

## ENJOYABLE GAME DESIGN: A STUDY OF MOTOR-IMPAIRED USER'S PERCEPTION

Nurul Hidayah Mat Zain<sup>a\*</sup>, Azizah Jaafar<sup>a</sup>, Fariza Hanis Abdul Razak<sup>b</sup>

<sup>a</sup>Faculty Computer and Mathematical Sciences (FSKM), University Technology MARA (UiTM), 40450 Shah Alam, Selangor MALAYSIA

<sup>b</sup>Institute of Visual Informatics, University Kebangsaan Malaysia (UKM), 43600 Bangi, Selangor MALAYSIA

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\*Corresponding author  
nurulmz@fskm.uitm.edu.my

### Graphical abstract



### Abstract

Nowadays, playing computer games is a popular form of entertainment, which is particularly appealing to university students. This is the case because computer games offer enjoyable experience. However, studies which examine the users' perception on enjoyable game design are limited, specifically in relation to motor-impaired users. Analyses of such perceptions can support the designer in designing enjoyable games for special needs users. The present study explored motor-impaired users' perception based on constructs in Flow Theory. Six constructs, namely clear goal, feedback, user control, challenge, immersion and adaptively were used. In total, 42 students from UiTM Malaysia participated in this study. The data were analyzed using standard descriptive statistical methods. The findings of the study showed motor-impaired users' perception on enjoyable game design. Hopefully, the results of the study will emphasize the need for developing a rigorous game design which is enjoyable for motor-impaired users.

Keywords: Computer games, enjoyment, motor-impaired users, flow theory

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## 1.0 INTRODUCTION

Today, computer games have become a major form of entertainment. Computer games are a highly popular activity, with players spending almost seven hours per week playing games [1]. Eglez *et al.* [2] reported that players in the 14 to 18 years old spent the most time playing computer games, because they used the games to stimulate the senses and for emotional release. The large numbers of people who play computer games demonstrate the enjoyment derived from such games.

The computer games industry has expanded and is one of the fastest growing industries in the world [3]. Many studies have supported the use of computer games to accompany traditional lectures in order to enhance student learning [4]–[6]. It has been acknowledged that computer games can

encourage students to be more proactive and to become self-reliant learners [7]. Bourgonjon *et al.* [8] reported four factors which contributed to students' preferences for using computer games, namely personal experience, learning opportunities, ease of use and usefulness. Garris *et al.* [9] stated that computer games are used to help students in many learning areas. Previous studies have also described the advantages of computer games for business and health management simulation [10], [11]. An extensive literature review shows that using computer games may also improve the effectiveness of learning [11]–[13].

With such potential, the use of computer games for special needs users, such as motor-impaired users, blind users or a user with dyslexia [14], however, is still rather slow [15]. Yannakakis, and Hallam [16] suggested that an investigation needs to be

undertaken in relation to how to develop enjoyable computer games. They also identified that there are limited studies debating the matter. Similarly, Hidayah *et al.* [17] discussed the barriers for enjoyable game design for motor-impaired users. Therefore, in light of this research, we need to understand the motor-impaired users' perception on enjoyable game design.

The aim of this study is to investigate motor-impaired users' perception on enjoyable game design. The results of the study could be used as a guideline for computer game designers during the design process. The study sample was collected from university students who experienced hand discomforts such as numbness, tingling or weakness in their hands. We chose university students as a sample study because, in the previous research, the findings indicated that computer game playing was one of the most popular activities among university students [18], [19].

## 2.0 THEORETICAL BACKGROUND

### 2.1 Flow Theory

Flow is a state of complete absorption in an enjoyable activity [20]. People in this state perceive their activity to be enjoyable, even if no goal is reached. Flow Theory is the main concept used to explain the experience of users while playing computer games [21]. For a computer game user to be in a flow state, the challenge of the task and the skill level of the game must be balanced. If the task is too challenging, then the user can experience frustration due to having to struggle too much with the activity [17]. However, if the user's skills are greater than the challenge, the user might be bored.

Flow Theory was initially introduced in the 1960s as a description of the enjoyment derived from daily actions. As the theory increased in acceptance, Flow Theory was used to describe how people experience intrinsically motivating enjoyment [22]. Flow Theory has also been applied on users' enjoyment of games [23], [24].

Csikszentmihalyi [20] originally developed the flow concept (Figure 1) to define the emotional state of optimum pleasure which arises when people are engaged in activities. He also identified the following eight components of the flow experience:

- 1) Completion of tasks
- 2) Concentration on tasks
- 3) Clear goals of tasks
- 4) Immediate feedback on tasks
- 5) Control over actions
- 6) Effortlessness that removes awareness of frustrations
- 7) Self-consciousness disappears and a stronger sense of self-awareness arises
- 8) Sense of time is distorted

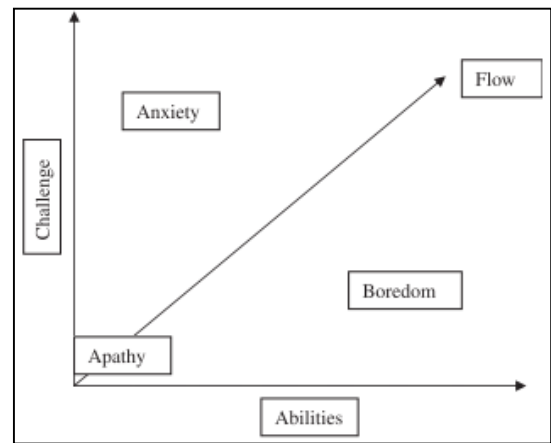


Figure 1 Modeling of flow (adapted from [25])

### 2.2 Motor-impaired Users

From the previous studies, generally motor-impaired users was defined as a user who experienced partial or total loss of the function of a body part as a result of a spinal cord injury, amputation, or musculoskeletal disorder [26]–[28]. Effect of motor impairments may result in muscle weakness, diminished stamina, lack of muscle control, involuntary movements, total paralysis, reduced levels of function in tasks that require general mobility and possible chronic pain. Moreover, Yuan *et al.* [29] define motor impairments is a loss or limitation of function in muscle control or movement or a limitation in mobility. Common causes include arthritis, paralysis, cerebral palsy, or repetitive strain injury.

Motor-impaired users in present study defined as a user who had symptoms commonly associated with hand muscle weakness such as Carpal Tunnel Syndrome (CTS). The symptoms including numbness, tingling, pain or burning sensations appear while computer-game playing.

### 2.3 Enjoyable Game Design

Several studies have identified the constructs pertinent to the enjoyment of computer games. Sweetser and Wyeth [30] developed the GameFlow Model based on Flow Theory which incorporates existing heuristics into a validated model that can be used to design, evaluate and understand the enjoyment in computer games. Their model consists of eight criteria, namely clear goals, feedback, concentration, challenge, skills, immersion, control and social engagement. Meanwhile, Fu *et al.* [31] developed an EGameFlow scale that measures user enjoyment in e-learning games. The scale developed in their study consists of the eight constructs specifically, goal clarity, feedback, immersion, control, challenge, social interaction, concentration and knowledge improvement. In the case of mobile game, Jegers [32] proposed three features

concerning pervasive computing, specifically incorporation of the physical and virtual, mobile game play and social interaction.

Several previous studies focused on the elements of games necessary to increase enjoyment. Klimmt *et al.* [33] described that thrilling elements of a game were more enjoyable than non-thrilling elements. Klimmt, C. *et al.* [34] also found that player enjoyment will decrease when they reduce immediate feedback on the game, while player enjoyment will not decrease when they reduce player control by increasing the speed of the game. Moreover, Schneider [35] revealed that players found the games more enjoyable when they were organized into a story, rather than a corresponding game without a story.

Upon an extensive review of the literature, it is believed that there is a gap in enjoyable game design research, specifically for motor-impaired users. To date, studies in this area have been limited and only a small number of studies on the topic have been implemented. Due to the lack of investigation into this area, we aim to explore the perceptions of university students who have symptoms hand motor-impairments regarding what constitutes enjoyable game design.

#### 2.4 Enjoyable Game Design for Motor-impaired Users (MIU)

Enjoyable game design is perhaps the most important issue in successful game design, but so far it has not been addressed for motor-impaired users. To analyze the enjoyable game design model in relation to motor-impaired users, some distinguishing characteristics and features of game design for motor-impaired users were highlighted. Considering some experimental prototypes and studies in related work, we identified adaptively was one of the main characteristic in game design for motor-impaired users. Figure 1 shows some of features in game design that related to motor-impaired users.

**Table 1** Some of features in game design that related to MIU

Features	Source
Provide various features to adapt to different users' requirements in terms of size, color, contrast and number of items displayed on the screen	[36]
Support a wide range of input devices, such as: mice, joysticks, switches, trackballs, gloves, webcams, microphones	[36]
The interface should be able to analyze the disabled user's interests and behavior and should adapt according to their need	[37]
Adaptive personalization mechanisms require no effort on the part of the user, and can improve performance especially when they greatly reduce the amount of navigation required to reach items	[38]
	[27]
	[28]

Features	Source
Give simple designs which can be quickly understood and thus support instantaneous use, or encourage further exploration	[36]
Part of the original interaction is completely removed, automated and use scanning mechanism	[29]

### 3.0 RESEARCH MODEL

The main purpose of this study is to investigate motor-impaired users' perception on enjoyable game design. In this study, we explore the constructs that potentially contribute to the motor-impaired users' enjoyment of computer game design. In this regard, we proposed several constructs, namely Clear Goal (CG), Feedback (FB), User Control (UC), Challenge (CH), Immersion (IM) and Adaptively (AD) as the independent variables. The constructs of clear goal, feedback, user control, challenge, immersion originated from GameFlow Model based on Flow Theory. We extend the model with added adaptive construct to develop the enjoyable game design for motor-impaired users. The proposed conceptual framework was presented in Figure 2.



**Figure 2** Proposed conceptual model

### 4.0 METHODOLOGY

#### 4.1 The Participants and Procedures

There were two procedures that participants were required to undergo in this study. In the first procedure, they had to perform a self-assessment to assess the severity of their symptoms of Carpal Tunnel Syndrome (CTS) using an adapted six item CTS symptom scale [39]. The assessments were

conducted using this scale because CTS users can be classified as motor-impaired users[40]. This scale was composed of six questions. Four questions use a five symptoms severity level, which comprises the following levels: none, mild, moderate, severe and very severe. The remaining two questions concern the frequency a symptom occurred, specifically: never, once, two or three times, four or five times and more than five times. The total scores used for symptom severity were categorized into the following groups: no symptoms (6), mild (7-12), moderate (13-18), severe (19-24) and very severe (25-30) [39].

In the next procedure, the same participants were required to answer questions pertaining to their perception of enjoyable game design. The items were adapted based on a study by Fu *et al.* [31], IJsselsteijn *et al.*[41] and Petrie, H., Bevan, N [42]. The instrument has 24 items with six constructs, and uses a five point Likert Scale option as follows: 1 (strongly disagree) to 5 (strongly agree). A list of items is shown in Table 1.

The participants included 50 students from the Faculty of Computer and Mathematical Sciences (FSKM), UiTM. Only students who had a CTS symptom severity total score of more than six were analyzed. In an attempt to reduce confusion in the data, respondents who suffered from other median nerve distribution problems were also excluded. A total of 42 respondents met the study inclusion criteria. Figure 3 shows processes of inclusion criteria.

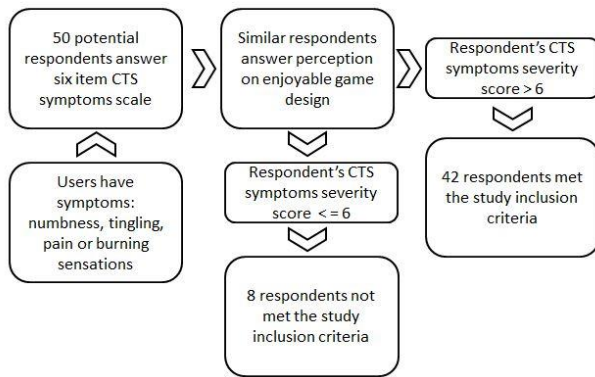


Figure 3 Process of inclusion criteria

### 4.2 Instruments

We executed Cronbach's alpha on all constructs for reliability analysis, with the results showing an Cronbach's alpha value of Clear Goal (CG) – 4 items (0.84), Feedback (FB) – 4 items (0.83), User Control (UC) – 3 items (0.76), Challenge (CH) – 3items (0.70), Immersion (IM) – 5 items (0.73) and Adaptively (AD) – 5 items (0.76). All construct had a good value level of 0.70 and above. Table 2 shows the full list of items.

Table 1 List of items

	Items	Mean	SD
CG1	The game should present the goal at the beginning of the game	3.93	0.89
CG2	The game goals should be presented clearly	3.95	1.03
CG3	The intermediate goals should be presented at the beginning of each scene	3.52	0.94
CG4	The intermediate goals should be presented clearly	3.57	0.89
FB1	I should receive feedback on my progress in the game	3.79	0.84
FB2	I should be notified of new tasks immediately	3.95	0.76
FB3	I should be notified of new events immediately	3.86	0.75
FB4	I should receive information about my success (or failure) immediately	4.07	0.71
UC1	I should feel a sense of the impact over the game	3.88	0.77
UC2	I should know the next step in the game	4.02	0.81
UC3	I should feel a sense of control over the game	3.95	0.76
CH1	The game should provide challenging tasks to be accomplished	3.95	0.83
CH2	The game should provide different levels of challenges that are tailored to different players	4.12	0.77
CH3	The game should provide 'hints' that help me overcome challenging tasks	3.95	0.85
IM1	The game should be aesthetically pleasing	3.95	0.80
IM2	The game should make me feel imaginative	4.02	0.75
IM3	The game should make me feel like exploring	4.02	0.77
IM4	I should find the game impressive	4.17	0.66
IM5	The game should feel like a rich experience	4.10	0.79
AD1	The game should offer the user preferences	3.88	0.80
AD2	The game should simplify the interface	4.12	0.63
AD3	The game should enlarge the active area of the cursor	3.89	0.72
AD4	The game should support various input techniques	3.98	0.71
AD5	The game should offer flexibility	4.05	0.66

### 5.0 RESULTS

The results of the descriptive analysis for each item are based on a Likert Scale. Figure 4 shows the results of Clear Goal (CG) construct. In general, students agreed that to design enjoyable games, the game should present goals at the beginning of the game (n = 20, 47.6%), the game goals should be presented clearly (n = 15, 35.7%) and intermediate goals should be presented at the beginning of each scene (n = 19, 45.2%). Meanwhile, students answer was neutral towards intermediate goals should be presented clearly (n = 17, 40.5%).

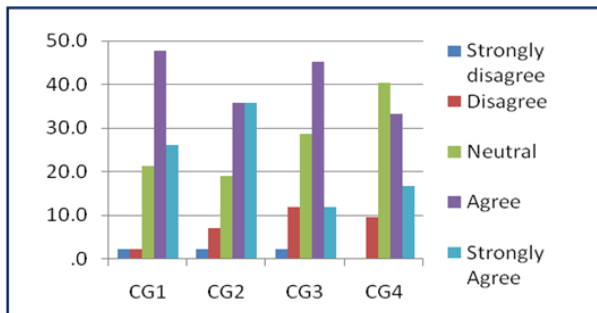


Figure 4 Result for clear goal constructs

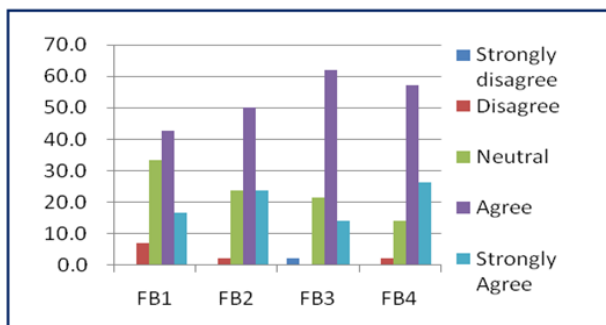


Figure 5 Result for feedback constructs

Figure 5 shows the results of the Feedback (FB) construct. It found that most students agreed that users should receive feedback on their progress in the game (n = 18, 42.9%), notified of new tasks, events immediately and should receive information about their success (or failure) immediately (n = 24, 57.1%). These results show that students gave all items the highest score of agree, followed by neutral and strongly agree.

Figure 6 presents the results of the User Control (UC) construct. The results revealed that most students agreed they should feel a sense of the impact over the game (n = 17, 40.5%), they should know the next step in the game (n = 21, 50.0%) and they should feel a sense of control over the game (n = 21, 50.0%). The study results also show that none of the students strongly disagreed with any of the items, with less than 10% disagreeing.

Figure 7 shows the results of the Challenge (CH) construct. In general, student agreed that to design enjoyable games, the game should provide challenging tasks to be accomplished (n = 25, 52.4%), provide different levels of challenges that are tailored to the different players (n = 23, 54.8%) and provide 'hints' that helps users overcome the challenging tasks (n = 21, 50.0%). On the scale, the answers of the students were more towards agreeing and strongly agree.

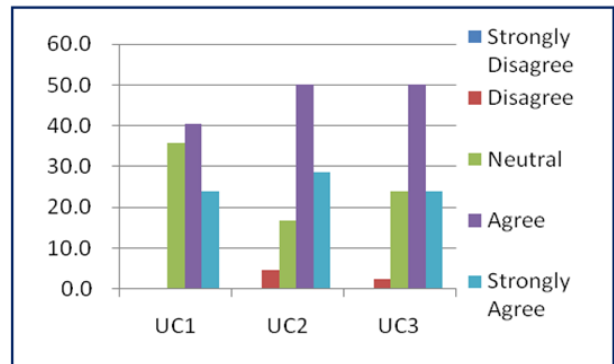


Figure 6 Result for user control constructs

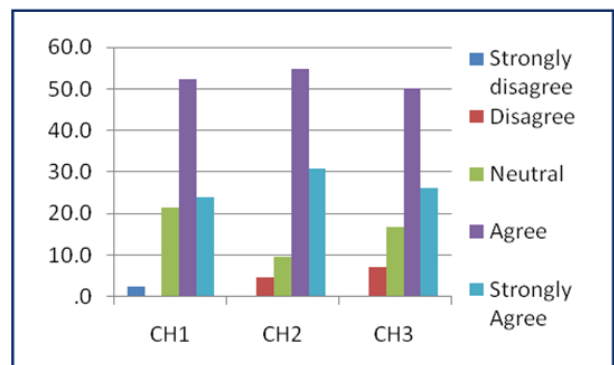


Figure 7 Result for challenge (CH) construct

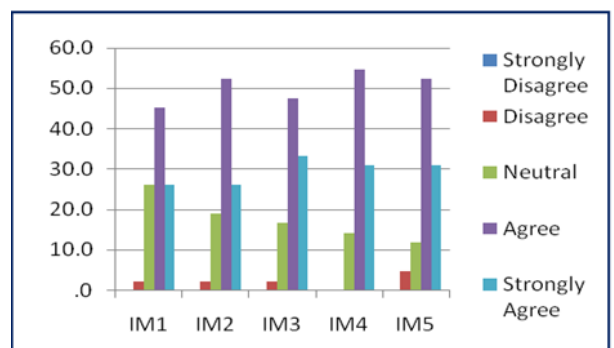


Figure 8 Result for immersion (IM) construct

Figure 8 presents the results for the Immersion (IM) construct. The results show that most students had positive IM when using computer games. On the scale, students answered more towards agree and strongly agree. None of the students strongly



disagreed with any of the items. Thus, integrating elements of immersion into the game design would help learning to be more enjoyable for students, especially for those who are motor-impaired.

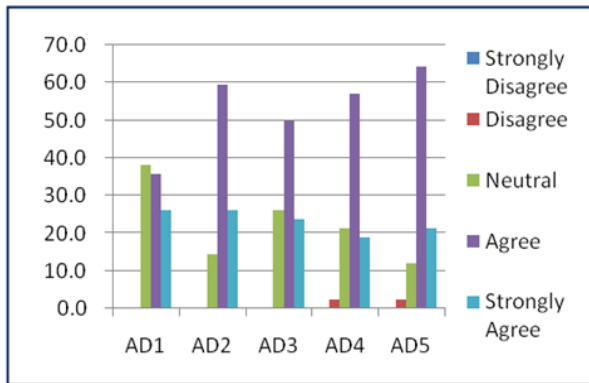


Figure 9 Result adaptively (AD) construct

Figure 9 shows the results of the Adaptively (AD) construct. For this construct, the results show that most students agreed that to design enjoyable games, the game should offer user preferences ( $n = 15$ , 35.7%), have a simple interface ( $n = 25$ , 59.5%), enlarge the active area of the cursor ( $n = 21$ , 50.0%), support various input techniques ( $n = 24$ , 57.0%) and offer flexibility ( $n = 27$ , 64%). Based on the results, the highest score on the scale is agreed, followed by strongly agree and neutral. None of the students chose strongly disagrees for any of the items, with less than 5% disagreeing.

## 6.0 DISCUSSION

Flow refers to a state of deep absorption in an activity. Concentration, interest and enjoyment of an activity should be experienced simultaneously in order to flow to occur [43]. The present study was carried out using constructs that related to enjoyable game design based on Flow Theory. Previous research was examined the perception on enjoyable game design within ordinary user [30], [31]. This study, however, mainly focused amongst motor-impaired users. The study sample was collected from university students because, in the previous study, the findings indicated that computer-game playing was one of the most popular activities among university students [18].

From the analysis, it shows that users agreed that several items in constructs namely, clear goal, feedback, user control, challenge, immersion, and adaptively can influence enjoyable experience for motor-impaired users while playing computer games. Present research also has shown the potential of the concept of flow in research on enjoyable game design for motor-impaired users. An effort to help motor-impaired users has prompted the researcher to

develop computer games that have features enhance the enjoyable experience while playing computer game, specifically for motor-impaired users.

## 7.0 CONCLUSION

The aim of this study was to explore the motor-impaired users' perception on enjoyable game design, specifically in relation to motor-impaired users. Descriptive analysis was presented using SPSS. It is interesting to note that university students in Malaysia are highly interested in experiencing enjoyment while playing computer games. Future related studies will need to be undertaken in relation to the computer game enjoyment, based on this study. The results also emphasize the need to develop a rigorous and enjoyable interaction design for motor-impaired users, specifically for those users who have hand motor-impairments.

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