# Enjoyable Game Design: Validation of Motor-Impaired User GameFlow Model

Nurul Hidayah Mat Zain, Azizah Jaafar, and Fariza Hanis Abdul Razak

*Abstract*—**The availability of a scale that effectively measures enjoyable design specifically for motor-impaired users (MIU) can support the game designer to understand the experience from the extraordinary user's perspective. The MIU-GameFlow Model in this study involves seven elements: concentration, challenge, player control, clear goal, feedback, immersion, and flexibility. In this study, we focused on validation of the MIU-GameFlow Model. The validation of the MIU-GameFlow Model was carried out by conducting expert reviews of two accessible games (one high-rating game and one low-rating game) using the MIU-GameFlow Model criteria. The result was an understanding of enjoyable game design in accessible games and the testing of the MIU-GameFlow Model as an evaluation tool. The MIU-GameFlow Model criteria were capable of differentiating the high-rated and low-rated games. We concluded that the MIU-GameFlow Model can be used in evaluating enjoyable game designs for MIU.**

*Index Terms*—**Motor impaired users, enjoyable design, game design, computer games.**

## I. Introduction

One of the main issues in designing a computer game is understanding how to design a computer game for special needs users [1], [2]. Understanding the needs of extraordinary users such as motor-impaired users (MIU) in computer games can enrich the user experience. This is very important, since the user experience will eventually be an important element in the computer game's success [3]. However, research in this area is still narrow, especially in regard to the enjoyment experience context [4]. Hence, we conclude that there is a need for studies that establish a model for under-standing enjoyable game design for MIU. The aim of this study is to elaborate the validation of the MIU-GameFlow Model.

## II. Literature Review

### A. Theoretical Background

A variety of theories and methods have been used by academics to understand the user experience [5], but relatively few studies have specifically addressed the design of computer games for MIU enjoyment [6]. Flow Theory was introduced by Csikszentmihalyi [7] in the 1960s to describe enjoyment as a consequence of daily activities. Csikszentmihalyi [8] described flow as an emotional state of optimal pleasure which arises when individuals are engaged in activities. People in this state perceive their activity to be enjoyable, even if no goal is reached. Flow Theory [9] comprises eight components: task completion, task concentration, clear goals of tasks, immediate feedback, control actions, effortlessness that eliminates frustrations, the disappearance of self-conscientiousness and the increase of self-awareness, and the distortion of the sense of time. Flow Theory is the key idea used to explain the experience of users while playing computer games [10].

The GameFlow Model was proposed by Sweester and Wyeth [11]. The model is constructed from Flow Theory and incorporates appropriate criteria from the computer game usability and user experience literature. The Game Flow Model consists of eight core elements, namely, concentration, challenge, skills, control, clear goals, feedback, immersion, and social engagement.

Fu *et al*. [12] proposed the EGameFlow scale that measures user enjoyment of e-learning games. The scale was built by restructuring the GameFlow criteria into appropriate criteria and combining them with the factor of knowledge improvement. EGameFlow can determine the strengths of a game in terms of user enjoyment from the students' perspective. The principal elements in this scale are concentration, goal clarity, feedback, challenge, autonomy, immersion, social interaction and knowledge improvement.

The tripartite Media Enjoyment Model was presented by Nabi and Krcmar [13] to conceptualize enjoyment as an attitude with affective, cognitive and behavioral antecedents and consequences. The affective element emphasizes empathy and positive and negative moods; the cognitive aspect emphasizes judgments of the game characters' actions; and the behavioral feature is connected to selective exposure in terms of the player's viewing intent as well as their behavior during viewing.

### B. MIU-GameFlow Model

To study the GameFlow and EGameFlow in relation to enjoyable game design for MIU, we first needed to highlight the unique characteristics of game design for MIU. Based on a review of the literature on game design, we identified flexibility as one of the main characteristics of games designed for MIU. The results from interviews with an expert panel and review of the literature led to the outline of a proposed model of enjoyable game design for MIU. Some of the criteria in the original GameFlow and EGameFlow tools

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were excluded from the MIU-GameFlow Model due to the evaluation process. Other criteria were reformulated and some new criteria were added (Table I).

TABLE I: MIU-GAMEFLOW MODEL

| Element | Criteria |
|---|---|
| Concentration | The game grabs the user's attention |
| | The game's content stimulates the user's attention |
| | The game's activities are suitable for users |
| | The game makes users remain concentrated on the game |
| Challenge | The game has different levels of challenges |
| | The game offers rewards for each challenge |
| | The game's difficulty levels are appropriate to the user |
| | The game's challenges are appropriate for users' ability levels |
| | The game offers "hints" to help users overcome the challenges |
| Player Control | The game is easy to play |
| | The game has simple interaction |
| | Part of the game's interaction is automated |
| | The game offers interaction based on users' preferences |
| | The game has a tutorial that is easy to follow |
| Clear Goal | The game has clear goals |
| | The game has clear intermediate goals |
| | The game's goals are presented at the beginning of the game |
| | The game's intermediate goals are presented at the beginning of scenes |
| Feedback | The game gives feedback on the user's progress |
| | The game gives feedback on the user's success or failure |
| | The game gives feedback on users' actions |
| | The user is notified of a new activity immediately |
| | The break reminder is notified at the appropriate time |
| Immersion | Users feel imaginative |
| | Users become unaware of surroundings while playing the game |
| | The game involves the user's emotion |
| | The game has a narrative |
| | The game makes the user forget about time passing |
| Flexibility | The game offers user preferences |
| | The game offers a switch keyboard |
| | The game offers voice recognition |
| | The game offers the scanning mechanism |
| | The game enlarges the active area of the cursor |

## III. VALIDATING THE MIU-GAMEFLOW MODEL

Validation is an important phase, especially when a new measurement is being developed and there is no existing measurement that operationalises the concept as the researcher intends [14]. In order to validate the MIU-GameFlow Model criteria and to expose any weaknesses and ambiguities, we followed the method proposed by Sweester and Wyeth [15]. In this approach, two games were evaluated by expert review using the MIU-GameFlow Model criteria.

Two similar games were chosen, with the aim to match the games as closely as possible in game type, year of production and genre. The two chosen games (Mini Golf Accessible and One-Switch Football) were the accessible game type and the sports game genre and both were released in the period from 2009 to 2011. The major difference between the two games was that one game was rated highly (10/10) for input-related accessibility features by SpecialEffect [16], an association

that aims to make game playing more accessible to players with disabilities or mobility issues. The second game was a low-rated game. The IGDA special interest group on game accessibility [17] defined game accessibility as an ability to play a game even when the user is functioning under limiting conditions. Limiting conditions can be functional limitations, disabilities such as vision impairment or hearing impairment, or mobility limitations.

Both games were assigned a value between one and five, representing the extent to which the game supported the criteria (see Table I). The values from one to five represented "strongly disagree", "disagree", "less agree", "agree" and "strongly agree", respectively. These values were incorporated into the overall value of each element, as well as the MIU-Game Flow Model evaluates the overall game.

## IV. EVALUATION OF MINI GOLF ACCESSIBLE GAME

### A. Concentration

Mini Golf Accessible met the concentration criteria by stimulating the user's attention with the teeing ground, water hazard, rough, out of bounds, sand bunker, fairway, putting green, flagstick and hole (Fig. 1). The characters in the game are detailed in appearance, and are represented through animation and audio. The game grabs the user's attention with multimedia elements that are implemented in the game. Each golf course has a different theme which affects the appearance of the teeing ground, water hazard and sand bunker. The Mini Golf Accessible game also makes users remain concentrated on the game through a visual introduction that makes the user want to know more. The user's attention is held throughout the game by the golf course interface. The game's activities are suitable for ordinary users or extraordinary users even though they may have had no experience playing golf in the real world.



Fig. 1. Mini Golf Accessible has a detailed game design – (1) Simple and easy to play, (2) Easy access to the main menu, (3) User preferences, (4) Player control while selecting the degree of power, (5) Multimedia elements, (6) Clear feedback when the user selects the arrow's direction, (7) Animation of the golf ball's direction, (8) Users are immediately notified about their score when the accessible game type a task is completed.

### B. Challenge

Mini Golf Accessible meets the challenge criteria by offering different levels of challenges. The game has different modes, including Tournament, Solo Play and Practice. The user can select any preference mode, but the game is less effective in offering hints to help users overcome the challenge. The game has difficulty levels that can provide a

challenge for novice to expert users (easy, medium and hard levels). The user can easily choose any difficulty level, which means the game's challenges are appropriate to the users' ability levels. The game offers rewards for each challenge by giving the user a trophy.

### C. Player Control

Mini Golf Accessible is excellent in developing interaction. Users are able to start playing games immediately without completing the tutorial, even though the users may have had no experiences on a golf course before. The game can be improved by offering a tutorial that is easy to follow. The interface is simple and the game is easy for MIU to play. The game has a simple interaction for the novice and expert user. The game also offers interaction based on the user's preferences whether using one key style, mouse/eye-gaze or keyboard (left/right/space/esc). The user can also choose a character that represents him/herself and the course golf mode (Fig. 2).

### D. Clear Goal

Mini Golf Accessible presents clear goals. The overview of the game provides a detailed, interesting background story. From the interface and the elements in the game, users can understand the goal of the game.

### E. Feedback

Mini Golf Accessible provides feedback to users on their goals, actions and status. Users are immediately notified when the golf course has been completed. At the end of each course, users receive their scores. The feedback can be improved by having the game offer a break reminder. The break reminder will notify users about taking a quick break at the appropriate time to prevent hand/wrist tension.



Fig. 2. The user can choose a character to represent him/herself and the course golf mode.

### F. Immersion

Mini Golf Accessible makes users feel the excitement, and they engage imaginatively with the golf course. However, the game lacks the surrounding that would evoke the golf field. The game involves the user's emotion by making the user feel engaged to get the highest score. The users become unaware of their surroundings while playing the game. By focusing their attention on getting a high score, the game makes users forget about time passing.

### G. Flexibility

Mini Golf Accessible provides sufficient flexibility in general. The game offers user preferences which allow users

to choose their character, difficulty level and game mode. The game applies a one-switch button and scanning mechanism. The scanning mechanism is an interaction method addressing users with motor impairments, which provides sequential access to the elements of a graphical user interface. It enables users to interact with the interface through at least a single binary switch using the switch keyboard. The switch keyboard is a mechanical, press keyboard-activated switch which is connected to the user's computer through a receiver. The game also enlarges the active area of the cursor so users can easily reach the area. Unfortunately, the game does not offer voice recognition.

## V. EVALUATION OF ONE-SWITCH FOOTBALL

### A. Concentration

One-Switch Football delivers a simple game. The game is average in terms of visual attractiveness, with simple character models to stimulate the user's attention. The game's sounds are average, with similar audio throughout the game to grab the user's attention. The user can view the game only from the top angle (Fig. 3). The game's introduction is visually attractive, but there is no storyline. The game poorly captures the user's attention in the introduction.
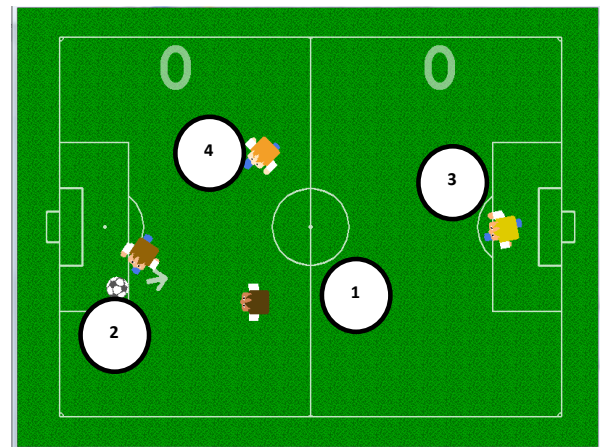


Fig. 3. (1) The user can view the One-Switch Football game only from the top angle, (2) The arrow speed is used to change direction, (3) The user plays with the similar timeline, (4) A familiar interface is used as it is easy to understand.

### B. Challenge

The level of challenge in One-Switch Football is below average. The game match is not as challenging as it lacks the element of strategy, only requiring arrow speed and luck when pressing the button. The game has no diversity in the types of matches. The user plays with a similar timeline. The game fails to pose a challenge. The game's level of challenge is for beginner and experienced users, but probably only accommodates beginner players. Users are able to reduce the arrow speed if they find it is too challenging at its set pace. This is a most useful alternative to the beginner users. The game's match is straightforward and is not sufficiently challenging to experienced users.

### C. Player Control

One-Switch Football provides average support and

development for user interactions. The game successfully meets some criteria and performs below average on others. The user is able to start playing the game without a tutorial. The game uses a familiar interface that is easy to understand by the user. The game has limitations in the user's interaction because the game only offers a one-switch button mechanism to play the game. Users are rewarded with a score. The game interface is easy for the users to control.

### D. Clear Goal

The objectives in One-Switch Football are limited and repetitive with no variation. The users will understand the goal of the game from the interface and the elements in the game.

### E. Feedback

One-Switch Football provides feedback and immediately notifies the user when they have scored a goal. The feedback could be improved if the game offered a break reminder. The break reminder notifies the user to take a break at the appropriate time to prevent hand/wrist tension.

### F. Immersion

The game is not complex enough to immerse the user. There is not enough background, character development or storyline for the user to become emotionally involved in the game or connected to the characters. There is no intuitive participation at all, which could be due to the type of game.

### G. Flexibility

One-Switch Football offers user preferences from which users can choose the difficulty level and the arrow speed (Fig. 4). The game applies a one-switch button and scanning mechanism as an interaction method. The game does not offer voice recognition and not enlarge the active area of the cursor, which can make the user confused about the parameters of the active area while playing the game.
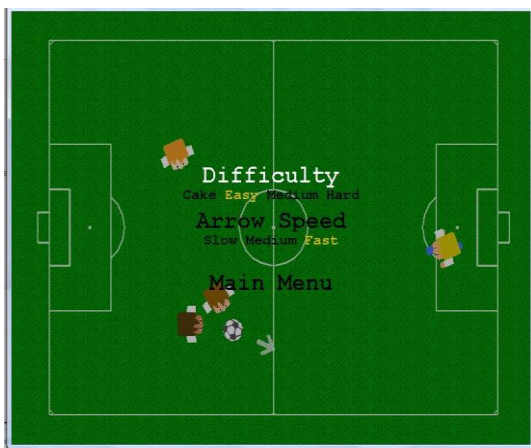


Fig. 4. User preference options in One-Switch Football.

## VI. MINI GOLF ACCESSIBLE VERSUS ONE-SWITCH FOOTBALL

Mini Golf Accessible outperformed One-Switch Football significantly (Table II), with an overall rating of 4.0 (80%) for Mini Golf Accessible and 2.8 (56%) for One-Switch Football. It was difficult to determine whether any element or criterion in particular contributed to the success of one game and the

failure of the other. One-Switch Football received particularly low scores on the elements of challenge and immersion, and average to above average scores on clear goal, concentration, player control and flexibility. The highest score in One-Switch Football was for feedback.

TABLE II: COMPARISON BETWEEN MINI GOLF ACCESSIBLE AND ONE-SWITCH FOOTBALL

| | Mini Golf | | | Football | | |
|---|---|---|---|---|---|---|
| **Concentration** | **E1** | **E2** | **E3** | **E1** | **E2** | **E3** |
| The game grabs the user's attention | 4.0 | 5.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| The game's content stimulates the user's attention | 4.0 | 4.0 | 4.0 | 3.0 | 3.0 | 3.0 |
| The game's activities are suitable for users | 4.0 | 3.0 | 5.0 | 3.0 | 3.0 | 3.0 |
| The game makes users remain concentrated on the game | 4.0 | 4.0 | 4.0 | 3.0 | 3.0 | 3.0 |
| *Mean* | | | **4.0** | | | **3.0** |
| **Challenge** | | | | | | |
| The game has different levels of challenges | 5.0 | 4.0 | 5.0 | 2.0 | 2.0 | 3.0 |
| The game offers rewards for each challenge | 4.0 | 4.0 | 4.0 | 3.0 | 3.0 | 2.0 |
| The game's difficulty levels are appropriate to the user | 5.0 | 4.0 | 5.0 | 3.0 | 3.0 | 2.0 |
| The game's challenges are appropriate for users' ability levels | 5.0 | 4.0 | 5.0 | 2.0 | 3.0 | 3.0 |
| The game offers "hints" to help users overcome the challenges | 4.0 | 4.0 | 4.0 | 1.0 | 2.0 | 1.0 |
| *Mean* | | | **4.4** | | | **2.3** |
| **Player Control** | | | | | | |
| The game is easy to play | 4.0 | 3.0 | 5.0 | 2.0 | 2.0 | 4.0 |
| The game has simple interaction | 4.0 | 4.0 | 5.0 | 3.0 | 3.0 | 5.0 |
| Part of the game's interaction is automated | 4.0 | 4.0 | 4.0 | 3.0 | 3.0 | 4.0 |
| The game offers interaction based on user preferences | 5.0 | 4.0 | 5.0 | 4.0 | 4.0 | 3.0 |
| The game has a tutorial that is easy to follow | 5.0 | 3.0 | 4.0 | 2.0 | 2.0 | 1.0 |
| *Mean* | | | **4.2** | | | **3.0** |
| **Clear Goal** | | | | | | |
| The game has clear goals | 5.0 | 5.0 | 5.0 | 3.0 | 3.0 | 3.0 |
| The game has clear intermediate goals | 5.0 | 4.0 | 4.0 | 3.0 | 3.0 | 2.0 |
| The game's goals are presented at the beginning of the game | 4.0 | 3.0 | 4.0 | 2.0 | 2.0 | 3.0 |
| The game's intermediate goals are presented at the beginning of scenes | 3.0 | 3.0 | 4.0 | 2.0 | 2.0 | 3.0 |
| *Mean* | | | **4.1** | | | **2.6** |
| **Feedback** | | | | | | |
| The game gives feedback on the user's progress | 4.0 | 3.0 | 5.0 | 3.0 | 3.0 | 4.0 |
| The game gives feedback on the user's success or failure | 4.0 | 3.0 | 5.0 | 4.0 | 3.0 | 4.0 |
| The game gives feedback on the user's actions | 4.0 | 4.0 | 4.0 | 3.0 | 4.0 | 4.0 |
| The user is notified of a new activity immediately | 3.0 | 3.0 | 4.0 | 2.0 | 2.0 | 4.0 |
| The break reminder is notified at the appropriate time | 4.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 |
| *Mean* | | | **3.7** | | | **3.2** |
| **Immersion** | | | | | | |
| Users feel imaginative | 3.0 | 3.0 | 4.0 | 2.0 | 2.0 | 2.0 |
| Users become unaware of their surroundings while playing the game | 3.0 | 4.0 | 4.0 | 2.0 | 2.0 | 2.0 |

| | E1 | E2 | E3 | | | |
|---|---|---|---|---|---|---|
| The game involves the user's emotion | 4.0 | 4.0 | 5.0 | 3.0 | 2.0 | 3.0 |
| The game has a narrative | 4.0 | 4.0 | 5.0 | 2.0 | 3.0 | 2.0 |
| The game makes the user forget about time passing | 4.0 | 4.0 | 4.0 | 3.0 | 2.0 | 2.0 |
| *Mean* | | | 3.9 | | | 2.3 |
| **Flexibility** | | | | | | |
| The game offers user preferences | 5.0 | 4.0 | 5.0 | 3.0 | 3.0 | 3.0 |
| The game offers a switch keyboard | 5.0 | 4.0 | 5.0 | 4.0 | 4.0 | 5.0 |
| The game offers voice recognition | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| The game offers the scanning mechanism | 5.0 | 5.0 | 5.0 | 4.0 | 4.0 | 4.0 |
| The game enlarges the active area of the cursor | 4.0 | 5.0 | 5.0 | 3.0 | 3.0 | 2.0 |
| *Mean* | | | 4.0 | | | 3.0 |
| *Overall* | | | 4.0 | | | 2.8 |

**E1 = Expert 1, E2 = Expert 2 and E3 = Expert 3.

## VII. DISCUSSION

Evaluating two accessible games - one high-rating, and one low-rating with the MIU-GameFlow criteria provided insights into how the criteria are applied in accessible games, what makes computer games enjoyable to MIU and the importance of each MIU-GameFlow element. The element of flexibility seemed to be particularly important in designing an enjoyable game for MIU.

The following points can be made on each of the MIU-GameFlow elements:

- Concentration was apparent in the Mini Golf Accessible game through the detailed teeing ground, water hazard, rough, out of bounds, sand bunker, fairway, putting green, flagstick and hole features, as well as through the characters' appearance, animation and audio.
- Challenge was present in the Mini Golf Accessible game through the variations of the golf course mode, diffi-culty settings, mission variation, increasing difficulty and the task of mastering a new hole.
- Player Control is developed by enabling the user to play the game immediately without reading the manual. In the case of Mini Golf Accessible, the interface is simple and the game is easy for MIU to play. It uses simple interaction and offers interaction based on user preferences.
- Clear Goals are presented through an introduction that provides the background, goals, scenes that present the goal and storyline, as well as clear objectives.
- Feedback involves notifying the player of achievement or failure of task, status, providing a score and summary at the end of the game, as well as audio feedback on actions.
- Immersion is achieved through concentration, feeling a connection to the story and characters, and feeling engaged in the game.
- Flexibility comes in the form of a variety of interactions and user preferences that the user can choose throughout the game.

## VIII. CONCLUSION

Through the evaluation, it was recognized that some of the MIU-Game Flow criteria are hard to measure through an expert review and would require player-testing to evaluate. In order to determine whether or not a game is suitable for MIU, it would be necessary for the game to be played by MIU, and the users would need to be observed while playing the game. In particular, the immersion element is not something that can be accurately evaluated through expert evaluation. Future work will involve developing the MIU-GameFlow criteria into a usable design and evaluation tool for game developers and researchers.

The MIU-GameFlow criteria could be used as a guideline for an expert review to evaluate enjoyable game design for MIU in player-testing evaluations. The use of the criteria in the expert evaluation enabled many problems in the two games to be identified. The criteria were successfully able to differentiate the enjoyable game design of Mini Golf Accessible and the less enjoyable game design of One-Switch Football. Further research will expand on this study to provide a comprehensive model for enjoyable game design for MIU. Finally, the MIU-GameFlow Model serves as an initial concept for academics and game developers seeking to understand, evaluate and design an enjoyable game design for MIU.

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