Player Experience Research. *Proceedings of DiGRA 2009: Breaking New Ground: Innovation in Games, Play, Practice and Theory*. Retrieved from http://en.wikipedia.org/wiki/Gameplay#cite_note-nackeDiGRA-16

Nielsen, J. (2005). 10 Usability Heuristics for User Interface Design.

Nielsen, J., & Molich, R. (1990). Heuristic evaluation of user interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems: Empowering people* (pp. 249–256). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=97281

Omar, H., & Jaafar, A. (2008). Playability Heuristics Evaluation (PHE) approach for Malaysian educational games. *Information Technology, 2008. ITSim 2008 ...*. Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4632053

Overmars, M. (2012). A Brief History of Computer Games, 1–35.

Paavilainen, J. (2010). Critical Review on Video Game Evaluation Heuristics : Social Games Perspective. *Human Factors*, 56–65.

Papastergiou, M. (2009). Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation. *Computers & Education*, *52*(1), 1–12. doi:10.1016/j.compedu.2008.06.004

Pinelle, D., Wong, N., & Stach, T. (2008). Heuristic evaluation for games: usability principles for video game design. In *Proceeding of the twenty-sixth annual*

SIGCHI conference on Human factors in computing systems (pp. 1453–1462). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=1357054.1357282

Pinelle, D., Wong, N., Stach, T., Gutwin, C., Street, U., & Hall, G. (2009). Usability heuristics for networked multiplayer games. *Proceedings of the ACM 2009 ...*, 169–178. Retrieved from http://dl.acm.org/citation.cfm?id=1531700

Richard, R. (2001). *Game Design Theory and Practice (2nd ed.).* Wordware Publishing Inc., Plano, TX, USA.

Rollings, A., & Adams, E. (2003). *Andrew Rollings and Ernest Adams on Game Design* (p. 648). New Riders. Retrieved from http://www.amazon.com/Andrew-Rollings-Ernest-Adams-Design/dp/1592730019

Rosenbaum, S., Rohn, J. A., & Humburg, J. (2000). A Toolkit for Strategic Usability : Results from Workshops , Panels , and Surveys. In T. Turner, G. Szwillus, M. Czerwinski, & F. Paterno (Eds.), *CHI 2000 Proceedings* (Vol. 2, pp. 337–344). ACM Press. doi:10.1145/332040.332454

Rouse, R., & Ogden, S. (2005). *Game Design : Theory & Practice*. *Design* (p. 698). Wordware Pub. Retrieved from http://books.google.com.mx/books?id=tGePP1Nu_P8C

Schaffer, N. (2007). Heuristics for usability in games. *White Paper. Online: http://www. playerfriendly. com/ ...*, (April), 1–30. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Heuristics+for+Usability+in+Games#3

Shackel, B. (1991). Usability - context, framework, definition, design and evalution. In B. Shackel & S. J. Richardson (Eds.), *Human Factors for Informatics Usability* (pp. 21–38). Cambridge University Press. Retrieved from http://books.google.ch/books?id=KSHrPgLlMJIC

Shengyuan, Y., Xiaoyang, Y., & Hongguo, Z. (2007). Research of Software User Interface Evaluation Method based on Subjective Expectation, (4), 3190–3195.

Sivaji, a. (2012). Website user experience (UX) testing tool development using Open Source Software (OSS). *2012 Southeast Asian Network of Ergonomics Societies Conference (SEANES)*, 1–6. doi:10.1109/SEANES.2012.6299576

Song, S., Lee, J., & Hwang, I. (2007). A new framework of usability evaluation for massively multi-player online game: case study of World of warcraft game. In *Proceedings of the 12th international conference on Human-computer interaction: applications and services* (pp. 341–350). Springer-Verlag. Retrieved from http://dl.acm.org/citation.cfm?id=1769492

Systems, A., & Platform, O. (2013). Automation Systems the Optimisation Platform.

Tan, W., Liu, D., & Bishu, R. (2009). Web evaluation: Heuristic evaluation vs. user testing. *International Journal of Industrial Ergonomics*, *39*(4), 621–627. doi:10.1016/j.ergon.2008.02.012

Tetris: A History. (2012). Retrieved September 25, 2012, from http://www.atarihq.com/tsr/special/tetrishist.html

Tobii. (2010). Tobii Eye Tracking. *Technology*. Retrieved from http://www.tobii.com/Global/Analysis/Training/WhitePapers/Tobii_EyeTracking_Introduction_WhitePaper.pdf?epslanguage=en

U-Play. (2012). Train Crisis HD. Retrieved August 12, 2012, from https://play.google.com/store/apps/details?id=com.uplayonline.traincrisis

Userfeel. (2012). Remote usability testing. Retrieved October 14, 2012, from http://www.userfeel.com/

utp-project. (2012a). Spell It!! Retrieved May 15, 2012, from https://play.google.com/store/apps/details?id=source.mobilequiz

utp-project. (2012b). Animal Idioms. Retrieved May 15, 2012, from https://play.google.com/store/apps/details?id=source.animalidioms

utp-project. (2012c). Comic Maths. Retrieved May 15, 2012, from https://play.google.com/store/apps/details?id=comicMaths.pack

utp-project. (2012d). Chase Me. Retrieved May 12, 2012, from https://play.google.com/store/apps/details?id=tap.pack

Wiberg, C., Jegers, K., & Desurvire, H. (2009a). How Applicable is Your Evaluation Methods – Really? Analysis and Re-design of Evaluation Methods for Fun and Entertainment. *2009 Second International Conferences on Advances in Computer-Human Interactions*, 324–328. doi:10.1109/ACHI.2009.54

Wiberg, C., Jegers, K., & Desurvire, H. (2009b). How Applicable is Your Evaluation Methods–Really? Analysis and Re-design of Evaluation Methods for Fun and Entertainment. *Advances in Computer- ...*, 2–7. Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4782534

Wiberg, C., Jegers, K., & Desurvire, H. (2009c). How Applicable is Your Evaluation Methods–Really? Analysis and Re-design of Evaluation Methods for Fun and Entertainment. *Advances in Computer- ...*, 2–7.

APPENDIX A

QUESTIONNAIRE

Questionnaire used in Preliminary Study-I

UNIVERSITI TEKNOLOGI PETRONAS

Questionnaire ID #_____

Respected Sir/Madam,

I am MSc Scholar in Computer & Information Sciences Department, Universiti Teknologi PETRONAS. The main objective of this survey is to understand preferences of game users.

Your feedback will be valuable input to the study and will be used for academic purpose only. Your contribution and time is highly appreciated.

Yours truly,

Sarmad
Postgraduate Student (MSc)
Univerisiti Teknologi PETRONAS
Bandar Seri Iskandar, 31750 Tronoh, Perak.
Email: sarmad.iu@gmail.com

Section A

Name: _____ **Department:** _____

Program & Year: _____ **Male / Female:** _____

1. What types of games do prefer to play?
   a. Mobile Games ☐ b. Computer Games ☐ c. Console Games ☐
2. How frequent you play games in a day?
   a. 0-3 hours ☐ b. 3-6 hours ☐ c. 6-10 hours ☐
   d. 10-15 hours ☐
3. What type of Games genre do you like to play?
   a. Puzzle ☐ b. Simulation ☐ c. Arcade ☐
   d. Adventure ☐ e. Strategy ☐

4. What type of gaming style do you prefer to play?

   a. Single Player ☐ b. Multiplayer ☐ c. Both ☐

5. In Multiplayer games what type of communication you prefer to communication with other players?

   a. Voice chat ☐ b. Text chat ☐ c. Both ☐

6. If you want to play multiplayer game on Mobile, which connectivity you prefer?

   a. Bluetooth ☐ b. Wifi ☐ c. GPRS ☐

Section B

The following statements concern your perception about yourself in a variety of situations. For each item of the statements below, please indicate the extent of your agreement and disagreement by ticking (√) the appropriate number according to the following scale.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

S.No	Questions	1	2	3	4	5
1	Introductory images and videos in games are useful.					
2	Game cheats and trainers are necessary.					
3	The game help is usually helpful.					
4	Repetitive tasks/mission/objectives in games are enjoyable.					
5	I prefer to personalize game settings, such as game speed, game difficulty.					
6	While playing mobile game, I prefer to pause the whenever you want.					
7	In Mobile games I want to save the game at any stage.					
8	I prefer single player games over multiplayer.					

Section C

1. Which is your favorite game on PC & Mobile Phones? What features do you like in it?

   _____

   _____

   _____

2. Have you ever used game cheats or trainers? Please write the reason

   _____

   _____

   _____

3. Do you like to play the one game again & again? Please write the reason

   _____

   _____

   _____

4. How Mobile games can be improved? What is your opinion?

   _____

   _____

   _____

THANK YOU

APPENDIX B

QUESTIONNAIRE

Questionnaire used in Preliminary Study-II

UNIVERSITI TEKNOLOGI PETRONAS

Questionnaire ID #_____

Respected Sir/Madam,

I am MSc Scholar in Computer & Information Sciences Department, Universiti Teknologi PETRONAS. The main objective of this survey is to understand the importance and efficiency of educational mobile games.

Your feedback will be valuable input to the study and will be used for academic purpose only. Your contribution and time is highly appreciated.

Yours truly,

Sarmad
Postgraduate Student (MSc)
Univerisiti Teknologi PETRONAS
Bandar Seri Iskandar, 31750 Tronoh, Perak.
Email: sarmad.iu@gmail.com

Section A

Name: _____ **Department:**_____

Program & Year: _____ **Male / Female:** _____

Game: _____

1. What type of games you?
   a. Mobile Games ☐ b. Computer Games ☐ c. Console Games ☐
2. How frequent you play games in a day?
   a. 0-2 hrs ☐ b. 2-4 hrs ☐ c. 4-6 hrs ☐ d. 6-8 hrs ☐
3. What type of Games do you play?
   a. Puzzle ☐ b. Simulation ☐ c. Arcade ☐ d. Adventure ☐
   e. Strategy ☐
4. What type of Games do you prefer?
   a. Single Player ☐ b. Multiplayer ☐ c. Both ☐

Section B

The following statements concern your perception about yourself in a variety of situations. For each item of the statements below, please indicate the extent of your agreement and disagreement by ticking (√) the appropriate number according to the following scale.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

S.No	Questions	1	2	3	4	5
1	Game text font and colors are appealing					
2	Game colors and design is pleasant					
3	Game interactivity is suitable for learning					
4	Game learning objectives are clear					
5	Game shows your progress					
6	Game activities are interesting and engaging					
7	Game can be used as self-learning tool					
8	Game learning material supporting in daily life					
9	Game menus are easy to navigate					
10	Game menus name are easily understandable					
11	Game contains rewards					
12	Game is not boring and can be played repeatedly					
13	Game help is useful and understandable					
14	Game control keys are convenient					
15	Game is not to easy nor to difficult					
16	Game supports different levels of difficulty					
17	Game supports customization of audio-visual					
18	Game is pauseable					

THANK YOU

APPENDIX C

SOURCE CODE

Source code of Playability Heuristic Evaluation System (PHES)

index.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Playability Heuristics Evaluation System</title>
<link rel="stylesheet" type="text/css" href="css/styles.css" />
<script src="Scripts/AC_RunActiveContent.js" type="text/javascript"></script>
</head>
<body>
<div class="container">
<div class="containerLogin">
<div class="login">
<img src="images/logoLeft.png" style="margin: 0 0 0 0; float:left;" />
</div><!-- end of login div -->
<div class="container_form">
<span class="adminTXT"><span class="login_headerTXT">Please login to access the
system or create new account.</span> </span>
<br /><br /><br />
<form action="main.php" method="POST">
<div class="main">
<input type="text" name="username" class="input_txt" />
<br />
<input type="password" name="password" class="input_txtP" />
<br /><br />
<input type="image"  class="login_btn" src="images/login_btn.png" />
<br />
<a href="forgotpassword.php" class="forgotpass">I forgot my password</a>
 <a href="signup.php" class="signup">Signup</a>
</div><!-- end of form -->
</form>
<img src="images/nameProject.png" alt="Playability Heuristic Evaluation System"
style="margin: 33px 0 0 0;" />
</div>
</div><!-- end of container login -->
</div><!-- end of container div -->
</body>
</html>
```

header.php

```
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Playability Heuristics Evaluation System</title>
```

```
<script src="js/dropmenu.js" type="text/javascript"></script>
<link rel="stylesheet" type="text/css" href="css/mainStyles.css" />
</head>
<body>
<div class="header">
<div class="header_body">
<div class="logoMain"><a href="ums.php"><img src="images/logoMain.png"
alt="Playability Heuristics Evolution System" border="0" /></a></div>
    <ul class="welcome">
        <li>Welcome,</li>
     <li><a href="userprofile.php" target="home" class="userlogedin"><?php
printf("%s",$_COOKIE[un]); ?></a>
     <li class="logout"><a href="index.php" class="welcomeLink">Logout</a></li>
  </ul>
        <nav class="navbar">
        <div class="navbar-inner">
        <div class="container">
        <ul class="nav">
<li class="dropdown">
<a href="javascript:void(0);">Home</a>
<!-- Dropdown menu -->
<ul>
<li><a href="ums.php" title="">Introduction to PHE System</a></li>
<li><a href="javascript:void(0);" title="">Workflow</a></li>
<li><a href="listusers.php" title="">List Registered Users</a></li>
<li><a href="userprofile.php" title="">User Profile</a></li>
<li><a href="addnewuser.php" title="">Add New User</a></li>
<li><a href="index.php" title="">Logout</a></li>
</ul>
</li>
<li class="dropdown">
<a href="javascript:void(0);">Heuristic Evaluation</a>
<!-- Dropdown menu -->
<ul>
<li><a href="startevaluation.php" title="">New Evaluation</a></li>
<li><a href="modifyevaluation.php" title="">Modify Evaluation</a></li>
</ul>
</li>
<li class="dropdown">
<a href="javascript:void(0);">Heuristics Database</a>
<!-- Dropdown menu -->
<ul>
<li><a href="addnewheuristics.php" title="">Add Heuristics</a></li>
<li><a href="modifyheuristics.php" title="">Modify Heuristics</a></li>
<li><a href="deleteheuristics.php" title="">Delete Hueristics</a></li>
<li><a href="listheuristics.php" title="">List Hueristics</a></li></ul>
```

```
</li>
<li class="dropdown">
<a href="javascript:void(0);">Games Database</a>
<!-- Dropdown menu -->
<ul>
<li><a href="addnewgame.php" title="">Add New Game</a></li>
<li><a href="modifygame.php" title="">Modify Games</a></li>
<li><a href="deletegame.php" title="">Delete Games</a></li>
<li><a href="listgames.php" title="">List Games</a></li>
</ul>
</li>
<li class="dropdown">
<a href="javascript:void(0);">Results</a>
<!-- Dropdown menu -->
<ul>
<li><a href="demographicsresult.php" title="">Demographic Results</a></li>
<li><a href="overallresults.php" title="">Overall Results</a></li>
</ul>
</li>
</li>
</ul>
 </div>
 <!-- end .container -->
</div><!-- end .navbar-inner -->
</nav>
<div class="header_shadow"><img src="images/header_shadow.png" /></div>
</div><!-- end of header_body -->
</div>
<!-- end of header -->
</body>
</html>
```

footer.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<div class="footer">
<div class="footer_body">
Copyright &copy <a href="http://www.utp.edu.my/" class="footerLink">Universiti
Teknologi PETRONAS</a>, Malaysia. All Rights Reserved
</div><!-- end of footer_body -->
```

Addnewgame.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<?php include("header.php"); ?>
<body>
<div class="container">
<div class="contents">
<div class="headingTitle"><h1 class="titleTXT">Add New Game</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
<div class="insideContent">
<div class="m">
<script type="text/javascript" src="../js/formfieldlimiter.js">
/***********************************************
* Form field Limiter v2.0- © Dynamic Drive DHTML code library (www.dynamicdrive.com)
* This notice MUST stay intact for legal use
* Visit Project Page at http://www.dynamicdrive.com for full source code
***********************************************/
</script>
<script>
   function docheck(){
      if(document.form.gname.value==""){
      alert("Please enter a Game name!");
      return false;
      }
      if(document.form.gmode.value==""){
      alert("Please enter the Game Mode!");
      return false;
      }
      if(document.form.ggenre.value==""){
      alert("Please enter the Game Genre!");
      return false;
      }
                  if(document.form.gplatform.value==""){
      alert("Please write Game Platform!");
      return false;
      }
                  if(document.form.gdescription.value==""){
      alert("Please write Game Description!");
      return false;
      }

   }
</script>
<fieldset>
```

```
<legend>Game Database >> Add New Game</legend>
<form name="form" action="addnewgame.php" method="POST" onsubmit="return
docheck()">
<table>
<tr>
<td>Game Name</td>
<td>: <input type="text" name="gname"  style="width:58mm" value=""></td>
</tr>
<tr>
<td>Game Mode</td>
<td>:  <select name="gmode" style="width:60mm" onchange="showUser(this.value)">
<option value=""> - Select Game Mode -</option>
<?php
require("library/connection.php");
$sql = "SELECT gmode FROM tbl_gmode ORDER BY gmode ASC";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
do {
?>
<option value="<?php printf("%s",$myrow["gmode"]); ?>"><?php
printf("%s",$myrow["gmode"]); ?></option>
<?php
} while ($myrow = mysql_fetch_array($result));
} else {
}
mysql_close($con);
?>
</tr>
<tr>
<td>Select Genre &amp;nbsp;&amp;nbsp; </td>
<td>:  <select name="ggenre" style="width:60mm" onchange="showUser(this.value)">
<option value=""> - Select Genre -</option>
<?php
require("library/connection.php");
$sql = "SELECT genname FROM tbl_ggenre ORDER BY genname ASC";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
do {
?>
<option value="<?php printf("%s",$myrow["genname"]); ?>"><?php
printf("%s",$myrow["genname"]); ?></option>
<?php
} while ($myrow = mysql_fetch_array($result));

} else {
```

```
}
mysql_close($con);
?>
</tr>
<td>Game Platform</td>
<td>:  <select name="gplatform" style="width:60mm" onchange="showUser(this.value)">
<option value=""> - Select Game Platform -</option>
<?php
require("library/connection.php");
$sql = "SELECT nplatform FROM tbl_gplatform ORDER BY nplatform ASC";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
do {
?>
<option value="<?php printf("%s",$myrow["nplatform"]); ?>"><?php
printf("%s",$myrow["nplatform"]); ?></option>
<?php
} while ($myrow = mysql_fetch_array($result));

} else {

}
mysql_close($con);
?>
</tr>
<tr>
<td>Game Description:</td>
<td> &amp;nbsp;&amp;nbsp;<textarea name="gdescription" rows="6" cols="7120"></textarea><div
id="des-status"></div></td>
</tr>
<tr>
</tr><tr><td><br/></td><td></td></tr>
<td></td>
<td><input type="submit" name="submit" value="ADD"><td>
</tr>
</table>
</form>
</fieldset>
<script type="text/javascript">
fieldlimiter.setup({
        thefield: document.form.gdescription, //reference to form field
        maxlength: 250,
        statusids: ["des-status"], //id(s) of divs to output characters limit in the form [id1, id2,
etc]. If non, set to empty array [].
        onkeypress:function(maxlength, curlength){ //onkeypress event handler
                if (curlength<maxlength) //if limit hasn't been reached
```

```
                        this.style.border="1px solid gray" //"this" keyword returns form field
                else
                        this.style.border="2px solid red"
        }
})
</script>
</div>
</div><!-- end of insideContent -->
<img src="images/contentBG_bottom.png" />
</div><!-- end of contentBG -->
</div>
</div><!-- end of container -->
<?php include("footer.php"); ?>
</body>
</html>
<?php
if ($_POST['submit']){
require("library/connection.php");
$_POST['gname'] = mysql_real_escape_string($_POST['gname']);
$_POST['gmode'] = mysql_real_escape_string($_POST['gmode']);
$_POST['ggenre'] = mysql_real_escape_string($_POST['ggenre']);
$_POST['gplatform'] = mysql_real_escape_string($_POST['gplatform']);
$_POST['gdescription'] = mysql_real_escape_string($_POST['gdescription']);
$sql="INSERT INTO tbl_game (gname, gmode, ggenre, gplatform, gdescription,email)
VALUES
('$_POST[gname]','$_POST[gmode]','$_POST[ggenre]','$_POST[gplatform]','$_POST[gdesc
ription]','$_COOKIE[us]')";
if (!mysql_query($sql,$con))
  {
  ?>
  <script type="text/javascript">
  alert("Error: <?php echo mysql_error() ?>");
  </script>
  <?php
  die();
  }
?>
<script type="text/javascript">
alert("Game name '<?php echo $_POST[gname] ?>' has been added successfully!");
document.location.href='addnewgame.php'
</script>
<?php
mysql_close($con);
}
?>
```

Deletegame.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<?php include("header.php"); ?>
<body>
<div class="container">
<div class="contents">
<div class="headingTitle"><h1 class="titleTXT">Delete Game</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
<div class="insideContent">
<div class="m">
<script>
   function docheck(){
      if(document.form.id.value==""){
      alert("Please select a Game!");
      return false;
      }
   }
</script>
<form name="form" action="deletegame.php" method="POST" onsubmit="return
docheck()">
<fieldset>
<legend>Game Database >> Delete Game</legend>
<table>
<tr>
<td>Select Game       </td>
<td>: <select name="pid" style="width:60mm" onchange="showUser(this.value)">
<option value=""> - Select Game -</option>
<?php
require("library/connection.php");
$sql = "SELECT gname FROM tbl_game ORDER BY gname ASC";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
do {
?>
<option value="<?php printf("%s",$myrow["gname"]); ?>"><?php
printf("%s",$myrow["gname"]); ?></option>
<?php
} while ($myrow = mysql_fetch_array($result));
} else {
}
mysql_close($con);
?>
<tr>
```

```
</tr><tr><td><br/></td><td></td></tr>
<td></td>
<td><input type="submit" name="submit" onClick="return confirm('Are you sure you want
to delete this Game?\n\n')" value="DELETE"><td>
</tr>
</table>
</fieldset>
</form>
</div>
</div><!-- end of insideContent -->
<img src="images/contentBG_bottom.png" />
</div><!-- end of contentBG -->
</div>
</div><!-- end of container -->
<?php include("footer.php"); ?>
</body>
</html>
<?php
if ($_POST['submit']){
require("library/connection.php");
$_POST['id'] = mysql_real_escape_string($_POST['id']);
$sql="DELETE FROM tbl_game WHERE gname='$_POST[id]' AND
email='$_COOKIE[us]'";
if (!mysql_query($sql,$con))
  {
  ?>
  <script type="text/javascript">
  alert("Error: <?php echo mysql_error() ?>");
  </script>
  <?php
  die();
  }
?>
<script type="text/javascript">
alert("All data of the Game '<?php echo $_POST[id] ?>' has been deleted successfully!");
document.location.href='deletegame.php'
</script>
<?php
mysql_close($con);
}
?>
```

Modifygame.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<?php include("header.php"); ?>
<body>
<div class="container">
<div class="contents">
<div class="headingTitle"><h1 class="titleTXT">Modify Game</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
<div class="insideContent">
<div class="m">
<script type="text/javascript">
function showUser(str)
{
if (str=="")
  {
  document.getElementById("txtHint").innerHTML="";
  return;
  }
if (window.XMLHttpRequest)
  {// code for IE7+, Firefox, Chrome, Opera, Safari
  xmlhttp=new XMLHttpRequest();
  }
else
  {// code for IE6, IE5
  xmlhttp=new ActiveXObject("Microsoft.XMLHTTP");
  }
xmlhttp.onreadystatechange=function()
  {
  if (xmlhttp.readyState==4 && xmlhttp.status==200)
    {
    document.getElementById("txtHint").innerHTML=xmlhttp.responseText;
    }
  }
xmlhttp.open("GET","dmgame.php?q="+str,true);
xmlhttp.send();
}
</script>
<script>
    function docheck1(){
        if(document.form.gname.value==""){
        alert("Please enter a Game name!");
        return false;
```

```
        }
        if(document.form.gmode.value==""){
        alert("Please enter the Game Mode!");
        return false;
        }
if(document.form.ggenre.value==""){
        alert("Please write Game Genre!");
        return false;
        }
       if(document.form.gplatform.value==""){
        alert("Please write Game Platform");
        return false;
        }
        if(document.form.description.length>250){
        alert("Maximum characters can input for remark input field is 250");
        return false;
        }

    }
</script>
<fieldset>
<legend>Game Database >> Modify Game</legend>
<form name="form" action="modifygame.php" method="POST" onsubmit="return
docheck1()">
<table>
<tr>
<td>        Heuristic Keyword       
 </td>
<td>: <select name="pid" style="width:60mm" onchange="showUser(this.value)">
<option value=""> - Select Game -</option>
<?php
require("library/connection.php");
$sql = "SELECT gname FROM tbl_game ORDER BY gname ASC";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
do {
?>
<option value="<?php printf("%s",$myrow["gname"]); ?>"><?php
printf("%s",$myrow["gname"]); ?></option>
<?php
} while ($myrow = mysql_fetch_array($result));
} else {
}
mysql_close($con);
?>
```

```
</table>
<table>
<tr><td>
<div id="txtHint"></div>
</td></tr></table>
<div class="a"></div>
</form>
</fieldset>
</div>
</div><!-- end of insideContent -->
<img src="images/contentBG_bottom.png" />
</div><!-- end of contentBG -->
</div>
</div><!-- end of container -->
<?php include("footer.php"); ?>
</body>
</html>
<?php
if ($_POST['submit']){
require("library/connection.php");
$_POST['gname'] = mysql_real_escape_string($_POST['gname']);
$_POST['gmode'] = mysql_real_escape_string($_POST['gmode']);
$_POST['ggenre'] = mysql_real_escape_string($_POST['ggenre']);
$_POST['gplatform'] = mysql_real_escape_string($_POST['gplatform']);
$_POST['gdescription'] = mysql_real_escape_string($_POST['gdescription']);
$sql="UPDATE tbl_game SET
gname='$_POST[gname]',gmode='$_POST[gmode]',ggenre='$_POST[ggenre]',gplatform='$_
POST[gplatform]',gdescription='$_POST[gdescription]' WHERE gname='$_POST[pid]'
AND email='$_COOKIE[us]'";
if (!mysql_query($sql,$con))
  {
  ?>
  <script type="text/javascript">
  alert("Error: <?php echo mysql_error() ?>");
  </script>
  <?php
  die();
  }
?>
<script type="text/javascript">
alert("Game Name '<?php echo $_POST[gname] ?>' has been modified successfully!");
</script>
<?php
mysql_close($con);
}
?>
```

Dmgame.php

```
<?php
$q=$_GET["q"];
require("library/connection.php");
$sql="SELECT * FROM tbl_game WHERE gname= '".$q."'";
$result = mysql_query($sql);
while($row = mysql_fetch_array($result))
  {
  echo "<tr>";
  echo "<td>               Game Name
            </td>";
  echo "<td>: <input type='text' style='width:60mm' name='gname' value='". $row['gname']
."'/></td>";
  echo "<br/></tr>";
  echo "<tr>";
  echo "<td>                 Game Mode
            &nbs
p;</td>";
  echo "<td>: <input type='text' style='width:60mm' name='gmode' value='". $row['gmode']
."'/></td>";
  echo "<br/></tr>";
  echo "<tr>";
  echo "<td>               Game Genre  
           </td>";
  echo "<td>: <input type='text' style='width:60mm' name='ggenre' value='". $row['ggenre']
."'/></td>";
  echo "<br/></tr>";
  echo "<td>               Game Platform
        </td>";
  echo "<td>: <input type='text' style='width:60mm' name='gplatform' value='".
$row['gplatform'] ."'/></td>";
  echo "<br/></tr>";
  echo "<td>               Game Description
 </td>";
  echo "<td>:    <textarea name='gdescription' rows='7' cols='100'>".
$row['gdescription'] ."</textarea></td>";
  echo "<br/></tr>";
  echo "<tr>";
  echo "<tr>";
  echo "<td colspan='2'><br/>                 
                  
            &nbs
p;           <input
type='submit' name='submit' value='UPDATE'><td>";
  echo "</tr>";
  }mysql_close($con);?>
```

Addnewheuristic.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<?php include("header.php"); ?>
<body>
<div class="container">
<div class="contents">
<div class="headingTitle"><h1 class="titleTXT">Add New Heuristics</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
<div class="insideContent">
<div class="m">
<script type="text/javascript" src="../js/formfieldlimiter.js">
/***********************************************
* Form field Limiter v2.0- © Dynamic Drive DHTML code library (www.dynamicdrive.com)
* This notice MUST stay intact for legal use
* Visit Project Page at http://www.dynamicdrive.com for full source code
***********************************************/
</script>
<script>
   function docheck(){
      if(document.form.category.value==""){
      alert("Please enter a Heuristic name!");
      return false;
      }
      if(document.form.keyword.value==""){
      alert("Please enter the heuristic keyword!");
      return false;
      }
      if(document.form.description.value==""){
      alert("Please write some description!");
      return false;
      }
                  if(document.form.subcat.value==""){
      alert("Please write Sub-Category!");
      return false;
      }
   }
</script>
<fieldset>
<legend>Heuristic Database >> Add Heuristic</legend>
<form name="form" action="addnewheuristics.php" method="POST" onsubmit="return
docheck()">
```

```
<table>
<tr>
<td>Heuristics Author</td>
<td>: <input type="text" style="width:60mm" name="author" value=""></td>
</tr>
<tr>
<td>Heuristics Category</td>
<td>: <input type="text" style="width:60mm" name="category" value=""></td>
</tr>
<tr>
<td>Heuristics Keyword</td>
<td>: <input type="text" style="width:60mm" name="keyword" value=""></td>
</tr>
<tr>
<td>Heuristic Description:</td>
<td>   <textarea name="description" rows="5" cols="90"></textarea><div
id="des-status"></div></td>
</tr>
<tr>
</tr><tr><td><br/></td><td></td></tr>
<tr>
<td></td>
<td><input type="submit" name="submit" value="ADD" ></td>
</tr>
</table>
</div>
</form>
<script type="text/javascript">
fieldlimiter.setup({
	thefield: document.form.description, //reference to form field
	maxlength: 250,
	statusids: ["des-status"], //id(s) of divs to output characters limit in the form [id1, id2,
etc]. If non, set to empty array [].
	onkeypress:function(maxlength, curlength){ //onkeypress event handler
		if (curlength<maxlength) //if limit hasn't been reached
			this.style.border="1px solid gray" //"this" keyword returns form field
		else
			this.style.border="2px solid red"
	}
})
</script>
</div><!-- end of insideContent -->
<img src="images/contentBG_bottom.png" />
</div><!-- end of contentBG -->
</div>
</div><!-- end of container -->
```

```
</div>
<?php include("footer.php"); ?>
</body>
</html>
<?php
if ($_POST['submit']){
require("library/connection.php");
$rann=mt_rand();
$_POST['author'] = mysql_real_escape_string($_POST['author']);
$_POST['category'] = mysql_real_escape_string($_POST['category']);
$_POST['keyword'] = mysql_real_escape_string($_POST['keyword']);
$_POST['description'] = mysql_real_escape_string($_POST['description']);
$sql="INSERT INTO tbl_heu (author, description, keyword, category, email)
VALUES
('$_POST[author]','$_POST[description]','$_POST[keyword]','$_POST[category]','$_COOKI
E[us]')";
if (!mysql_query($sql,$con))
  {
  ?>
  <script type="text/javascript">
  alert("Error: <?php echo mysql_error() ?>");
  </script>
  <?php
  die();
  }
?>
<script type="text/javascript">
alert("Heuristic name '<?php echo $_POST[keyword] ?>' has been added successfully!");
document.location.href='addnewheuristics.php'
</script>
<?php
mysql_close($con);
}
?>
```

Deleteheuristic.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<?php include("header.php"); ?>
<body>
<div class="container">
<div class="contents">
<div class="headingTitle"><h1 class="titleTXT">Delete Heuristics</h1></div>
<div class="contentBG">
```

```
<img src="images/contentBG_top.png" />
<div class="insideContent">
<div class="m">
<script>
   function docheck(){
      if(document.form.id.value==""){
      alert("Please select a Heuristic!");
      return false;
      }
   }
</script>
<fieldset>
<legend>Heuristic Database >> Delete Heuristic</legend>
<form name="form" action="deleteheuristics.php" method="POST" onsubmit="return
docheck()">
<table>
<tr>
<td> Heuristic Name </td><td> :
<select name="id" style="width:60mm">
<option value=""> - Select Heuristic -</option>
<?php
require("library/connection.php");
$sql = "SELECT description,keyword FROM tbl_heu ORDER BY sno ASC";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
do {
?>
<option value="<?php printf("%s",$myrow["keyword"]);printf(" -
"."%s",$myrow["description"]); ?>"><?php printf("%s",$myrow["keyword"]);printf(" -
"."%s",$myrow["description"]); ?></option>
<?php
} while ($myrow = mysql_fetch_array($result));
} else {
}
mysql_close($con);
?>
</select>
</td>
</tr>
<tr><td><br/></td><td></td></tr>
<tr>
<td></td>
<td style="padding-left:20px"><input type="submit" name="submit" onClick="return
confirm('Are you sure you want to delete this heuristic?\n\n')" value="DELETE"><td>
</tr>
</table>
```

```
<div class="a"></div>
</fieldset>
</form>
</div>
</div><!-- end of insideContent -->
<img src="images/contentBG_bottom.png" />
</div><!-- end of contentBG -->
</div>
</div><!-- end of container -->
<?php include("footer.php"); ?>
</body>
</html>
<?php
if ($_POST['submit']){
require("library/connection.php");
$_POST['id'] = mysql_real_escape_string($_POST['id']);
$sql="DELETE FROM tbl_heu WHERE keyword='$_POST[id]'";
if (!mysql_query($sql,$con))
  {
  ?>
  <script type="text/javascript">
  alert("Error: <?php echo mysql_error() ?>");
  </script>
  <?php
  die();
  }
?>
<script type="text/javascript">
alert("All data of the project name '<?php echo $_POST[id] ?>' has been deleted
successfully!");
document.location.href='deleteheuristics.php'
</script>
<?php
mysql_close($con);
}
?>
```

Modifyheuristic.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<?php include("header.php"); ?>
<body>
<div class="container">
<div class="contents">
```

```
<div class="headingTitle"><h1 class="titleTXT">Modify Heuristics</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
<div class="insideContent">
<div class="m">
<script type="text/javascript">
function showUser(str)
{
if (str=="")
  {
  document.getElementById("txtHint").innerHTML="";
  return;
  }
if (window.XMLHttpRequest)
  {// code for IE7+, Firefox, Chrome, Opera, Safari
  xmlhttp=new XMLHttpRequest();
  }
else
  {// code for IE6, IE5
  xmlhttp=new ActiveXObject("Microsoft.XMLHTTP");
  }
xmlhttp.onreadystatechange=function()
  {
  if (xmlhttp.readyState==4 && xmlhttp.status==200)
    {
    document.getElementById("txtHint").innerHTML=xmlhttp.responseText;
    }
  }
xmlhttp.open("GET","dmheu.php?q="+str,true);
xmlhttp.send();
}
</script>
<script>
   function docheck1(){
      if(document.form.category.value==""){
      alert("Please enter a Heuristic name!");
      return false;
      }
      if(document.form.keyword.value==""){
      alert("Please enter the heuristic keyword!");
      return false;
      }
                  if(document.form.description.value==""){
      alert("Please write some description!");
      return false;
      }
```

```
                    if(document.form.subcat.value==""){
        alert("Please write Sub-Category!");
        return false;
        }
        if(document.form.description.length>250){
        alert("Maximum characters can input for remark input field is 250");
        return false;
        }
    }
</script>
<fieldset>
<legend>Heuristic Database >> Modify Heuristic</legend>
<form name="form" action="modifyheuristics.php" method="POST" onsubmit="return
docheck1()">
<table>
<tr>
<td>Heuristic Keyword&amp;nbsp; &amp;nbsp; &amp;nbsp; &amp;nbsp;</td>
<td>: <select name="pid" style="width:60mm" onchange="showUser(this.value)">
<option value=""> - Select Heuristic -</option>
<?php
require("library/connection.php");
$sql = "SELECT keyword FROM tbl_heu";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
do {
?>
<option value="<?php printf("%s",$myrow["keyword"]); ?>"><?php
printf("%s",$myrow["keyword"]); ?></option>
<?php
} while ($myrow = mysql_fetch_array($result));
} else {
}
mysql_close($con);
?>
</table>
<table>
<tr><td>
<div id="txtHint"></div>
</td></tr></table>
<div class="a"></div>
</form>
</div>
</div><!-- end of insideContent -->
<img src="images/contentBG_bottom.png" />
</div><!-- end of contentBG -->
</div>
```

```
</div><!-- end of container -->
<?php include("footer.php"); ?>
</body>
</html>
<?php
if ($_POST['submit']){
require("library/connection.php");
$_POST['category'] = mysql_real_escape_string($_POST['category']);
$_POST['keyword'] = mysql_real_escape_string($_POST['keyword']);
$_POST['subcat'] = mysql_real_escape_string($_POST['subcat']);
$_POST['description'] = mysql_real_escape_string($_POST['description']);
$sql="UPDATE tbl_heu SET
category='$_POST[category]',keyword='$_POST[keyword]',subcat='$_POST[subcat]',descrip
tion='$_POST[description]' WHERE keyword='$_POST[pid]' AND email='$_COOKIE[us]'";
if (!mysql_query($sql,$con))
  {
  ?>
  <script type="text/javascript">
  alert("Error: <?php echo mysql_error() ?>");
  </script>
  <?php
  die();
  }
?>
<script type="text/javascript">
alert("Heuristic Keyword '<?php echo $_POST[keyword] ?>' has been modified
successfully!");
</script>
<?php
mysql_close($con);
}
?>
```

Dmheu.php

```
<?php
$q=$_GET["q"];
require("library/connection.php");
$sql="SELECT * FROM tbl_heu WHERE keyword= '".$q."'";
$result = mysql_query($sql);
while($row = mysql_fetch_array($result))
  {
  echo "<tr>";
  echo "<td>Heuristic Category        </td>";
  echo "<td>: <input type='text' style='width:60mm' name='category' value='".
$row['category'] ."'/></td>";
```

```
  echo "<br/></tr>";
  echo "<tr>";
  echo "<tr>";
  echo "<td>Heuristic Keyword
        </td>";
  echo "<td>: <input type='text' style='width:60mm' name='keyword' value='".
$row['keyword'] ."'/></td>";
  echo "<br/></tr>";
  echo "<tr>";
  echo "<td>Sub-Category        
      </td>";
  echo "<td>: <input type='text' style='width:60mm' name='subcat' value='". $row['subcat']
."'/></td>";
  echo "<br/></tr>";
  echo "<td>Description
           </td>";
  echo "<td>         : <textarea name='description' rows='7'
cols='70'>". $row['description'] ."</textarea></td>";
  echo "<br/></tr>";
  echo "<tr>";
  echo "<tr>";
  echo "<td colspan='2'><br/>                 
                  
            &nbs
p; <input type='submit' name='submit' value='UPDATE'><td>";
  echo "</tr>";
  }
mysql_close($con);
?>
```

Addnewuser.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<?php include("header.php"); ?>
<body>
<div class="container">
<div class="contents">
<div class="headingTitle"><h1 class="titleTXT">Add New User</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
```

```
<div class="insideContent">
<div class="m">
<script>
   function docheck(){
      if(document.form.fullname.value==""){
      alert("Please enter you Name!");
      return false;
      }
      if(document.form.username.value==""){
      alert("Please enter username");
      return false;
      }
      if(document.form.password.value==""){
      alert("Please enter password");
      return false;
      }
                  if(document.email.value==""){
      alert("Please enter email address");
      return false;
      }
   }
</script>
<fieldset>
<legend>Home >> Add New User</legend>
<form name="form" action="addnewuser.php" method="POST" onsubmit="return
docheck()">
<div class="a"><div class="l">Full Name</div><div class="r"><INPUT type="text"
name="fullname"></div></div>
<div class="a"><div class="l">Username</div><div class="r"><INPUT type="text"
name="username"></div></div>
<div class="a"><div class="l">Password</div><div class="r"><INPUT type="password"
name="password"></div></div>
<div class="a"><div class="l">Email Address</div><div class="r"><INPUT type="text"
name="email"></div></div>
```

```
<div class="a"><div class="l">Contact No</div><div class="r"><INPUT type="text"
name="contact"></div></div>
<div class="a"><div class="l">Job Title</div><div class="r"><INPUT type="text"
name="jobtitle"></div></div>
<div class="a"><div class="l">Organization</div><div class="r"><INPUT type="text"
name="orginization"></div></div>
<div class="a"><div class="l"> </div><div class="r"><INPUT class="button"
type="submit" name="submit" value="Register"></div></div>
<div class="a"></div>
</form>
</div>
</div><!-- end of insideContent -->
<img src="images/contentBG_bottom.png" />
</div><!-- end of contentBG -->
</div>
</div><!-- end of container -->
<?php include("footer.php"); ?>
</body>
</html>
<?php
if ($_POST['submit']){
require("library/connection.php");
$rann=mt_rand();
$_POST['name'] = mysql_real_escape_string($_POST['name']);
$_POST['uername'] = mysql_real_escape_string($_POST['username']);
$_POST['password'] = mysql_real_escape_string($_POST['password']);
$_POST['email'] = mysql_real_escape_string($_POST['email']);
$_POST['contact'] = mysql_real_escape_string($_POST['contact']);
$_POST['jobtitle'] = mysql_real_escape_string($_POST['jobtitle']);
$_POST['orginization'] = mysql_real_escape_string($_POST['orginization']);
$sql="INSERT INTO tbl_users(fullname, username,
password,email,contact,jobtitle,orginization,date)
VALUES
('$_POST[fullname]','$_POST[username]','$_POST[password]','$_POST[email]','$_POST[co
ntact]','$_POST[jobtitle]','$_POST[orginization]','$_COOKIE[us]')";
```

```
if (!mysql_query($sql,$con))
  {
  ?>
  <script type="text/javascript">
  alert("Error: <?php echo mysql_error() ?>");
  </script>
  <?php
  die();
  }
?>
<script type="text/javascript">
alert("User '<?php echo $_POST[username] ?>' has been created successfully!");
document.location.href='addnewuser.php'
</script>
<?php
mysql_close($con);
}
?>
```

Signup.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Playability Heuristics Evaluation System</title>
<link rel="stylesheet" type="text/css" href="css/MainStyles2.css" />
<script src="Scripts/AC_RunActiveContent.js" type="text/javascript"></script>
</head>
<body>
<div class="container">
<div class="login">
```

```
<img src="images/logoLeft.png" style="margin: 0 0 0 0; float:left;" />
</div><!-- end of login div -->
<div class="headingTitle"><h1 class="titleTXT">Create New Account</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
<div class="m">
<script>
   function docheck(){
      if(document.form.fullname.value==""){
      alert("Please enter you Name!");
      return false;
      }
      if(document.form.username.value==""){
      alert("Please enter username");
      return false;
      }
      if(document.form.password.value==""){
      alert("Please enter password");
      return false;
      }
     if(document.email.value==""){
      alert("Please enter email address");
      return false;
      }
   }
</script>
<div class="insideContent">
<form name="form" action="signup.php" method="POST" onsubmit="return docheck()">
<fieldset><legend>Enter Your Details</legend>
<div class="a"><div class="l">Full Name</div><div class="r"><INPUT type="text"
name="fullname"></div></div>
<div class="a"><div class="l">Username</div><div class="r"><INPUT type="text"
name="username"></div></div>
```

```
<div class="a"><div class="l">Password</div><div class="r"><INPUT type="password"
name="password"></div></div>
<div class="a"><div class="l">Email Address</div><div class="r"><INPUT type="text"
name="email"></div></div>
<div class="a"><div class="l">Contact No</div><div class="r"><INPUT type="text"
name="contact"></div></div>
<div class="a"><div class="l">Job Title</div><div class="r"><INPUT type="text"
name="jobtitle"></div></div>
<div class="a"><div class="l">Organization</div><div class="r"><INPUT type="text"
name="orginization"></div></div>
<div class="a"><div class="l"> </div><div class="r"><INPUT class="button"
type="submit" name="submit" value="Register"></div></div>
<div class="a"></div>
</fieldset>
</form>
</div><!-- end of insideContent -->
</div><!-- end of contentBG -->
<img src="images/contentBG_bottom.png" />
</div>
</div><!-- end of container -->
<div class="footer">
<div class="footer_body">
Copyright &copy <a href="http://www.utp.edu.my/" class="footerLink">Universiti
Teknologi PETRONAS</a>, Malaysia. All Rights Reserved
</div><!-- end of footer_body -->
</div><!-- end footer -->
</body>
</html>
<?php
if ($_POST['submit']){
require("library/connection.php");
$rann=mt_rand();
$_POST['name'] = mysql_real_escape_string($_POST['name']);
$_POST['uername'] = mysql_real_escape_string($_POST['username']);
$_POST['password'] = mysql_real_escape_string($_POST['password']);
```

```
$_POST['email'] = mysql_real_escape_string($_POST['email']);
$_POST['contact'] = mysql_real_escape_string($_POST['contact']);
$_POST['jobtitle'] = mysql_real_escape_string($_POST['jobtitle']);
$_POST['orginization'] = mysql_real_escape_string($_POST['orginization']);
$sql="INSERT INTO tbl_users(fullname, username,
password,email,contact,jobtitle,orginization)
VALUES
('$_POST[fullname]','$_POST[username]','$_POST[password]','$_POST[email]','$_POST[co
ntact]','$_POST[jobtitle]','$_POST[orginization]')";
if (!mysql_query($sql,$con))
  {
  ?>
  <script type="text/javascript">
  alert("Error: <?php echo mysql_error() ?>");
  </script>
  <?php
  die();
  }
?>
<script type="text/javascript">
alert("Your Account '<?php echo $_POST[username] ?>' has been created successfully!\n
Please Login to Access the System");
document.location.href='index.php'
</script>
<?php
mysql_close($con);
}
?>
```

Userprofile.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<?php include("header.php"); ?>
<body>
```

```
<div class="container">
<div class="contents">
<div class="headingTitle"><h1 class="titleTXT">User Profile</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
<div class="insideContent">
<div class="m">
<script>
   function docheck1(){
      if(document.form.oldpassword.value==""){
      alert("Please Enter the Old Password!");
      return false;
      }
      if(document.form.newpassword.value==""){
      alert("Please enter the New Password!");
      return false;
      }
      if(document.form.rnewpassword.value==""){
      alert("Please Enter the Confirm New Password!");
      return false;
      }
      if(document.form.nw.value!=document.form.pw.value){
      alert("New Password and Confirm New Password is not the same!");
      return false;
      }
   }
</script>
<fieldset>
<legend>Home >> User Profile</legend>
<p></p>
<form name="form" action="userprofile.php" method="POST" onsubmit="return
docheck1()">
<table>
<?php
require("library/connection.php");
//$sql = "SELECT ip FROM data";
//$result = mysql_query($sql,$con);
//if ($myrow = mysql_fetch_array($result)){
//$ip=$myrow["ip"];
//}
$sql = "SELECT * FROM tbl_users WHERE username='$_COOKIE[un]'";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
do {
//$string = preg_replace("(\r\n\r\n|\n\n|\r\r)", "<p />", $myrow["resources"]);
//$string = stripcslashes(preg_replace("(\r\n|\n|\r)", "<br />", $string));
```

```
?>
<tr>
<td>Username</td>
<td>: <input type="text" name="username" style="width:60mm" value="<?php
printf("%s",$_COOKIE[un]); ?>" disabled="disabled"> </td>
</tr>
<tr>
<td>Name</td>
<td>: <input type="text" name="fullname" style="width:60mm" value="<?php
printf("%s",$myrow["fullname"]); ?>" </td>
</tr>
<tr>
<td>Job Title</td>
<td>: <input type="text" name="jobtitle" style="width:60mm" value="<?php
printf("%s",$myrow["jobtitle"]); ?>" </td>
</tr>
<tr>
<td>Orginization</td>
<td>: <input type="text" name="orginization" style="width:60mm" value="<?php
printf("%s",$myrow["orginization"]); ?>"> </td>
</tr>
<tr>
<td>Contact</td>
<td>: <input type="text" name="contact" style="width:60mm" value="<?php
printf("%s",$myrow["contact"]); ?>"> </td>
</tr>
<tr>
<td>Email</td>
<td>: <input type="email" name="email" style="width:60mm" value="<?php
printf("%s",$myrow["email"]); ?>"> </td>
</tr>
<tr>
<td>Old Password</td>
<td>: <input type="password" name="oldpassword" style="width:60mm" value=""> </td>
</tr>
<tr>
<td>New Password</td>
<td>: <input type="password" name="newpassword" style="width:60mm" value=""> </td>
</tr>
<tr>
<td>Confirm New Password</td>
<td>: <input type="password" name="rnewpassword" style="width:60mm" value=""> </td>
</tr>
<tr><td><br/></td><td></td></tr>
<tr>
```

```
<td align="center" colspan="2"><input type="submit" name="submit"
value="UPDATE"><td>
</tr>
<?php
} while ($myrow = mysql_fetch_array($result));
} else {
}
?>
</table>
</form>
</fieldset>
</div>
</div><!-- end of insideContent -->
<img src="images/contentBG_bottom.png" />
</div><!-- end of contentBG -->
</div>
</div><!-- end of container -->
<?php include("footer.php"); ?>
</body>
</html>
<?php
if ($_POST['submit']){
require("library/connection.php");
function myAddSlashes($text) {
        if(get_magic_quotes_gpc())
                return $text;
        else
                return addslashes($text);
}
$oldpassword=myAddSlashes($_POST["oldpassword"]);
$newpassword=myAddSlashes($_POST["rnewpassword"]);
$sql = "SELECT * FROM tbl_users WHERE username='$_COOKIE[us]' AND
password='$oldpassword'";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
$sql="UPDATE tbl_users SET password='$newpassword' WHERE
username='$_COOKIE[us]'";
if (!mysql_query($sql,$con))
  {
  die('Error: ' . mysql_error());
  }
?>
<script>
alert("Your password has been modified successfully!");
</script>
<?php
```

```
}else{
?>
<script>
alert("Your old password is incorrect!\nPassword not changed.");
</script>
<?php
}
mysql_close($con);
}
?>
```

Forgetpassword.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Playability Heuristics Evaluation System</title>
<link rel="stylesheet" type="text/css" href="css/MainStyles2.css" />
<script src="Scripts/AC_RunActiveContent.js" type="text/javascript"></script>
</head>
<body>
<div class="container">
<div class="login">
<img src="images/logoLeft.png" style="margin: 0 0 0 0; float:left;" />
</div><!-- end of login div -->
<?php
define('IN_SCRIPT', true);
// Start a session
//session_start();
//Connect to the MySQL Database
include 'library/connection.php';
//this function will display error messages in alert boxes, used for login forms so if a field is
invalid it will still keep the info
//use error('foobar');
function error($msg) {
?>
```

```
<html>
<head>
<script language="JavaScript">
<!--
alert("<?=$msg?>");
history.back();
//-->
</script>
</head>
</html>
<?
exit;
}
//This functions checks and makes sure the email address that is being added to database is valid in format.
function check_email_address($email) {
// First, we check that there's one @ symbol, and that the lengths are right
if (!ereg("^[^@]{1,64}@[^@]{1,255}$", $email)) {
// Email invalid because wrong number of characters in one section, or wrong number of @ symbols.
return false;
}
// Split it into sections to make life easier
$email_array = explode("@", $email);
$local_array = explode(".", $email_array[0]);
for ($i = 0; $i < sizeof($local_array); $i++) {
if (!ereg("^(([A-Za-z0-9!#$%&'*+/=?^_`{|}~-][A-Za-z0-9!#$%&'*+/=?^_`{|}~\.-]{0,63})|(\"[^(\\|\")]{0,62}\"))$", $local_array[$i])) {
return false;
}
}
if (!ereg("^\[?[0-9\.]+\]?$", $email_array[1])) { // Check if domain is IP. If not, it should be valid domain name
$domain_array = explode(".", $email_array[1]);
if (sizeof($domain_array) < 2) {
```

```
return false; // Not enough parts to domain}
for ($i = 0; $i < sizeof($domain_array); $i++) {
if (!ereg("^(([A-Za-z0-9][A-Za-z0-9-]{0,61}[A-Za-z0-9])|([A-Za-z0-9]+))$",
$domain_array[$i])) {
return false;
}}}
return true;}
if (isset($_POST['submit'])) {
if ($_POST['forgotpassword']=='') {
error('Please Fill in Email.');}
if(get_magic_quotes_gpc()) {
$forgotpassword = htmlspecialchars(stripslashes($_POST['forgotpassword']));
}
else {
$forgotpassword = htmlspecialchars($_POST['forgotpassword']);
}
//Make sure it's a valid email address, last thing we want is some sort of exploit!
if (!check_email_address($_POST['forgotpassword'])) {
error('Email Not Valid - Must be in format of name@domain.com');
}
// Lets see if the email exists
$sql = "SELECT * FROM tbl_users WHERE email = '$forgotpassword'";
$result = mysql_query($sql)or die('Could not find member: ' . mysql_error());
if (!mysql_result($result,0,0)>0) {
error('Email Not Found!');
}
//Generate a RANDOM MD5 Hash for a password
$random_password=md5(uniqid(rand()));
//Take the first 8 digits and use them as the password we intend to email the user
$emailpassword=substr($random_password, 0, 8);
//Encrypt $emailpassword in MD5 format for the database
$newpassword = md5($emailpassword);
// Make a safe query
$query = sprintf("UPDATE tbl_users SET `password` = '%s'
WHERE `email` = '$forgotpassword'",
```

```
mysql_real_escape_string($newpassword));
mysql_query($query)or die('Could not update members: ' . mysql_error());
//Email out the infromation
$subject = "Your New Password";
$message = "Your new password is as follows:----------
Password: $emailpassword ----------
Please make note this information has been encrypted into our database
This email was automatically generated.";
if(!mail($forgotpassword, $subject, $message,  "FROM: $site_name <$site_email>")){
die ("Sending Email Failed, Please Contact Site Admin! ($site_email)");
}else{
error('New Password Sent!.');
}
}
else {
?>
<div class="headingTitle"><h1 class="titleTXT">Forgot Password</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
<div class="insideContent">
<div class="m">
<form name="forgotpassword" action="" method="post">
<table>
<tr>
<div class="l"><td>Email Address:</td></div>
<td><input name="forgotpassword" type="text" value="" id="forgotpassword" /></td>
</tr>
<tr>
<div class="l"><td><input type="submit" name="submit" value="Submit"
class="mainoption" /></td></div>
</tr>
<div class="a"></div>
</table>
</form>
<?}?>
```

```
</div><!-- end of insideContent -->
</div><!-- end of contentBG -->
<img src="images/contentBG_bottom.png" />
</div>
</div><!-- end of container -->
<div class="footer">
<div class="footer_body">
Copyright &copy <a href="http://www.utp.edu.my/" class="footerLink">Universiti
Teknologi PETRONAS</a>, Malaysia. All Rights Reserved
</div><!-- end of footer_body -->
</div><!-- end footer -->
</body>
</html>
```

Listgames.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<?php include("header.php"); ?>
<head>
<style type="text/css" title="currentStyle">
@import "/style/demo_table.css";
</style>
<script type="text/javascript" language="javascript" src="../js/jquery.js"></script>
<script type="text/javascript" language="javascript" src="../js/jquery.dataTables.js"></script>
<script type="text/javascript" charset="utf-8">
jQuery.fn.dataTableExt.aTypes.push(
                        function ( sData ) {
                                return 'html';
                        }
                        );

                        $(document).ready(function() {
                                $('#example').dataTable();
                        } );
                </script>
</head>
<body>
<script>
   function doCheck(){
      if(document.form.id.value==""){
```

```
        alert("Please select a project name!");
        return false;
        }
        if(document.form.id1.value==""){
        alert("Please select the status!");
        return false;
        }
    }
</script>
<div class="clear"></div>
<div class="containerMain">
<div class="contents">
<div class="headingTitle"><h1 class="titleTXT">Stored Games In Database</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
<div class="insideContent">
<fieldset>
<legend>Games Database >> List Games</legend>
<table cellpadding="0" cellspacing="0" border="1" bordercolor="black" class="display"
id="example">
            <thead>
                    <tr align="left">
                            <th>Title</th>
                            <th>Type</th>
                            <th>Genre</th>
                            <th>Platform</th>
                            <th>Description</th>

                    </tr>
            </thead>
            <tbody>
<?php
require("library/connection.php");
//$sql = "SELECT ip FROM data";
//$result = mysql_query($sql,$con);
//if ($myrow = mysql_fetch_array($result)){
//$ip=$myrow["ip"];
//}
$sql = "SELECT * FROM tbl_game ORDER BY gname ASC";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
do {
$string = preg_replace("(\r\n\r\n|\n\n|\r\r)", "<p />", $myrow["resources"]);
$string = stripcslashes(preg_replace("(\r\n|\n|\r)", "<br />", $string));

?>
```

```
		<tr>
		<td><?php printf("%s",$myrow["gname"]); ?></td>
		<td><?php printf("%s",$myrow["gmode"]) ?></td>
		<td><?php printf("%s",$myrow["ggenre"]) ?></td>
		<td><?php printf("%s",$myrow["gplatform"]) ?></td>
		<td><?php printf("%s",$myrow["gdescription"]) ?></td>
		</tr>
<?php
} while ($myrow = mysql_fetch_array($result));
} else {
}
?>
</table>
</div>
</fieldset>
</form>
</div><!-- end of insideContent -->
<img src="images/contentBG_bottom.png" />
</div><!-- end of contentBG -->
</div>
</div><!-- end of container -->
<?php include("footer.php"); ?>
</body>
</html>
```

Listheuristics.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<?php include("header.php"); ?>
<head>
<style type="text/css" title="currentStyle">
@import "/style/demo_table.css";
</style>
<script type="text/javascript" language="javascript" src="../js/jquery.js"></script>
<script type="text/javascript" language="javascript" src="../js/jquery.dataTables.js"></script>
<script type="text/javascript" charset="utf-8">
                        jQuery.fn.dataTableExt.aTypes.push(
                                function ( sData ) {
                                        return 'html';
                                }
                        );

                        $(document).ready(function() {
```

```
                $('#example').dataTable();
            } );
        </script>
</head>
<body>
<script>
   function doCheck(){
      if(document.form.id.value==""){
      alert("Please select a project name!");
      return false;
      }
      if(document.form.id1.value==""){
      alert("Please select the status!");
      return false;
      }
   }
</script>
<div class="clear"></div>
<div class="containerMain">
<div class="contents">
<div class="headingTitle"><h1 class="titleTXT">Stored Heuristics In Database</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
<div class="insideContent">
<fieldset>
<legend>Heuristic Database >> List Heuristics</legend>
<table cellpadding="0" cellspacing="0" border="1" bordercolor="black" class="display"
id="example">
        <thead>
            <tr align="left">
                <th>Proposed Author</th>
                <th>Heuristic Keyword</th>
                <th>Heuristic Description</th>
                <th>Heuristic Category</th>

            </tr>
        </thead>
        <tbody>
<?php
require("library/connection.php");
//$sql = "SELECT ip FROM data";
//$result = mysql_query($sql,$con);
//if ($myrow = mysql_fetch_array($result)){
//$ip=$myrow["ip"];
//}
```

```
$sql = "SELECT * FROM tbl_heu ORDER BY sno ASC";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
do {
$string = preg_replace("(\r\n\r\n|\n\n|\r\r)", "<p />", $myrow["resources"]);
$string = stripcslashes(preg_replace("(\r\n|\n|\r)", "<br />", $string));
?>
        <tr>
        <td><?php printf("%s",$myrow["author"]); ?></td>
        <td><?php printf("%s",$myrow["keyword"]) ?></td>
        <td><?php printf("%s",$myrow["description"]) ?></td>
        <td><?php printf("%s",$myrow["subcat"]) ?></td>
        </tr>
<?php
} while ($myrow = mysql_fetch_array($result));
} else {
}
?>
</table>
</div>
</fieldset>
</form>
</div><!-- end of insideContent -->
<img src="images/contentBG_bottom.png" />
</div><!-- end of contentBG -->
</div>
</div><!-- end of container -->
<?php include("footer.php"); ?>
</body>
</html>
```

Listusers.php

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<?php include("header.php"); ?>
<head>
<style type="text/css" title="currentStyle">
@import "/style/demo_table.css";
</style>
<script type="text/javascript" language="javascript" src="../js/jquery.js"></script>
<script type="text/javascript" language="javascript" src="../js/jquery.dataTables.js"></script>
<script type="text/javascript" charset="utf-8">
                        jQuery.fn.dataTableExt.aTypes.push(
```

```
                                function ( sData ) {
                                        return 'html';
                                }
                        );

                        $(document).ready(function() {
                                $('#example').dataTable();
                        } );
                </script>
</head>
<body>
<script>
   function doCheck(){
      if(document.form.id.value==""){
      alert("Please select a project name!");
      return false;
      }
      if(document.form.id1.value==""){
      alert("Please select the status!");
      return false;
      }
   }
</script>
<div class="clear"></div>
<div class="containerMain">
<div class="contents">
<div class="headingTitle"><h1 class="titleTXT">Registered Users</h1></div>
<div class="contentBG">
<img src="images/contentBG_top.png" />
<div class="insideContent">
<fieldset>
<legend>Home >> List Registed Users</legend>
<table cellpadding="0" cellspacing="0" border="1" bordercolor="black" class="display"
id="example">
        <thead>
                <tr align="left">
                        <th>Name</th>
                        <th>Job Title</th>
                        <th>Orginization</th>
                        <th>Email</th>
                        <th>Contact</th>
                </tr>
        </thead>
        <tbody>
<?php
require("library/connection.php");
```

```
//$sql = "SELECT ip FROM data";
//$result = mysql_query($sql,$con);
//if ($myrow = mysql_fetch_array($result)){
//$ip=$myrow["ip"];
//}
$sql = "SELECT * FROM tbl_users ORDER BY fullname ASC";
$result = mysql_query($sql,$con);
if ($myrow = mysql_fetch_array($result)){
do {
$string = preg_replace("(\r\n\r\n|\n\n|\r\r)", "<p />", $myrow["resources"]);
$string = stripcslashes(preg_replace("(\r\n|\n|\r)", "<br />", $string));
?>
        <tr>
        <td><?php printf("%s",$myrow["fullname"]); ?></td>
        <td><?php printf("%s",$myrow["jobtitle"]) ?></td>
        <td><?php printf("%s",$myrow["orginization"]) ?></td>
        <td><?php printf("%s",$myrow["email"]) ?></td>
        <td><?php printf("%s",$myrow["contact"]) ?></td>
        </tr>
<?php
} while ($myrow = mysql_fetch_array($result));
} else {
}
?>
</table>
</div>
</fieldset>
</form>
</div><!-- end of insideContent -->
<img src="images/contentBG_bottom.png" />
</div><!-- end of contentBG -->
</div>
</div><!-- end of container -->
</body>
</html>
<?php include("footer.php"); ?>
```

mainStyle.css

```
@import url("dropdown/dropdowneffect.min.css");
@import url("dropdowneffect-responsive.min.css");
body {
	font-family:Arial, Helvetica, sans-serif;
	font-size:12px;
	background-color:#c2e1f4;
	background-image:url(../images/bg-scanlines.png);
	background-repeat:repeat;
	margin:0;
	padding:0;
}
.clear {
	margin:0;
	padding:0;
	background:none;
	clear:both;
}
.containerMain {
	width:1004px;
	height:auto;
	min-height:470px;
	margin: 0 auto;
}
.header {
	width:100%;
	height:132px;
	background-image:url(../images/header_bg.jpg);
	background-repeat:repeat-x;
}
.header_body {
	width:1004px;
	height:132px;
	margin: 0 auto;
	position:relative;
}
.header_shadow {
	width:582px;
	height:3px;
	position:absolute;
	top:132px;
	left:300px;
}
.logoMain {
	width:501px;
	height:126px;
```

```
		position:absolute;
		z-index:0;
		left: 42px;
		top: 7px;
}
ul.welcome {
		display:block;
		width:300px;
		height:50px;
		float:right;
		list-style:none;
		margin:0;
		padding:0;
		font-family:"Trebuchet MS", Tahoma, Arial;
		font-size:13px;
		color:#aaaaaa;
}
ul.welcome li {
		margin: 2px 0 0 0;
		padding: 20px 2px 0 10px;
		float:left;
}
ul.welcome li.logout {
		display:block;
		width:50px;
		height:70px;
		padding: 20px 0 0 70px;
		background-image:url(../images/logoutIMG.png);
		background-position:top left;
		background-repeat:no-repeat;
}
a.welcomeLink {
		font-family:"Trebuchet MS", Tahoma, Arial;
		font-size:13px;
		color:#aaaaaa;
		text-decoration:none;
}
a.welcomeLink:hover {
		color:#e1e0e0;
		text-decoration:underline;
}
.navbar {
		padding-top:0px;
		margin-bottom:60px;
}
.navbar .container {
```

```
        width: 940px;
        padding-bottom:0px;
        border-bottom:0px solid #eee;
        margin-bottom:0px;
        position: absolute;
        top:75px;
}
.navbar-inner {
        background:transparent!important;
        background-image: none!important;
        box-shadow:none;
        -moz-box-shadow:none;
        -webkit-box-shadow:none;
        padding:19px 0 0 0;
        filter:none;
}
.navbar .nav-responsive {
        display:none;
}
.navbar .brand {
        font-weight:bold;
        font-size:36px;
        letter-spacing:-2px;
        line-height:0.7em;
        color:#000;
        -webkit-transition:all 0.1s;
        -moz-transition:all 0.1s;
        -o-transition:all 0.1s;
        -ms-transition:all 0.1s;
        transition:all 0.1s;
}
.navbar .brand:hover {
        color:#7ED090;
}
.navbar .nav {float:right}
.navbar .nav > li:hover {
        border-bottom:1px solid #ccc;
}
.navbar .nav > li.active {
        border-bottom:1px solid #aaa;

}
.navbar .nav > li.active > a,
.navbar .nav > li.active:hover > a {
        background:none;
        font-weight:bold;
```

```
        font-weight:normal;
        color:#000;
}
.navbar .nav > li {
        margin:4px 0 0 10px;
        position:relative;
}
.navbar .nav > li a, .navbar .nav > li a:hover {
        text-decoration:none;
}
.navbar .nav > li > a {
        color: #444!important;
        font-size:1.1em;
        text-shadow: 0 -1px 0 rgba(255,255,255, 0.25);
}
.navbar .nav > li > a:hover {
        color:#222;
}
.navbar li a {
        display:block!important;
}

        .navbar .nav li.dropdown:hover {
                border-radius:3px;
        }
        .navbar .nav li.dropdown:hover {
                background:#444;
        }
        .navbar .nav li.dropdown a {
                text-decoration: none;
        }
        .navbar .nav li.dropdown:hover a {
                color:#fff!important;
        }
        .navbar .nav li.dropdown ul li:first-child {
                border-radius:0 3px 0 0;
                -moz-border-radius:0 3px 0 0;
                -webkit-border-radius:0 3px 0 0;
        }
        .navbar .nav li.dropdown ul li:last-child {
                border-radius:0 0 3px 3px;
                -moz-border-radius:0 0 3px 3px;
                -webkit-border-radius:0 0 3px 3px;
        }
        .navbar .nav li ul {
                margin:0;
```

```
                display:none;
                z-index:99;
        }
        .navbar .nav li ul li {
                margin:0;
                padding:0;
                background:#444;
                width:160px;
                border-bottom:1px solid rgba(255,255,255,0.1);
                -webkit-transition:all 0.3s;
                -moz-transition:all 0.3s;
                -o-transition:all 0.3s;
                -ms-transition:all 0.3s;
                transition:all 0.3s;
        }
        .navbar .nav li ul li:hover {
                background:#F26A46;
        }
        .navbar .nav li ul li a {
                padding:6px 10px;
                margin:0;
                display:inline-block;
                text-decoration:none;
                color:#fff;
                font-size:0.9em;
        }
        .navbar .nav li:hover ul {
                margin:0;
                list-style-type:none;
                margin:0;
                display:block;
                position:absolute;
                top:2.9em;
}

.contents {
        width:939px;
        height:auto;
        margin: 30px 0 0 20px;
}

.headingTitle {
        width:939px;
        height:66px;
        background-image:url(../images/content_header.jpg);
        background-position:top left;
```

```
	background-repeat:no-repeat;
}
h1.titleTXT {
	font-family:"Trebuchet MS", Tahoma, Arial;
	color:#595959;
	font-size:23px;
	margin: 15px 0 0 30px;
	float:left;
}
.contentBG {
	background-image:url(../images/contentBG_middle.png);
	background-repeat:repeat-y;
	background-position:top left;
	margin:0;
	padding:0;
	min-height:380px;

}
.insideContent {
	width:820px;
	height:auto;
	min-height:380px;
	padding:0;
	margin: 0 0 0 60px;
	background-image:url(../images/unilogo.gif);
	background-repeat:no-repeat;
	background-position:center 0;
}
h3.headingThree {
	font-family:"Trebuchet MS", Tahoma, Arial;
	font-size:15px;
	color:#666464;
}
.footer {
	width:100%;
	height:45px;
	background-image:url(../images/footer_bg.gif);
	background-repeat:repeat-x;
	background-position:top left;
	margin: 30px 0 20px 0;
}
.footer_body {
	width:800px;
	height:45px;
	margin:0 auto;
	padding: 11px 0 0 250px;
```

```
	font-family:"Trebuchet MS", Tahoma, Arial;
	font-size:15px;
	color:#FFFFFF;
}
a.footerLink {
	font-family:"Trebuchet MS", Tahoma, Arial;
	font-size:15px;
	color:#FFFFFF;
	text-decoration:none;
}
a.footerLink:hover {
	text-decoration:underline;
}
fieldset{
border-color:#4156C5;
padding-left: 3px;
padding-bottom: 3px;
padding-right: 3px;
padding-top: 0px;
width:99%;
}
legend{
font-size: 10pt;
font-weight:bold;
color:#6E6E6E;
}
.m
{
	width: 560px;
	padding: 20px;
	height: auto;
}
.l
{
	width: 140px;
	margin: 0px;
	padding: 0px;
	float: left;
	text-align: right;
}
.r
{
	width: 300px;
	margin: 0px;
	padding: 0px;
	float: right;
```

```
        text-align: left;
}
.a
{
        clear: both;
        width: 470px;
        padding: 10px;
}
```