CHAPTER 2

LITERATURE REVIEW

2.1 Overview

The enhancement of technology has opened new opportunities for everyone over the globe including Malaysia. The healthcare sector has benefited a lot from the growth of technology and its development to ensure they served people with the best equipment. Rehabilitation is one of the fields that had been given chances to apply the assistive technology using serious games for patients who undergo therapies and exercises. Though Malaysia is on its way to developing its assistive technology for the community, yet they still have chances to try the facilities in a few rehabilitation centers.

A rehabilitation centre is a place where persons with disabilities undergo therapies to sustain their live performances and stay healthy. Throughout the rehabilitation sessions, they receive care from professionals including doctors, nurses and the physiotherapists. As this research is aimed to explore serious games as the assistive technology tools, there are subsections briefly explaining assistive technology and serious games. The assistive technologies used for this research are robotic, simulator, and virtual reality as SOCSO Tun Abdul Razak Rehabilitation Centre provides it for rehabilitation therapies and exercises.

Other than that, some subsections are defined the user experience and its factors affecting the use of serious games for rehabilitation. The factors are motivation and

usability. On the top of that, as this research is aiming to enhance user experience model, there are tables of justification on the existing model and definition on each model that suitable for this research. At the end of this chapter, there is conceptual framework clarification and justification on the research hypothesis and the concept of this research as a whole.

2.2 Rehabilitation

World Health Organization (WHO) has discussed on rehabilitation in which can be defined as a series of steps that help to achieve and sustain the optimal functioning in contact with a person who has experienced or is likely to experience impairment. The United Nations Convention on Rights of Persons with Disabilities (CRPD) in the Article 26, habilitation and rehabilitation are appropriate measures that enable persons with disabilities to attain and maintain their maximum independence with physical, mental, social and vocational abilities (Bowker et al., 2006).

Rehabilitation involves body functions and participation which are factorized by individuals and the environment such as education and civic life (Bowker et al., 2006). WHO in their article in Newsroom says that rehabilitation reduces the impact of a broad range of health conditions for specific period along with the help from the rehab team and the individual itself. Rehabilitation gives benefits and changes the functioning of an individual over time (Ahmed et al., 2003). The rehabilitation phase plays an important role in making sure the processes reaching the rehabilitation goals.

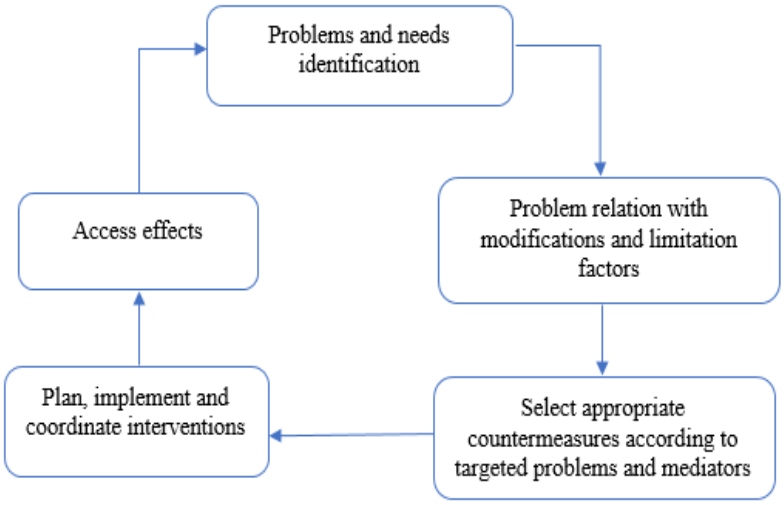

Figure 2.1: Rehab Cycle Diagram (Steiner et al., 2002)

The rehabilitation phase consists of several steps that complete one another as a circle. Each of the phases aims to develop a proper plan and assist persons with disabilities to reach their ultimate goals at the end of the rehabilitation session. Table 2.1 below shows the explanation of the flow chart in Figure 2.1.

Table 2.1: Rehabilitation Phase

Step	Description
Problems and needs identification	Rehabilitation involves the identification of a person's problems and needs
Problem relation with modifications and limitation factors	Find the relevant factors that relates to problems and needs of the person and environment

Select countermeasures according to targeted problems	Choose the relevant ways to respond to the problems
Plan, implement and coordinate interventions	Planning and implementation of the measures and rehabilitation goals are defined through this stage
Assess effects	Assessment of the effect of the person through plans and implementation on the previous stage

2.2.1 Physical Therapy and Rehabilitation Assessment

As this research is focusing on physical rehabilitation using serious games as the tools for persons with disabilities to undergo the exercise and therapy, the physical therapy sessions are conducted with assessment from the professionals. Physical rehabilitation is known as physical therapy that helps patients to achieve or regain the capacity that lacks or lost after having an accident, illness or age-related deterioration (D'Ornellas et al., 2014). Hence, it focuses on people who are suffering from pain and facing difficulties in body functioning and are not able to live a normal life.

Physical therapy is involving the upper part and the lower part of the body where the exercises are feasible and effective for improving balance and confidence

in persons with disabilities. During the physical activities and exercises, the upper part of the body which known as the upper limb is the important part in balancing the whole part of the body (Kim & Lee, 2017) however the range of motion and time taken for a lower limb to have balancing body is greater compared with an upper limb (Kwakkel & Wagenaar, 2002). The exercises can improve their performance while undergoing rehabilitation (Bourque et al., 2019). Physical therapy is involving lots of exercises that facilitate their abilities to improve and maintain joint integrity and increase independence via a range of motion.

Figure 2.2: Rehabilitation Session

Figure 2.2 shows one of the physical activities (PA) during the therapy session in the rehabilitation center. Persons with disabilities who undergo physical therapy are admitted for several months to repetitive sessions for rehabilitation which relies almost entirely on aid and monitoring from the therapists (D'Ornellas et al., 2014). Thus, an assessment is needed to evaluate the standard task given by the therapist.

Traditionally, the assessment of physical rehabilitation is based on the therapist's observations and judgement (Mousavi Hondori & Khademi, 2014) The rehabilitation assessment is focusing on understanding the impact of an injury faced and identifying the best plans and actions to help persons with disabilities to return to the community. Diagnosis and evaluation in medical rehabilitation according to (Biefang & Potthoff, 1995) should be based on the method used. There are standardized procedures and instrumented tests for rehabilitation assessment which are taken from various measurements. Berg Balance Scale is one of the important assessments in calculating the risk of fall and standing balance of the patients (Downs et al., 2013; Stevenson, 2014).

Table 1 Characteristics and results from the Berg Balance Scale (BBS) and the Modified Motor Assessment Scale (M-MAS UAS-95) at baseline

	Participants during the period;		
	0 to 3 months	3 to 6 months	6 to 12 months
Characteristics	**n=72**	**n=71**	**n=65**
Age, years, median (range)	73 (50–94)	73 (47–92)	73 (47–90)
Patients, n (%)			
Female	33 (46)	27 (38)	26 (40)
Male	39 (54)	44 (62)	39 (60)
Stroke classification (TOAST), n (%)			
Large vessel disease	17 (24)	18 (25)	17 (26)
Small vessel disease	21 (29)	21 (30)	17 (26)
Cardioembolic stroke	15 (21)	11 (15)	11 (17)
Cryptogenic stroke	13 (18)	14 (20)	12 (19)
Intracerebral haemorrhage	6 (8)	7 (10)	8 (12)
Side of Lesion-, n (%)			
Right side lesion	35 (49)	32 (45)	28 (43)
Left side lesion	37 (51)	39 (55)	37 (57)
Hypertension	47 (65)	44 (62)	41 (63)
Diabetes mellitus	17 (24)	18 (25)	17 (26)
Results from clinical scales 1–7 days after stroke onset			
BBS median (range) (n)	35 (0–56) (n=71)	41 (0–56) (n=70)	41 (0–56) (n=64)
M-MAS UAS-95 median (range)	45 (12–55) (n=65)	47 (12–55) (n=65)	50 (16–55) (n=59)

Figure 2.3: Berg Balance Scale Measurement (Persson et al., 2013)

Figure 2.3 shows the Berg Balance Scale for the physical assessments. The balancing scale in the Berg Balance Test is valid and reliable which comprising sets of 14 simple balance-related tasks for persons with disabilities who undergo rehabilitation (Downs, 2015; Saverino et al., 2016). The comprehensive application of the Berg Balance Scale for balancing assessment is originally developed for the stroke population, and now it has been widely used to be use in spinal cord injury rehabilitation (Lemay & Nadeau, 2010) Other than balancing assessment, mobility is another key attribute to physical quality that underpins on one's movement.

Range of motion (ROM) is an essential measurement and assessment for evaluating and diagnosing the adhesive of the shoulder (Lee et al., 2015). This method is chosen to increase training intensity by either diminished fatigue or reduced work output through a range of movements exercises (Howe & Waldron, 2017). The ROM is important in improving mobility and supporting the development of movement quality. The assessment of mobility is tested traditionally using the ROM test for the outcome measure to be accurate and reliable. Table 2.2 shows the ROM measurement on fundamental exercises.

Table 2.2: ROM Measurement

Exercises	Position
Shoulder Flexion Test	Lays the supine with the knees flexed 90° and the plantar surface of the feet flat against the ground. The head should be positioned looking towards

	the ceiling and the shoulder is flexed 90° with the elbow extended and palms facing each other
Shoulder Rotation Test	Lies supine on a plinth with the knees flexed to 90° and the plantar surface of the feet flat against the table. With the head resting on the plinth, the face is looking forward towards the ceiling. The shoulder abducted 90° where the upper arms are rest and the elbow flexed to 90° and the palm facing towards the feet

Source: Howe & Waldron, 2019

One of the reliable tests for mobility and ROM assessment for patients is by using stroke rehabilitation assessment of movement (STREAM). This clinical measurement is used to evaluate the recovery of movement and basic mobility in stroke patients (Daley et al., 1999). The reliability of STREAM was demonstrated to provide a comprehensive, objective, and quantitative evaluation of motor functioning in stroke patients. Table 2.3 shows the testing positions of STREAM instrument.

Table 2.3: Testing Positions of STREAM Instrument

Testing Position	Testing Movements (Subscale)
Supine	Scapular protraction (U), Elbow extension (U), Bending hip and knee (L), Rolling (M), Supine to sitting
Sitting	Scapular elevation (U), Raising hand to touch the top of the head (U), Raising arm to fullest elevation (U), Knee extension (L), Sitting to stand (L)

Standing	Standing for 20 counts (M), Hip abduction (L), Knee flexion (L), 3 steps backwards (M), 10m walk (M)

Source: Wang et al., 2002

Figure 2.4 below shows the STREAM scale with the correlation of common outcome measures such as the balance scale and box and block test that affected or not on the upper extremity.

STREAM	Evaluation	Box and Block Test (Affected UE)	Box and Block Test (Unaffected UE)	Barthel Index	Balance Scale	TUG Ability	Gait Speed
Total	Initial	.73	.36	.78	.75	.80	.74
	5 weeks	.77	.37	.71	.68	.64	.62
	3 months	.78	.44	.75	.65	.57	.73
UE	Initial	.78	.31	.67	.57	.69	.56
	5 weeks	.79	.36	.66	.61	.49	.53
	3 months	.76	.31	.67	.53	.60	.64
LE	Initial	.53	.40	.71	.73	.75	.74
	5 weeks	.64	.29	.59	.55	.59	.55
	3 months	.70	.30	.63	.55	.51	.65
Mobility	Initial	.66	.55	.84	.88	.85	.83
	5 weeks	.69	.40	.75	.71	.57	.65
	3 months	.66	.40	.82	.78	.62	.76

[a] UE=upper extremity, LE=lower extremity, TUG=Timed "Up & GO" Test. All correlations significant at the P=.0001 level except for the unaffected UE during the Box and Block Test at all 3 evaluations (P<.025).

Figure 2.4: STREAM Measurement (Ahmed et al., 2003)

2.2.2 Rehabilitation in Malaysia

The expats who introduced physiotherapy to Malaysia in the 1960s have pioneered rehabilitation in the country. Kuala Lumpur General Hospital created its first physiotherapy department on that year. Alhough healthcare in Malaysia has been significantly improved over 20 years, yet people with disabilities still face numerous obstacles in their daily interactions. After a few years of the campaign for various types of disabilities, the Persons with Disabilities Act came into effect in 2008 in Malaysia (Naicker et al., 2019).

The Malaysian Disability Act 2008 defines persons with disabilities as those who have long-term physical, mental, intellectual, or sensory impairments (N. A. Ahmad et al., 2017; Naicker et al., 2019). The demands for provision services like health, welfare, education, and work increases from time to time. With the increment of awareness about the persons with disabilities act, the charity-based services turn to rights-based services (Naicker et al., 2019). Over the years, the rehabilitation resources become more comprehensive.

Though rehabilitation services in the healthcare sector are provided by the government hospitals under the Ministry of Health, the facilities available in some of smaller government hospitals are basic unlike the tertiary hospitals which have advanced technologies and therapies. The rehabilitation centres which are equipped with various types of assistive technology are Cheras Rehabilitation Hospital and SOCSO Tun Abdul Razak Rehabilitation Centre. However, for this study the researcher has chosen SOCSO Tun Abdul Razak

Rehabilitation Centre to be the venue as the centre is using serious games in more than one assistive technology for rehabilitation (Naicker et al., 2019).

Despite the facilities and services, there are currently only approximately 100 professionals in rehabilitation medicine for the projected 3 million persons with disabilities in Malaysia. Hence, there are remarkably few rehabilitation doctors for every disabled person (N. A. Ahmad et al., 2017; Naicker et al., 2019). Rehabilitation in Malaysia is in the phase of growth with the help of sophisticated technology. However, the only equipped hospital and rehabilitation centre to undergo therapy sessions with assistive technology is too few.

2.3 Serious Games in Assistive Technology

Technologies are any human-created artefacts that extend human abilities. Human culture can be seen to largely comprise technologies which extend human abilities and can be seen to mark the major turning points in human history (O'Neill & Gillespie, 2014) The most cited literature in the US on the definition of assistive technology in 1988 is any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized that is used to increase, maintain, or improve functional capabilities of individuals with disabilities (Scherer, 2002). Hence, assistive technology is meant to help people in their primary functional tasks.

Assistive technology or known as rehabilitation technology that has various type of equipment which can be used during the rehabilitation sessions (Bowker et al., 2006). Thus, it is used in the rehabilitation field as an attempt to increase the quality of recovery

(M. A. Ahmad et al., 2019). In assistive technology, serious games come with immersive characteristics that can bring new experiences for persons with disabilities to perform their rehabilitation (Li et al., 2018; Merilampi et al., 2017). Serious games are a combination of digital gaming and physical exercise which give users the experience to have self-monitoring while doing the therapeutic exercises in rehabilitation (Vugts et al., 2016).

Despite being originally designed for entertainment, serious games are increasingly used for health promotion. There is rapid growth in the popularity and the use of serious games as health programs in society and communities (Li et al., 2018). It is an important act to restore health to its original though with a slow process as rehabilitation is an action aimed to assist someone to stay healthy through physical, occupational and cognitive therapy (Bowker et al., 2006), Serious games in this research discusses on selected assistive technology in SOCSO Tun Abdul Razak Rehabilitation Centre: robotic, simulator, and virtual reality.

The immersive type of serious games helps the user to feel the real-life scenarios while undergoing the exercises (Chen et al., 2013). Human and computer interaction (HCI) has become a broad subject to be discussed. Various types of research have been done to prove the relationship between both humans and computerss by measuring the quality of interaction. Despite computers, there is also the involvement of robotics as the interaction with human has broadened the field of research on HCI. Serious games build an interaction between human and computer (HCI) also human and robot (HRI). Thus, the interaction and relationship between a person and a computer system create an experience (Santoso et al., 2017).

2.3.1 Serious Games in Simulator

The HCI and HRI used serious games in assistive technology to interact with users and it is focusing on physical, cognitive, and physiological well-being while playing the games for rehabilitation (Baur et al., 2018; Jerčić et al., 2018). A simulator is a realistic imitation of the controls and operation of any complex systems that are used for the training process. It is a computer program that enables to execution of programs written for a different operating system. Technologies today reached a level of maturity and affordability whereby simulation-based systems can guarantee effective knowledge and skills that transfer from the point of educational delivery via hand-held computing platforms (Stone, 2011).

The content of simulator programs has great potential to increase user engagement in video games. It is also helping in increasing the self-motivation of players as they immerse themselves while playing the games (Georgiou & Demiris, 2017). The process of imitating should be real based on the scenarios that happened in real life by inserting the real actors. The idea of using simulator in driving as originates from the first flight simulator which was developed in the early 1910s. It was created to be used for training pilots and reducing operating costs compared to the real equipment (Lozano-Quilis et al., 2014).

In SOCSO Tun Abdul Razak Rehabilitation Centre, car driving simulator is one of the assistive technologies that used serious games for rehabilitation. The specific group who can play the simulator are the ones who have been diagnosed with lower limb disabilities such as amputee, stroke, and traumatic brain injury. A car driving simulator is one of the driving simulations that are used as an assessment

and training in rehabilitation. The car driving simulator has also been found to be helpful for older adults that suffered a stroke and feel frustrated with their loss of independence to drive.

Figure 2.5: Car Driving Simulator

A simulator offer a medium for training and evaluating individuals at high risk since everybody has different terms of skills and preferences. The simulated driving practice has been found to facilitate the older adults driving skills and alleviate stress occasioned by therapy (Fernandez-Cervantes & Stroutia, 2019). Figure 2.5 shows the car driving simulator in SOCSO Tun Abdul Razak Rehabilitation Centre. The significance of using a car simulator in rehabilitation besides assessment is to help person with disabilities to get immersed and comfortable (Georgiou & Demiris, 2017) before they get to drive the real car.

The true science underpinning simulation is the science that helps guarantee the transfer of skills from the simulated to the reality of human factors. A simulation that is a well-established discipline that focuses on the abilities and limitations of the end user when designing interactive systems as opposed to the more

commercially explicit components of technology (Stone, 2011). The previous research papers show the advantages of a car driving simulator facilitating the user to feel reliable to the systems which is valid, adaptable, and cooperative to be used.

The design of the application also gives user experiences on the effectiveness and enjoyment of the system. Other than that, the simulator is used to improve driving habit and keep high engagement on the user to adapt to it. This help to extract the user's behavioral and psychological while driving and the evaluation are focusing on their experiences and attention.

Table 2.4: Summary Studies of Serious Games in Car Driving Simulator

Author	Tittle/Country	Data Analysis	Advantages
(Gómez et al., 2018)	*Driving Simulator Platform for Development and Evaluation of Safety and Emergency Systems* USA	Twenty postgraduate students, where the seven female participants and male were 13. They were invited to participate which its required to have a valid driving license and driving experience in the manual gear shift. The students' age averaged 27.2 years and were divided into two groups in order to verify the DAS model influence in the two collision situations	Research centers and car makers have a driving simulator available based on significant advantages such as facilitating the design, development and test of the proposals
(Fitz-walter et al., 2017)	*Computer in Human Behaviour: Driven to Drive? Investigating The Effect of Gamification on Learner Driver Behavior, Perceived Motivation and User Experience*	The groups field study was undertaken with 25 learner drivers over a four-week period during which the effect of the gamification on behavior change, perceived motivation and user experienced in the terms of logbook	Present an updated design of the application and investigates the effect of an application when tested in the field

	Australia		
Georgiou & Demiris, 2017	*Adaptive User Modelling in Car Racing Games Using Behavioral and Physiological Data* United Kingdom	Total users of 52 can associate key model variables and outcomes to user responses.	User-tailored tracks to improve driving habits and user experience and to keep engagement at high levels by proposing an adaptive user modelling approach

From Table 2.4 the list of previous research that use serious games in simulator shows lots of advantages for the towards user who undergoes the rehabilitation therapies and exercises. The importance of serious games in the simulator is to improve driving habits and user experience (Georgiou & Demiris, 2017). The effect of serious games on users' behaviour and perceived their motivation and user experience is lead to the enhancement and development of simulator (Fitz-walter et al., 2017). Hence, the attributes involved in each research are different, yet the focus of the previous research is to give a real-life experience through an adaptable simulator by playing serious games.

2.3.2 Serious Games in Robotic

Assistive technology is now part of the rehabilitation process where it works as an assistant for users to perform their activities of daily life (ADL). (Krucoff et al., 2016) stated that researchers have been working to restore the nervous system and reduce the neurological deficits of people suffering from stroke, spinal cord injury and traumatic brain injury as their impaired motor function is among the most prominent factors limiting the quality of life (Baur et al., 2018). Interactive robots are expected to be increasingly adopted in society and this including in developing countries.

The robots provide long-term value to the lives of people as there is a compelling need for a positive user experience when there is an interaction between both users and robots. In recent times, there is an increase in the number of interactive robots active in human environments (Van Greunen, 2019). Robots are increasingly investigated in motor rehabilitation due to the limitations of conventional therapeutic approaches where multicenter clinical trials have shown that robots can achieve long-term results comparable to exercise with a therapist (Novak et al., 2014).

In SOCSO Tun Abdul Razak Rehabilitation Centre, there are lots of robots that have been used as the assistive technology for rehabilitation. The equipment such as Cyberdyne from Japan, Lokomat and Erigo from Switzerland. However, not all robotic-based assistive technology are using serious games for rehabilitation. Serious games in robotic for rehabilitation are used to facilitate the transfer and

consolidation of multiplayer health-related gaming to robot-assisted neuromuscular therapy. This type of rehabilitation has also been used in researches such as Smart Chair Ski-Jumping Game (Merilampi et al., 2019) and The Tower of Hanoi (ToH) Serious Games (Jerčić et al., 2018).

As for all types of interactive systems in the human environment, participation of the robots in human daily life gives contribution especially when it has become as one of the rehabilitation tools. Robotic devices which act as one of the rehabilitation tools can offer patients with various types of feedback and modes of interaction that influenced the learning process at different levels (Colombo et al., 2007). The following summary studies in table 2.5 is showing on advantages of robot-aided and devices technology in rehabilitation.

Performing rehabilitation using robot-aided and devices that is enjoyable and fun are keys to gaining motivation. The technology presence is reliable and interactive which meets the user satisfaction with the usefulness and intensity of exercise. Based on recent studies, robotic devices have been used to generate custom training forces to trick subjects into altering their targeted movements to a pre-chosen movement as an after-effect of adaptation.

Table 2.5: Summary Studies of Serious Games in Robotic

Author	Tittle/Country	Data Analysis	Advantages
(Merilampi et al., 2019)	*A Smart Chair Physiotherapy Exergames for Fall Prevention – User Experience* Finland	2 different groups (Seniors and Students with Professionals). Of the participants (N=29), 14 of them were adults with an average age of 77.8 years old. The other 15 participants were students and professionals with an average age of 28.6 years old	Help in having good sitting while playing. Based on the questionnaire, the visual design is considered as relatively good for both groups (adults and students)
(Jerčić et al., 2018)	*The Effect of Emotions and Social Behavior on Performance in a Collaborative Serious Game Between Humans and Autonomous Robots* Sweden	N=70 (M=58, F=12) in the age range between 19 and 31. Each participant performed an experimented with four conditions with non-direct gestured movements. After completing the four conditions of playing games, participants will answer the GEW questionnaire.	The findings give positive emotion and sufficient arousal which might increase the performance on the task

(Goršič et al., 2017)	*A Multisession Evaluation of An Adaptive Competitive Arm Rehabilitation Game* USA	The game was evaluated by two groups participants (n=15) with chronic arm impairment who exercised at home with an unimpaired friend or relative and (n=20) in the acute or sub-acute phase of stroke who exercise in pairs of 10 at the rehabilitation clinic.	Multiplayer modes can enhance the player's perceived game experience and positively influence the player's performance
(Novak et al., 2014)	*Increasing Motivation in Robot-Aided Arm Rehabilitation with Competitive and Cooperative Gameplay* Switzerland	The game was on a computer monitor and controlled using shoulder movements in the ARMin robot. 3 game modes were tested: single-player, competitive and cooperative. All modes were played by (n=30) unimpaired subjects and (n=8) impaired chronic stroke subjects. Nearly all unimpaired subjects preferred	Competitive exercise has high a potential for unsupervised home rehabilitation as the enjoyment and exercises intensity were improved compared to exercise alone
(Andrade et al., 2016)	*Dynamic Difficulty Adjustment with Evolutionary*	User performance is estimated from its ability to achieve targets (game score) performing movements. A meta-profile for	Two games were created for rehabilitation purposes. These are

	Algorithm in Games for Rehabilitation Robotic Brazil	user behaviour was developed allowing to create and simulate different virtual users and game experiences on the computer	used in combination with freedom in robot devices
(Jonsdottir et al., 2018)	*Serious Games for Arm Rehabilitation of Persons with Multiple Sclerosis: A Randomized Controlled Pilot Study* Germany	A pilot single-blind randomized (2:1) controlled in a clinical trial was carried out. (n=16) participants with a mean age of 56.8 years and (n=10) participants used a serious games platform while 6 participants played with a commercial Wii platform for 4 weeks.	Serious games in group have been measure as to have improvements in arm function and are beneficial to MS user
(Hughes et al., 2014)	*Translation of Evidence-Based Assistive Technologies into Stroke Rehabilitation: User's Perceptions of The Barriers and Opportunities* United Kingdom	Structural comparative questionnaires have been designed, piloted and completed through distribution to P&Cs and HCPs. Questionnaires were designed based on themes identified from four focus groups held with HCP and P&Cs and piloted with a sample. 292 HCPs and 123 P&Cs were analyzed based on the questionnaires	The technologies are suitable for home use and could be mainly used outside the therapy session

From Table 2.5 serious games in robotic shows the benefits for users who undergo rehabilitation therapies and exercises. The importance of robots in assisting users to perceived game experience and positively influence users' performances by sustaining motivation (Goršič et al., 2017). Ease of use, comfortable, enjoyment, interaction, reliability and motivation are the attributes that have been emphasized in the previous studies.

2.3.3 Serious Games in Virtual Reality

With the rise of technology, virtual reality has been one of the platforms for serious games in rehabilitation that aims to facilitate patients with the gaming environment. This environment provides the patients with a fun experience while at the same time encouraging them to complete their personalized exercise sessions. Virtual reality platform has been used for rehabilitation purposed to overcome disabilities which resulted from brain injury. For an instant, memory impairment, attention deficit and unilateral visual neglect (Fernandez-Cervantes & Stroutia, 2019)

The virtual reality paradigm provides a natural interaction inside a synthetic world which is imperative to explore the proper design to attend to the needs of users. Virtual reality platform in serious games for rehabilitation has the potential to improve patient's outcomes in terms of emotion, behavior and attitude (M. A. Ahmad et al., 2019). The environment of virtual reality can be systematically configured with an interactive object placed according to individual physical abilities to move and stretch and reach so that the performance in the virtual reality

game can be a valid indicator of their exercise (Fernandez-Cervantes & Stroutia, 2019)

A previous study showed that patients in virtual reality cognitive training programs had better improvvements in repetition and memory retention than those in ordinary programs. It has been reported that elderly patients showed significant improvements in their emotional well-being after playing the games with a virtual reality training program (Li et al., 2018). In a research made by (Theng, 2012), the elderly is generally viewed as being adverse towards technology. However, it would be impossible for them to avoid technology. The early reports show positive outcomes from a single group that exposes the elderly to computers as they felt more confident and less alone.

MiRA is one of the serious games platforms used to tackle the issue of adherence through virtual reality (Mousavi Hondori & Khademi, 2014). In SOCSO Tun Abdul Razak Rehabilitation Centre, MiRA has been used to help enhance confidence while undergoing therapies and exercises through various types of games and movements that can be played by users as their daily therapies and exercises. Serious games in virtual reality for rehabilitation have been used in researches such as Thalmic Labs Myo Gesture Control (Dhawan et al., 2019), Virtual-Gym Bubbles (Fernandez-Cervantes & Stroutia, 2019)and Heart Collection Game Click or tap here to enter text.(Merilampi et al., 2018). Table 2.6 shows the summary studies of serious games in virtual reality.

Table 2.6: Summary Studies of Serious Games in Virtual Reality

Author	Tittle/Country	Data Analysis	Advantages
Merilampi *et.al*, 2018	*Activation Game for Older Adults – Development and Initial User Experience* Finland	Preliminary trial with a targeted group which consists of a total (N=25) that have been focused to 3 elderly care homes.	The new type of activation game with a specific controller handle based on an acceleration sensor that is easy to understand
(Wittmann et al., 2015)	*Assessment-Driven Arm Therapy at Home Using an IMU-Based Virtual Reality System* Switzerland	Preliminary results of patients (N=5), with an average age of 62.4 years old, first time stroke which motor deficit in the upper limb in 6 weeks of therapy without a therapist. On average, the patient's in-game assessed 3D workspace grew by 10.7% in volume and their score on the Fugl-Meyer Upper Extremity (FMA-UE) score improved by 5 points	Detailed assessment model of the workspace shape

(Fernandez-Cervantes & Stroutia, 2019)	*Virtual-Gym: A Virtual Reality Platform for Personalized Exergames* Canada	Descriptive N=9 (Male: 4, Female: 5) between the ages of 64 and 78. The participants are required to play three games of VR-Gym	Simplicity that reduces the feeling of stress and increases the feeling of competences
(Idriss et al., 2017)	Rehabilitation-Oriented Serious Game Development and Evaluation Guidelines for Musculoskeletal Disorders France	The case study for musculoskeletal disorders on the healthy control and patient groups showed the usefulness of the evaluation guidelines and associated games	Avatar movement improved by using a multi-sensor fusion approach Simplicity and challenging aspects are the main advantages of new technology
(Tobler-Ammann et al., 2017)	*User Perspectives on Exergames Designed to Explore the Hemineglected Space for Stroke Patients with Visuospatial Neglect: Usability Study* Switzerland	Participants (n=19) where patients (n=7) and therapists (n=12) evaluated to have used 5 times a week for 3 weeks. TAM questionnaire was filled out after the intervention. Descriptive analysis has been used to analyze TAM and comparative analysis to analyze the interviews.	Improve motor control in the affected arm due to hemiparesis following stroke without VSN symptoms.

		Illustration used to analyze focus group interview	
(Vugts et al., 2016)	Feasibility of Applied Gaming During Interdisciplinary Rehabilitation for Patients with Complex Chronic Pain and Fatigue Complaints: A Mixed-Methods Study Netherlands	Eligible patients are (N= 410) started an IRP during the study period, patients (n=116) participated in additional data collection where (n=108) with problematic fatigue and n=47 with moderate or severe pain. Qualitative data verified that hedonic motivation was the most important factor for behavioral intentions to use LAKA (P<.001)	Provide first empirical results on a novel applied game for behavioural change in patients with chronic pain and fatigue complaints. Comprehensive information is presented on processes of self-selection, acceptance and attrition which provides rare insights into risk factors for bias in CBI evaluations
(Lozano-Quilis et al., 2014)	Virtual Rehabilitation for Multiple Sclerosis Using a Kinect-Based System: Randomized Controlled Trial Spain	A randomized and controlled single-blinded study was carried out to assess the influence of a Kinect-based virtual rehabilitation system on the balance rehabilitation of patients with MS. Significant group-by-time interaction was detected in the scores of the	RemoviEM helped patients with MS became. RemoviEM obtained additional motivation and adhesion to the treatment from patients

		Berg Balance Scale and the Anterior Reach Test in standing position. The total of MS patients is 56 whom potential for the study	
(Rego et al., 2017)	*A Serious Games Platform for Cognitive Rehabilitation with Preliminary Evaluation* Portugal	A preliminary evaluation was held to evaluate the usability and attractiveness of the games. The total sample is out of 58 subjects, 36 of the users took part in online tests and 22 participated in classroom test	Contribution in cognitive rehabilitation for motivating patients
(Hoogland et al., 2019)	*Feasibility and Patient Experience of a Home-Based Rehabilitation Program Driven by a Tablet App and Mobility Monitoring for Patients after a Total Hip Arthroplasty* Netherlands	Enrolled 30 independently living patients aged 18-75 years who had undergone THA as a treatment for primary or secondary osteoarthritis (OA). After 5 times a week with overall 12 weeks of an exercise program with video instruction, the patients have done evaluated at the end of the program	Provide support for the feasibility home-based telemonitored rehabilitation program for patients after THA

(Merilampi et al., 2017)	*The Cognitive Mobile Games for Older Adults – A Chinese User Experience Study* Finland & China	Preliminary Trial with the targeted group where N=6 (Male = 2, Female = 4) with an average age of 82 years old. The participants need to fill in the questionnaire	Potential self-managed rehabilitation tool for Chinese elderly people
(Chen et al., 2013)	*A Case Study of User Immersion-Based Systematic for Serious Heritage Games* China	Likert scale measurement questionnaire was designed to evaluate users' entertainment level for the serious games. Interactive computer simulations are used to execute a user (N=15 at the age between 16 and 19) test to know the learning outcome.	Proposed two important design factors that impact on user immersion in serious heritage games which are user interface space volume and subsystem sequence
(Ling et al., 2017)	*Usability Test of Exercise Games Designed for Rehabilitation of Elderly Patients after Hip Replacement Surgery: A Pilot Study* Netherlands	Total of 9 participants including 2 physiotherapists and 7 patients which been asked to play 6 exercise games each lasting for 5 min. The mean age of the patients was 74.57 years. Surveys were developed to quantitatively measure the usability factors	The adaptability of patients while playing the games is beneficial to the patient's daily life activities such as walking. The various types of games with different difficulties helped them to know their abilities

(Pramana et al., 2018)	*Using Mobile Health Gamification to Facilitate Cognitive Behavioral Therapy Skills Practice in Child Anxiety Treatment: Open Clinical Trial* United States	UCD approach was used to gather requirements and iteratively design the system, leveraging the SmartCAT 1.0 system. The SmartCAT system consists of a smartphone app for children and an integrated clinician portal. SmartCAT is frequently used throughout the treatment. A total of participants (N=35) at the aged of 9-14 years olds met the criteria for the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) diagnosis	Sessions and assessments tracking for the therapist on participants. The inclusion of gamification effectively increases user engagement and retention
(Brox et al., 2017)	*User-Centered Design of Serious Games for Older Adults Following 3 Years of Experience with Exergames for Seniors: A Study Design*	A total of 16 seniors with an average age above 80 years participated for 3 years in UCD	Best practice guide to the development of serious games for physical activity from user-centered design

	Norway		
(Tan & Zary, 2019)	*Diagnostics Markers of User Experience, Play and Learning for Digital Serious Games: A Conceptual Framework Study*	Diagnostic criteria for serious games were created which has comprised the clusters of UX, play and learning whereby each cluster were grouped and the results were recorded	Come out with e-learning modules using serious games by using diagnostic criteria

Serious games in virtual reality holds patients' attention throughout the slow and steady processes and motivates them during their road to recovery. Moreover, it offers the capacity for individual treatment in addition to standard physiotherapy in rehabilitation. Hence, virtual reality technology rehabilitation has the potential to improve patient participation, enable intensive therapy and reduce the demand on health care professionals (M. A. Ahmad et al., 2019). From Table 2.6 shows the list of previous studies on serious games in virtual reality. As it developed to be entertaining and motivating, serious games in virtual reality are providing an easy to understand games to reduce the feeling of stress and increase the feeling of competences (Fernandez-Cervantes & Stroutia, 2019; Merilampi et al., 2018). There are lots of attributes highlighted in every research conducted previously such as simple, meaningful, real, challenging, easy to start, user-friendly and interactive.

2.3.4 Serious Games in Hybrid Technology

Hybrid serious games are the combination and formation of two or more types of rehabilitation tools that work as one. Robotic assistance and virtual reality have the potential to enhance the rehabilitation of neuromuscular deficits beyond the levels possible with conventional training strategies (Baur et al., 2014). Furthermore, robot-aided rehabilitation is frequently combined with virtual reality as a twofold which give a varied range of tasks that can be trained in a short time and able to increase patient motivation that has been described by professionals as an important determinant of rehabilitation outcome (Novak et al., 2014).

The following summary studies are focusing on hybrid serious games between robot-aided with virtual reality. The advantages in the previous research papers stated that hybrid serious games for rehabilitation have performed simultaneous and quick activation to facilitate muscle contraction for the user while playing the games. Physiologically hybrid serious games of robotic and virtual reality help users to engage with the potential and boost motivation to them in an immersive environment. Table 2.7 shows the summary of previous studies on hybrid technology.

Table 2.7: Summary Studies of Serious Games in Hybrid Technology

Author	Tittle/Country	Data Analysis	Advantages
(Prahm et al., 2017)	*Game-Based Rehabilitation for Myoelectric Prosthesis Control* Austria	Significant improvement in fine accuracy electrode activation and separation and endurance control from EMG assessments. The deviation around the EMG goal value diminished and the opposing electrode activated less frequently.	Participants sustained contractions from flexor and extensor muscle activation over varying periods of time and performed precisely time contractions and executed simultaneous contractions of both muscle groups
(Dhawan et al., 2019)	*Prosthetic Rehabilitation Training in Virtual Reality* Australia	Conducted with 2 samples (N=34, non-amputees and N=2, transradial amputees) which need to be filled in the survey which collected subjectively	The system was designed to be easy to and incorporate similar controls that transradial amputees would have on myoelectric prosthetic
Baur et al., 2018	*Trends in Robot-Assisted and Virtual Reality-Assisted Neuromuscular Therapy: A*	A systematic search was conducted through EMBASE, Medline, PubMed, Cochrane, CINAHL and PsycINFO. 13 articles met the inclusion criteria. Multiplayer modes are	Two-player rehabilitation games create greater enjoyment as well as potentially more intensive exercise compared to single-player games

	Systematic Review of Health-Related Multiplayer Games Switzerland	used in health-related multiplayer games which are competitive, collaborative and co-active modes. It positively affected game experience in 9 studies and game performance in 6 studies	
(Mubin et al., 2019)	*Exoskeleton with Virtual Reality, Augmented Reality and Gamification for Stroke Patient's Rehabilitation: Systematic Review* United Arab Emirates (UAE)	30 studies were identified based on inclusion criteria and included randomized controlled trials. Participants (n=385) in various studies field	Results from this systematic review depict that most rehab services are carried out in groups in clinics while home-based rehab is rarely attempted
(Mubin et al., 2020)	*Exploring Serious Games for Stroke Rehabilitation: A Scoping Review* United Arab Emirates (UAE)	Many medical respositories were searched for relevant articles in a window of 2008-2018 where 18 studies were chosen for the scoping review depending on the inclusion criteria, design principles used in these studies	Main findings from the review concerning the attributes of existing games for stroke rehabilitation

As for this research, serious games in assistive technology have been chosen to be the product for persons with disabilities to undergo their rehabilitation sessions and therapies. The three assistive technologies: simulators, robotics and virtual reality that used serious games for rehabilitation are aiming to help them improve their performance in specific movements and visual coordination (de O. Andrade et al., 2013). Demographic changes in the last few decades have been challenging for physiotherapists and the healthcare sector, yet the recent advances in technology have allowed them to benefit from the growth of technology in rehabilitation.

Serious games are game systems with nonentertainment purposes that can be used to support or motivate activities, in this research it benefits for physical rehabilitation (Almeida & Nunes, 2020). It is a commonly used method in rehabilitation method as the traditional and standard rehabilitation process is single and repetitive, yet it is often difficult to maintain the interest (de O. Andrade et al., 2013; Ning et al., 2015). Hence, the use of serious games as an aid to the healthcare process is a promising approach (de O. Andrade et al., 2013) to create quality attributes like fun, interactivity, and immersion of the game in exercises to improve experiences in person with disabilities (Ning et al., 2015).

Serious games for rehabilitation can be more engaging than other exercises as it replaces reward and motivation systems with real-life motivations as a complement (Shahmoradi et al., 2022). From this research, the objective is to focus on user experience factors in serious games for rehabilitation. Usability is a quality factor that measures the extent of simplicity that affect the receiver's success in a system (Muqtadiroh et al., 2017) meanwhile motivation is an improving factor to enhance motivation to learn and

developing motivational attributes in persons with disabilities who undergo rehabilitation (Hamzah et al., 2015).

The quality attributes from usability and motivation factors can be observed while using serious games for rehabilitation. Attributes are required to identify the quality of how serious games have been used in rehabilitation sessions and therapies to the extent of bringing new experiences to persons with disabilities (Holzinger et al., 2008) .Table 2.8 shows the keywords in the previous research that have been outlined and mentioned by their researchers for future enhancement and works and Table 2.9 shows the number of repetitions on each keyword in previous research.

Table 2.8: Keywords Used in Previous Research

Author & Year	Title of Research	Keywords
(Gómez et al., 2018)	Driving Simulator Platform for Development and Evaluation of Safety and Emergency Systems	Adaptive, cooperative, validity, reliability
(Fitz-walter et al., 2017)	Computers in Human Behavior Driven to Drive? Investigating The Effect of Gamification on Leaner Driver, Perceived Motivation and User Experience	Enjoyable, effectiveness
(Georgiou & Demiris, 2017)	Adaptive User Modelling in Car Racing Games Using Behavioral and Physiological Data	Experienced, expert, attention

(Merilampi et al., 2019)	A Smart Chair Physiotherapy Exergame for Fall Prevention – User Experience Study	Enjoyable, fun, useful, interesting
(Jerčić et al., 2018)	The Effect of Emotions and Social Behavior on Performance in Collaborative Serious Game between Humans and Autonomous Robots	Interactive, reliable, presence
(Goršič et al., 2017)	A Multisession Evaluation of An Adaptive Competitive Arm Rehabilitation Game	Enjoyment, motivating, exercise intensity
(Novak et al., 2014)	Increasing Motivation in Robot-Aided Arm Rehabilitation with Competitive and Cooperative Gameplay	Motivating, exercise intensity, enjoyment
(Andrade et al., 2016)	Dynamic Difficulty Adjustment with Evolutionary Algorithm in Games for Rehabilitation Robotic	Reachable, the games getting too fast, freedom of choosing games, balance
(Jonsdottir et al., 2018)	Serious Games for Arm Rehabilitation of Persons with Multiple Sclerosis: A Randomized Controlled Pilot Study	Motivating, positive feelings
(Hughes et al., 2014)	Translation of Evidence-Based Assitive Technologies into Stroke Rehabilitation: User's Perceptions of The Barriers and Opportunities	Satisfaction, durable, easy to set up, comfortable, low risk

(Merilampi et al., 2018)	Activation Game for Older Adults – Development and Initial User Experiences	Entertaining, motivating, meaningful, simple
(Wittmann et al., 2015)	Assessment-Driven Arm Therapy at Home using an IMU-Based Virtual Reality System	Dynamic movement, challenging
(Fernandez-Cervantes & Stroutia, 2019)	Virtual-Gym: A Gym Virtual Reality Platform for Personalized Exergames	Simplicity, variety
(Idriss et al., 2017)	Rehabilitation-Oriented Serious Game Development and Evaluation Guidelines for Musculoskeletal Disorders	Real, motivating, attractive, challenging
(Tobler-Ammann et al., 2017)	User Perspectives on Exergames Designed to Explore The Hemineglected Space for Stroke Patients with Visuospatial Neglect: Usability Study	Effective, satisfying, easy to start, efficient, user-friendly, the complexity of the UI
(Vugts et al., 2016)	Feasibility of Applied Gaming During Interdisciplinary Rehabilitation for Patients with Complex Chronic Pain and Fatigue Complaints: A Mixed-Methods Study	Feasible, illustrative, motivational, interactive

(Lozano-Quilis et al., 2014)	Virtual Rehabilitation for Multiple Sclerosis using a Kinect-Based System: Randomized Controlled Trial	User-friendly, interactive
(Rego et al., 2017)	A Serious Games Platform for Cognitive Rehabilitation with Preliminary Evaluation	Motivating, user interaction, competitive, cooperation
(Hoogland et al., 2019)	Feasibility and Patient Experience of a Home-Based Rehabilitation Program Driven by a Tablet App and Mobility Monitoring for Patients After A Total Hip Arthoplasty	Balance, challenge, reward
(Merilampi et al., 2017)	The Cognitive Mobile Games for Older Adults- A Chinese User Experience Study	Simplicity, suitable, entertaining, exciting, evidently catching
(Chen et al., 2013)	A Case of User Immersion-Based Systematic Design for Serious Heritage Games	Immersive, easy to navigate, motivating, learning
(Ling et al., 2017)	Usability Test of Exercise Games Designed for Rehabilitation of Elderly Patients After Hip Replacement Surgery: Pilot Study	Focus, motivating, immersive, simple, enjoyment
(Pramana et al., 2018)	Using Mobile Health Gamification to Facilitate Cognitive Behavioral Therapy Skills Practice in Child	Motivating, interactive, understandable, home-

	Anxiety Treatment: Open Clinical Trial	based task, digital reward, reduce anxiety
(Brox et al., 2017)	User-Centered Design of Serious Games for Older Adults Following 3 Years of Experience with Exergames for Seniors: A Study Design	More focus, motivating, in detail, different GUI
(Tan & Zary, 2019)	Diagnostic Markers of User Experience, Play, and Learning for Digital Serious Games: A Conceptual Framework Study	Self-assessment, e-learning, attention
(Prahm et al., 2017)	Game-Based Rehabilitation for Myoelectric Prosthesis Control	Quick, simultaneous, dexterity
(Dhawan et al., 2019)	Prosthetic Rehabilitation Training in Virtual Reality	Physiological exercise, engaging, motivating
(Baur et al., 2018)	Trends in Robot-Assisted and Virtual Reality-Assisted Neuromuscular Therapy: A Systematic Review of Health-Related Multiplayer Games	Enjoyment, cooperative, motivating, interactive
(Mubin et al., 2019)	Exoskeletons with Virtual Reality, Augmented Reality, and Gamification for Stroke Patients' Rehabilitation: Systematic Review	Immersive, motivation booster, potential rewards

(Mubin et al., 2020)	Exploring Serious Games for Stroke Rehabilitatioon: A Scoping Review	Meaningful to play, handling of failures, emphasizing challenges, value of user's feedback

Table 2.9: Repetition of Keywords in Previous Research

Keywords	Number of Repetition	Keywords	Number of Repetition
Meaningful	2	Different GUI	1
Error handling	2	Understandable	1
Low risk	1	Home-based task	1
Challenges	3	Reward	2
Value of feedback	1	Reduce anxiety	1
Immersive	3	Simple	5
Motivating	15	Easy	3
Enjoyment	5	Suitable	1
Potential	1	Entertaining	1
Cooperative	4	Exciting	1
Interactive	5	Evidently catching	1
Physiological	1	Balance	2
Engaging	1	Competition	1
Quick / Fast	2	User friendly	2
Simultaneous	1	Feasible	1
Dexterity	1	Illustrative	1
Self-assessment	1	Effective	2
E-learning	1	Satisfy	2
Attention / Focus	4	The complexity of UI	1

In detail	1	Real / Presence	2
Attractive	1		
Variety	1		
Dynamic	1		
Durable	1		
Comfortable	1		
Positive	1		
Reachable	1		
Freedom	1		
Exercise intensity	1		
Reliable	2		
Experience	1		
Expert	1		
Fun	1		
Useful	1		
Interesting	1		
Adaptive	1		
Validity	1		

The keywords mentioned in Table 2.8 from the previous research are meaningful and worthy to be discovered. From the table, the most repeated keyword mentioned in the previous studies is 'motivating' which refers to feelings and the outcome of persons with disabilities playing serious games for rehabilitation. It has been mentioned by the researchers for more than 10 times; hence it shows how motivation can affect the development of serious games in the rehabilitation. Other than that, the word 'enjoyment', 'interactive' and 'simple' are also being highlighted in the previous research which repeated almost 10 times.

Serious games bring new real-life experiences for persons with disabilities to undergo their rehabilitation exercises. Besides, 'cooperative', 'meaningful', 'challenging' and 'easy to use' serious games are other criteria that need to be embedded in the development of future serious games. The outlined keywords are tabulated in Table 2.9 shows the repetition number in the previous research. There are more than a hundred keywords mentioned in 30 different research papers that focusing on user experience in serious games for rehabilitation. As this research is focusing on user experience factors, the following subsections are discussing on the factors.

2.4 User Experience

Experience is a subjective scene which can either brings positivity or vice versa towards the user. The more differences in phenomena that happened in users to identify, the more complex it resulted in their life experiences. (Basri et al., 2017) in their research stated that many perspectives have been existed on user experience and it is understood in different ways by several disciplines such as user experience as a practice and user experience as a field of study. Other than that, (Tokkonen & Saariluoma, 2013) in their research has highlighted the importance of user experience in terms of quality, context and relationship with other people.

Though user experience can be defined differently according to multiple groups, a clear definition of user experience which is promising to nearly approach the real according to (Law et al., 2009) is constructed as a person's perceptions and responses that result from the use and/or anticipated use of product, system or service. Even though there is no consensus on the definition of user experience in literature,

there is a common understanding which shows the interception of the meaning and makes the user experience more holistic (Hellweger et al., 2015; Hellweger & Wang, 2015). Thus, user experience (UX) is summarized as a consequence of a user's internal state where the characteristics of the designed system and there is context stated within which the interaction occurs.

User experience is a quality of interaction which can measure and evaluate a participant has when interacting with a computer system (Santoso et al., 2017). The quality of the UX is not depending on the common agreement on nature and scope but on the growing interest and method. The evaluation of the usability of serious games can be shown in terms of user perspectives and feedback on them. (Santoso et al., 2016) states that usability is one of the existing software quality criteria that belongs to a non-functional requirement that defines how users learn and use the product, system and service to fulfill their objectives and satisfaction by following certain processes.

Serious games for rehabilitation are mainly aimed to help users gaining their abilities during the therapy session besides getting enjoyment and motivation through different types of rehabilitation tools. (Maclean et al., 2002) in their research stated that motivation was a frequently used concept and has been described as an important determinant of rehabilitation. The determinants of motivation are not only located in the user's personality but also in social factors.

2.4.1 User Experience in Serious Games

In the past few years, its seen a surge in digital games seeking to educate, train and inform the users on a broad spectrum of topics where serious games are often defined as the games that are developed for non-recreational purposes and used as an adjunct to education and therapy (Tan & Zary, 2019). The use of serious games at every level of age has helped users to reach certain target and goals. Children benefit from serious games in education meanwhile the eldest get the advantages of living a healthy life with them. The interaction of between human and computers has led a user to experience the assistance of serious games.

Serious games are now the new tool used in the therapy of rehabilitation field to help the eldest and people with disabilities to have a quality of life. Instead of doing the tedious and repeated exercises for therapy, they can have their own experiences in using serious games for getting sufficient balance and strength to manage their daily life (Brox et al., 2017). Recently, many studies have been conducted to investigate the effects of playing serious games on the eldest. The results of the studies have shown that there is social-related involved where emotion-related, behaviour-related and attitude-related have been identified (M. A. Ahmad et al., 2019).

The social impact of serious games on user experience is significantly higher in terms of empathy, positive affect and behavioural involvement where social interaction is intended (Pereira et al., 2019). The lower level of loneliness, social anxiousness has declined, and a sense of connecting or being with others are the positive effects of serious games on the eldest (Li et al., 2018). Thus, the

importance of serious games in assisting the eldest and people with disabilities have been widely used to improve their physical health and social skills. It has resulted in positive impacts on both health and well-being.

As the assistive technology tools, serious games have been played on many types of platforms. Robotic, virtual reality, and simulator are three types of medium for the eldest to stay healthy and do the repeating exercises in a different environment. The immersive and supportive characteristics of serious games have been the essential look for the eldest and people with disabilities to undergo therapies. The aim of helping them through the best technology, has resulted in the user-friendly, fun, learning-based serious games. Hence, it helps in outlining the new guidelines in developing serious games for future works as it helps in improving adherence which is often influenced by aspects such as lack of motivation (Hoogland et al., 2019).

Several strategies have been proposed to improve patients' motivation and exercise intensity during rehabilitation, yet robotic serious games are invented to explore the potential ways to reach the goals (Novak et al., 2014). Robotic serious games bring new experiences for users especially the eldest and people with disabilities. The way of playing serious games using a robotic platform is much easier as there is an element in adapting and helping users to undergo exercises (Merilampi et al., 2019). The factor of robotic serious games being more adaptive and easier has contributed to the impaired strength and balanced of the user.

A growing number of people nowadays have contributed to the interactive robots that act specifically for society. Social interactive robotics led to the human

and robotic interaction where it related to understanding, planning, and assessing automated framework for users (van Greunen, 2019). One of the main applications that use robotic serious games to undergo rehabilitation has shown the long-term results of positive impact. Furthermore, a robot-aided platform is frequently combined with virtual reality (Novak et al., 2014). Virtual reality has become one of the objectives in virtual rehabilitation to make the process of therapy a better experience for the eldest and people with disability (Pasqual et al., 2016).

The intellectual games which involve multilevel challenges, have proposed a structured model of developing virtual serious games for users to experience. The merger of game-based approaches and virtual reality environments can enhance the learning and training methodologies in rehabilitation (Checa & Bustillo, 2019). Virtual serious games are growing success due to a several factors that entertain and motivate users using multimodal interaction (Pasqual et al., 2016). Performing user experience on virtual reality has to speed up the product development in training, rehabilitation and mental health therapies (Lorenz et al., 2019).

The immersive characteristic of virtual reality serious games provides a real-life experience for users and it is easy to manipulate and arrange the virtual objects using the interaction ways developed for it (Nam et al., 2019). Hence, soft robotic paired with immersive virtual reality serious games has created a personalized assistive therapy experiences for the eldest and people with disabilities (Elor et al., 2019). Other than robotic and virtual reality serious games,

simulator have been used widely in rehabilitation. Driving simulation is part of rehabilitation therapies in which the eldest and people with disabilities to experience a realistic environment.

Research-based driving simulators have emerged as a safe, convenient way to assess driving performance (Tiu et al., 2020). Serious games using the driving simulator platform have made it easy for user drivers to record their mandatory practice sessions. The suggestion of perceiving motivation and user experience in the driving simulator has encouraged a discussion on the effectiveness of serious games in behaviour changes (Fitz-walter et al., 2017). User experience in serious games has driven a broad spectrum of development in rehabilitation and user behaviour.

Serious games bring new experiences towards users with different environments and learning outcomes. It helps inexperienced users to have the feeling of real-life situations and scenes that address the issue of being bored and tired of doing the tedious standard rehabilitation therapies. Thus, user experience has led to a new phenomenon in increasing motivation and improving the usability of serious games. There are existing models for usability and motivation that have been used for the past decades to pursue and develop new serious games for the eldest and people with disabilities in rehabilitation.

2.4.2 Usability Factor

Usability is part of user experience (UX) that can be defined as the capability of an entity to be in the design of products and evaluated by the inspections or usability

tests. Usability is part of the user experience that includes all the users' feedbacks, emotions, beliefs, preferences, behaviors and accomplishments which occur before, in the meantime and after using a product (Quiñones & Rusu, 2019). Usability is an interactive system that can be used by specified final users to achieve quantified objectives (Luis et al., 2004).

Usability in user experience is part of software quality which becoming more essential nowadays. The quality of use in usability has contributed to understanding the nature of user experience and product development (Klotins, 2011). Usability is a construct that is inherently defined as interactive (Thielsch et al., 2015). The models are conceptual views where the focus areas are to demonstrate the usability of the existing software (Madan & Dubey, 2012)

Over decades the term of usability has been redefined by many authors and the final definition of usability is best known and widely used from the ISO 9241 (ISO 9241-11, 1998). The extent of the definition to which a system, product or service can be used by the specified users to achieve the specified goals with efficiency and satisfaction in a specified context of use (Rusu et al., 2015). The mainstream activity of usability in user experience is evaluation. As there are various types of techniques and models to measure the user-oriented quality assessment of technology including satisfaction, efficiency, learnability, and usefulness (Mcnamara, 2006).

The evaluation of usability in serious games is depending on the model and techniques that have been chosen. However, the key to evaluating a software or a product or a system is to ensure the experience gained by the users and the

functionality of each software or product or system is useful (Mcnamara, 2006). Since the human and computer interaction (HCI) is showing the multiple disciplines of developing serious games as one of the assistive technology tools in rehabilitation, the principal approach to understanding the quality of interaction is by knowing the definition of usability and its measurement (Wright et al., 2001). The following Table 2.10 show the types of usability models that have been used by researches to analyze data models based on recent studies.

Table 2.10: Usability Models in Recent Studies

Model	Attributes	Focus
Nielsen's	Effectiveness, Efficiency, Satisfaction, Learnability	The term utility as how effective the system can meet user needs (Alturki & Gay, 2017)
	Later: Efficiency, Learnability, Satisfaction, Errors, Memorability	Studied and recognized the important attributes that influence the acceptance of the product and divided into practical and social acceptance (Madan & Dubey, 2012)
Technology Acceptance Model (TAM)	Perceived ease of use and usefulness	A useful framework for explaining the intention of use, usage and satisfaction (Charness et al., 2016)
		Discussed the theory of reasoned action (TPA) and behavior (TPB)

		which focuses on potential users (Hussain et al., 2016)
International Organization Standardization (ISO 9241-11)	ISO 9241-11: Effectiveness, Efficiency, Satisfaction	Usability in which a product can be used by specified users to achieve specified goals in a specific context of use (Alturki & Gay, 2017)
	ISO 9126: Understandability, Learnability, Operability, Attractiveness, Usability Compliance	

There exist several quality models like McCall (1977), FURPS (1987), Capability Maturity Models (1989), IEEE (1992), Dromey (1995), and ISO (1991) that are given by the researchers as an indispensable quality attribute for a software system (Madan & Dubey, 2012). However, from time to time the development of software or product is not totally depending on the quality of usability but in the experience felt by the users. A widely used inspection method to evaluate usability and user experience. Yet to support the process of developing the recommended elements of usability in user experience (Quiñones & Rusu, 2019). A brief explanation of the models in Table 2.10 is as follows.

(A) Nielsen's Usability Model

The history of the usability was used in replace using the term of user-friendly concept which was introduced in the 80s, however different researchers have produced different meaning of usability same goes for Nielsen. (Madan & Dubey, 2012) define usability as the ability of a user to use the thing to carry out a task successfully, whereas user experience takes a broader view in looking at the individual's entire interaction. Usability models are conceptual views which showing the focus area to demonstrate the functionality of the software and products.

Nielsen Model in 1993 studied and recognized the usability as an important attribute to influence the acceptance of a product. Nielsen's Usability Model contain four main attributes: effectiveness, efficiency, satisfaction and learnability however he later removed the effectiveness attribute and added memorability and errors in his new model (Alturki & Gay, 2017). The updated Nielsen Usability Model in 2006 consists of five main attributes: efficiency, learnability, satisfaction, errors and memorability (Madan & Dubey, 2012) which defines the term utility as how effectively the system can meet user needs.

Nielsen and Loranger in 2006 have defined usability as a quality attribute relating to how easy something is to use, more specifically how quick people can learn to use it (learnability), efficient while using it (efficiency), memorable and error-prone it is and how much users like using it (satisfaction) (Rusu et al., 2015). The term utility as how effective the system can meet user needs (Alturki & Gay, 2017). Studied and

recognized the important attributes that influence the acceptance of the product and divided it into practical and social acceptance (Madan & Dubey, 2012). Figure 2.6 shows the updated Nielsen Usability Model.

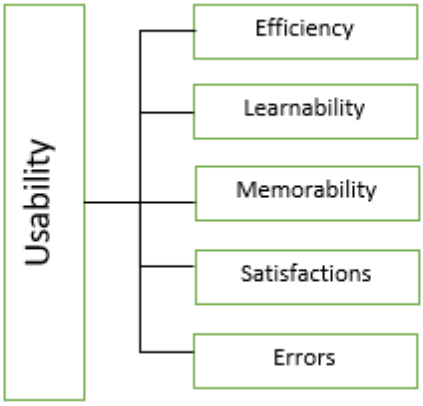

Figure 2.6: Nielsen's Usability Model (Alturki & Gay, 2017)

Each attribute brings a different function and focuses on usability for the user to experience while using the product. Nielsen's attributes in evaluating usability in user experience are more mature and better-motivated usability method (Klotins, 2011). The following Table 2.11 shows the definition of each attribute according to Nielsen.

Table 2.11: Nielsen's Usability Model Attributes

Attributes	Definition
Learnability	The system should be easy to learn, so that the user can rapidly start getting some work done with the system

Efficiency	The system should be efficient to use, so that once the user has learned the system, a high level of productivity is possible
Memorability	The system should be easy to remember, so that the casual user can return to the system after some period of not having used it
Errors	The system should have a low error rate, so that users make few errors during the use of the system, and so that if they do make errors, they can easily recover from them
Satisfaction	The system should be pleasant to use, so that users are subjectively satisfied when using it; they like it

Source: (Alturki & Gay, 2017; Korhan & Ersoy, 2015)

(B) Technology Acceptance Model

Information technology adoption and use in the workplace remains a central concern of information system research where significant progress has been made over the last decade in explaining and predicting user acceptance (Venkatesh et al., 2000). Motivational affordances and usability are two device characteristics thought to be predictive of acceptance because they directly relate to the perceived the usefulness and ease of use criteria of the Technology Model Acceptance (TAM) (Rupp et al., 2018).

Technology Acceptance Model (TAM) is an information technology framework for understanding users' adoption and use of

emerging technologies in the workplace environment and has been tested in older populations (Portz et al., 2019) . Technology Acceptance Model (TAM) is invented by Davis in 1986 to predict, explain and increase user acceptance by understanding the human and computer interaction. The first name of TAM comes from the theory of reasoned action (TRA) which focuses on predicting and explaining the user behaviour.

Davis has introduced an adaptation of TRA, which is specifically meant to explain the computer usage behaviour. TAM use TRA as the theoretical basis for linking the two key beliefs of perceived of usefulness and perceived ease of use (Davis et al., 1989). As a result, TAM is a conceptual framework based on the theory of psychology namely the theory of action (TPA) and behavior (TPB). This model explains the acceptance of given information technology to potential users where the original TAM suggests to perceived usefulness and ease of use. These two attributes influence the user's attitude towards technology which turns out to determine their intention in using or adopting the technology (Hussain et al., 2016).

A useful framework for explaining the intention of use, usage and satisfaction (Charness et al., 2016). The theory discusses a person's intent of use (acceptance of technology) and usage of behavior (actual use) of technology based on their perceptions of technology's usefulness and ease of use (Portz et al., 2019). Although some limitations on TAM such as limited skill, time, environmental or organizational, the two keys play an

important role in presuming the objectives (Naeini, 2012). Figure 2.7 shows the TAM attributes.

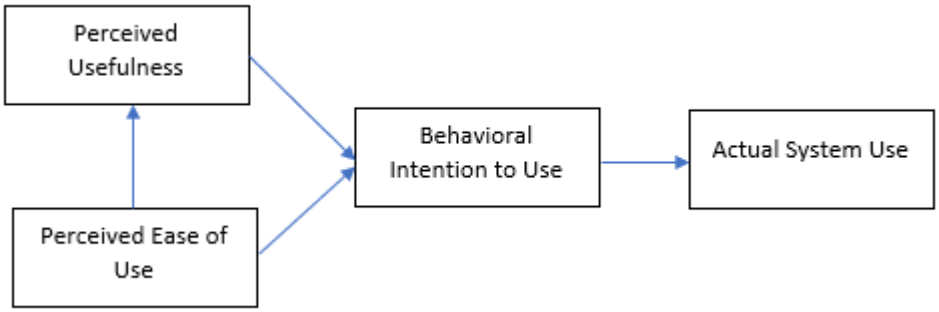

Figure 2.7: TAM attributes (Naeini, 2012)

(C) International Organization for Standardization (ISO)

The usability of software has become a major research them within the software engineering community. International Standardization for Organization (ISO) is defined as a set of attributes that bear on the effort needed for use and on the individual assessment of such use, by a stated or implied set of users (Abran et al., 2003b). ISO consists of three basic sub-attributes namely effectiveness, efficiency, and satisfaction invented in the year of 1998.

Usability in user experience according to the ISO 9241-11, 1998 is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use (Abran et al., 2003a). It is interesting to

investigate the user experience definition proposed by ISO which addresses the object is related to a product, system, or service. As it is hard to pick one word to define the user experience according to the ISO, hence the definition of usability and the use of UX is narrower than the general meaning.

There are usability standards which have been categorized into four different groups. The following Figure 2.8 shows the standard related to usability in user experience.

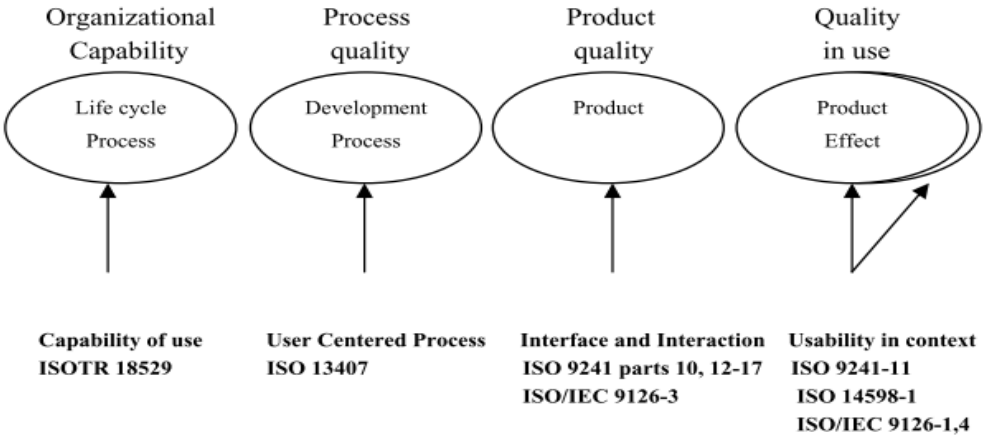

Figure 2.8: Categories of ISO Usability Standards

The ISO has developed the classified standards for software usability. Figure 2.8 shows the categories of the ISO usability standards which are divided into four groups. The first category is the product effect which focuses on the output, effectiveness, and satisfaction at the time of using the product. The second category is the product attribute which involves the interface and interaction of the product. The next category is

a process used to develop the product and the last category is the organization's capability to do the life cycle process (Abran et al., 2003a, 2003b).

Moving ahead, the ISO laid down from the year 2000 to 2002 edition with the main objective is to provide a framework to evaluate software quality from product perspectives which with new sub-attributes namely understandability, learnability, operability, attractiveness, and usability compliance (Abran et al., 2003a). There is total of 8 attributes in ISO for usability. Usability is when a product can be used by specified users to achieve specified goals in a specific context of use (Alturki & Gay, 2017).

The ISO is used for usability depending on the nature of the user, the task, and the environment. In a product-oriented approach, usability is seen as a relatively independent contribution to software quality (Abran et al., 2003b). Figure 2.9 shows the first sub-attributes of ISO in 1998.

Figure 2.9: ISO 9421-11 Attributes (Alturki & Gay, 2017)

From the recent usability models that have been used in recent studies, the researcher has summarized the focus and attributes explanation of each model in Table 2.12 below.

Table 2.12: Usability Model Summarization

Model	Attributes	Explanation	Focus
Nielsen's	Effectiveness	Related to the productivity of the system	User experience
	Satisfaction	Give pleasant feelings while using the system and can fulfill the task	
	Memorability	Can return to the previous state, not from the beginning	
	Learnability	Easy to learn and understandable	
	Errors	Should be less and be able to recover	
TAM	Perceived Ease of Use	Attitudes towards the system	Adaptation on to new technology
	Perceived Usefulness	Intention to use the system	
ISO 9241-11	Effectiveness	Completion of task within the time	System acceptance
	Efficiency	Accuracy of completion	
	Satisfaction	User acceptance	
ISO 9126	Understandability	Software product to enable a user to understand	System quality
	Learnability	Software product to learn the application	

	Operability	Enable users to operate and control the system
	Attractive	Attractive for the user to use
	Usability Compliance	Meet the standard and user's need

From the summary of usability models in Table 2.12, it is affirmed that usability is generally regarding how easy to learn, effective to use, and enjoyable. Usability is about efficiency, effectiveness, and overall satisfaction which combine with intuitive design, ease of learning, the efficiency of use, memorability, error frequency and severity, and subjective satisfaction regardless they are called attributes or goals (Rusu et al., 2015; Sharp et al., 2006).

It can be concluded from the summary in Table 2.9 that Nielsen's Usability Model is focusing on user experience where five attributes that can be discussed. TAM shows the user acceptance based on behavior and intention to use the system. The ISO starts with the aim for system quality based on preferences but towards the end, for improvement the ISO is focusing on the system quality. From these four models recently used in previous studies, the researcher has decided to choose Nielsen's usability model for occupying the research objective to investigate and recognize the usability attributes.

As in rehabilitation requires important attributes to sustain and prolong the therapies and exercises using serious games (Bowker et al., 2006), there are three (3) attributes from Nielsen's Usability Model that are suitable for rehabilitation. The rehabilitation assessment of persons with disabilities according to their daily

therapies and exercises is strongly emphasize on the impact of the injuries they faced. With less neurological impairment, the assessment is based on the observation and judgement of the therapists to identify the best plans and actions needed for them to learn and memorize (Mousavi Hondori & Khademi, 2014).

The three (3) attributes are learnability, memorability and satisfaction. Memorability on the other hand is a vital attribute that needs to be in serious games for rehabilitation as every person with disabilities undergoing their therapies has less neurological impairment. (Merilampi et al., 2017; Mousavi Hondori & Khademi, 2014). As efficiency according to Jakob Nielsen is to describe the system performance (Madan & Dubey, 2012), yet learnability is also can be expressed with efficiency and effectiveness (Winter et al., 2008). Hence, the researcher has decided to maintain the learnability attribute for this research.

Other than that in this research, the researcher is introducing one attribute that affects user experience in serious games for rehabilitation. Ease of use is one of the attributes of usability that can be perceived as the degree to which the user believes that using a particular system would be free of effort (Hussain et al., 2016). The attribute defines the process of a system which can describe efficiency (Madan & Dubey, 2012). As WHO defined persons with disabilities as someone who has experienced impairment and in this research the four (4) groups selected to be respondents are having a less neurological impairment, hence ease of use, learnability, memorability and satisfaction are the essential attributes for them to be able to learn and memorize during their rehabilitation sessions.

2.4.3 Motivation Factors

User experience is an important field in measuring the preferences of users of every level of age. As motivation is one of the criteria that have been discussed recently by the researchers to be as an added value in developing serious games, it is essential to have a heuristic guideline for the development. Motivation is vital in delivering impacts for people who undergo therapy or the eldest to stay healthy and keep their momentum growing (Merilampi et al., 2017). This indicates high motivation level and sense of usefulness in using serious games for sustaining their health.

The adjunct of motivation characteristic in developing serious games has led to the exploration of user experience. Some guidelines and theories that discussed on the importance of motivation in user behaviour and preferences such as the ARCS motivation model and the intrinsic and extrinsic motivation. Motivation is the extent to which continual effort is directed towards a goal (Hamzah et al., 2015). Motivational design can be used in enhancing the urge of learning, working, training, and developing motivation characteristics in users' self-motivation.

Motivation is most relatable to the internal perception that effecting the behavior. Behavior changes have often been measured in previous studies (Baur et al., 2018; Chen et al., 2013; Dhawan et al., 2019; Merilampi et al., 2017) by recording a participant's time and frequency spent on activity involving games. This usage data is generally obtained automatically by the system using various

sensors (Fitz-walter et al., 2017). The use of virtual reality and computer games in neurological rehabilitation has proven an effective strategy to provide an attractive system that motivates users to perform tasks that make the rehabilitation process easier (Jaffray, 2015).

A comprehensive definition of motivation is referring to those things that explain the direction, magnitude, and persistence of behaviours where there are many theories and concepts explaining on motivation. The following Table 2.13 shows the definition of the existing model that has been used recently by the researchers in the motivation of user experience.

Table 2.13: Motivation Model and Definition

Model	Definition
ARCS Motivation Model	The model is used to evaluate the motivational stimuli for learner's or user's motivation and performance
Intrinsic Motivation	The model is asserting the most important elements that make game-playing fun and engaging as well as sustain player's continual motives (Olens, 2012)
Extrinsic Motivation	The model is in contrasting with the intrinsic motivation which refers to the pursuit of an instrumental goal (Reiss, 2012)

There are various types of motivation models that have been used by the researchers in their recent studies. Intrinsic and extrinsic motivation is one of the motivation models recently used. The model is using two variables which brings the difference in terms of motivation. Intrinsic motivation is can be identified as enjoyment and entertainment meanwhile the extrinsic motivation is classified as usefulness (Shin et al., 2009). Intrinsic motivation can be defined as the desires to perform any task for one's sake meanwhile the extrinsic is more to contingent rewards (Tirole, 2003).

However, Keller's motivation model is focusing on is the one who is responsible to develop an instructional model that focuses on motivation. The ARCS motivation model by John Keller is an instructional model that use to motivate users and ensure the continuity of motivation during the completion of the tasks (Keller, 1987). This effort resulted from a synthesis of four categories of motivational variables that wre first called as, interest, relevance, expectancy, and outcomes in 1979 (Keller, 2016).

Studies proved that using the ARCS motivational model in educational and training design can successfully increase the motivation of users (Hamzah et al., 2015). Hence, the model is important for users to gain, sustain and maintain motivation and the spirit of learning while doing the exercises. There are four attributes in the ARCS motivation model which show the different focus and aim. The four components are Attention, Relevance, Confidence, and Satisfaction. Figure 2.10 shows the ARCS Motivation Model.

Figure 2.10: ARCS Motivation Model (Rogan, 2014)

The ARCS model is important to motivate learners and ensure the continuity of the motivation during the task completion. The model is based on a synthesis of motivational concepts and characteristics into four categories: attention (A), relevance (R), confidence (C), and satisfaction (S). Table 2.14 shows the definition of each attribute in the ARCS motivation model shown in figure 2.8.

Table 2.14: ARCS Motivation Attributes

Attributes	Focus
Attention	The attribute incorporates research on curiosity and arousal, interest, boredom, and other related areas of sensation seeking
Relevance	The attribute refers to the user's perceptions of instructional requirements that show consistency with the goals, compatible with the learning styles, and connected to their past experiences
Confidence	The attribute refers to the effects of positive expectancies for success, the experience of success,

	and attributions of successes to one;s own abilities and efforts
Satisfaction	The attribute includes the appropriate mix of intrisincally and extrisincally rewarding outcomes that sustain the desires of learning behaviours and discourage the undesireable ones

Motivation is one important factor in user experience and it is frequently used as the determinant for rehabilitation outcomes (Olens, 2012). To improve users' performances by gaining and sustaining motivation while playing serious games for rehabilitation, it is essential to have a motivation booster every time they played. Even if curiosity is aroused, motivation is lost if the content has no perceived value to the learner. Hence, the ARCS motivation model from Keller is selected to be used in this research.

Based on the ARCS motivation in Figure 2.10, the first lesson on the model design is to gain the user's attention. Tactics for this can range from simple unexpected events to mentally stimulating problems that engage a deeper level of curiosity at the beginning of a lesson. To improve rehabilitation efficiency, virtual reality help improves users' willingness and motivation to perform the exercises as the tools that have been used while playing are head-mounted displays, stereoscopic glasses and large screen projection (Surya et al., 2017). This can build the next requirement which is relevance. Even if curiosity is aroused, motivation is lost if the content has no perceived value to the learner.

The next condition is required for motivation is confidence based on the ARCS motivation model. This is accomplished by helping users establish positive

expectancies for success. The need to always keep updated with current technology and advancements are important because it can deliver a positive impact on the health field especially users and allow professionals to provide the best services to them (Jafni et al., 2019). If the users are attentive to the interesting content and moderately challenged, they will be motivated to undergo rehabilitation. But to sustain the motivation, user satisfaction is another key in this model which refers to positive feelings about accomplishments and learning experiences (Keller, 2000).

2.5 Attributes in User Experience Factors

User experience can be defined as a momentary, primarily evaluative feeling either good or bad while interacting with any product or service (Hassenzahl, 2008). Good user experience is the consequence of fulfilling the human needs for autonomy, competence, and stimulation of self-oriented through interacting with the product or service (Knijnenburg et al., 2012). In the user experience model highlighted in (Law et al., 2009), the researcher has described how certain objective aspects and factors are perceived in terms of its attributes such as does the product or service effortlessly delivers high-quality results or whether it is desirable for users.

User experience is an important keyword of the third wave of Human-Computer Interaction (HCI) (Bødker, 2006). Throughout many years, experiences are increasingly important and play important roles in providing needed knowledge on the relationship between the interactive technologies and user experiences (Roto et al., 2021). Previous

research has shown that games can work as motivators or to help change in user's behaviour (Baranowski et al., 2013) and the quality attributes in user experience are derived through developed guidelines from the human-computer interaction (Winter et al., 2008).

One of the research objectives is to explore the relationship between user experience factors through the attributes of motivation and usability of using serious games for rehabilitation. The user experience factors are referring to two models: Nielsen's Usability Model and ARCS Motivation Model. Before analyzing the relationships between user experience factors and serious games for rehabilitation in the next chapter, all quality attributes highlighted in the previous research need to be mapped according to the factors.

As Nielsen describes the schema of receiver success in a system by users and ensures they are affected by the simplicity of its attributes on it (Muqtadiroh et al., 2017). He understands usability as a property of several dimensions and yet, it consists of different components. Then, he came up with the usability model to explain the use of a system which comprise five quality attributes (Winter et al., 2008). However, for this research there are only three usability attributes used by Nielsen's: learnability, memorability and satisfaction and ease of use to measure the efficiency (Muqtadiroh et al., 2017). Table 2.15 below shows the definition of usability attributes from the previous research.

Table 2.15: Definition of Usability Attributes

Usability Attributes	Definition

Ease of Use	The system must be efficient to use and has a low error rate so that once the user has learned the system, a high level of productivity is possible (Gupta et al., 2014; Hussain et al., 2016)
Learnability	The system should be easy to learn, so that the user can rapidly start getting some work done and achieve their goal with the system (Alturki & Gay, 2017; Yuniarto et al., 2018)
Memorability	The system should be easy to remember, so that the user can return to the system after some period of time (Alturki & Gay, 2017; Korhan & Ersoy, 2015)
Satisfaction	The system should be pleasant to use, so that the user is subjectively satisfied while and after using it (Korhan & Ersoy, 2015; Yuniarto et al., 2018)

From Table 2.15 the definitions mentioned by the researchers on usability attributes are referring to the previous research. Nielsen suggested that the system must be in the easy to learn, easy to memorize, easy to be used and give pleasant feelings to the users (Yuniarto et al., 2018). Satisfaction is a measure of the response and feelings of users when they played or used the system, for example freedom from discomfort (Gupta et al., 2014). As to the previous research, serious games have offered quality attributes over many types of assistive technology such as simulators, robotics, and virtual reality.

As for usability factor, the outline criteria for each attribute have been mentioned based on the widely acceptance and consideration from other researchers on using Nielsen's Usability Model (Gupta et al., 2014; Holzinger et al., 2008). Meanwhile for the motivation factor, the outline criteria are based on the ARCS Motivation Model made by Keller. Motivation attributes are one of the topics that have been repeatedly mentioned

by the previous researchers. The way each researcher describes how important the attributes in motivation factor affect user experience while using serious games for rehabilitation has been tabulated in Table 2.16 below. Hence, Table 2.16 shows the definition of motivation attributes based on the previous research.

Table 2.16: Definition of Motivation Attributes

Motivation Attributes	Definition
Attention	The response of learners to perceive instructional stimuli given by instruction
Relevance	It is about helping learners connect their prior learning experience to the instructions provided
Confidence	It refers to emphasize the importance of building positive expectations for the performance of their students in the learning task
Satisfaction	It will be achieved at the end of the learning process, when learners are allowed to practice new knowledge and skills

Source: (Hamzah et al., 2015)

From Table 2.16, the definition of four main attributes in motivation factor which needed in enhancing motivation to learn, work and improve skills (Keller, 2010) . The attributes in the ARCS motivation model have been used recently in gamification and serious games development (Hamzah et al., 2015; Keller, 2016). Technology infusions into learning environments have grown exponentially and rehabilitation has been one of the fields in the healthcare sector that use technology for exercise sessions. The special characteristics of the model are important to ensure the continuity of motivation during the completion of tasks (Keller, 2000).

Table 2.17: Summary of Criteria on Quality Attributes

Attributes	Criteria
Ease of use	A low error rate, help users to feel at ease
Learnability	Easy to learn
Memorability	Easy to remember, repeated
Satisfaction	Pleasant feelings, freedom
Attention	Perceptual, inquiry
Relevance	Goal orientation, motive matching
Confidence	Reward, competition, challenges
Satisfaction	Achievement, self-expression

Table 2.17 shows the summary of criteria outlined from the definition of each quality attributes in motivation and usability factors. The criteria outlined in the previous research help the researcher to map the keywords used to its attributes. The keywords are displayed and highlighted by the previous researchers on user experiences with using serious games for rehabilitation. Hence, the following Table 2.18 shows the mapping of each keyword used onin previous research with the attributes of motivation and usability factors.

Table 2.18: Mapping Table on Quality Attributes

Attributes	Keywords	Author & Year
Ease of Use	Effective, experienced, expert, balanced, durable, easy to set up, low risk, simple, easy to start, efficient, easy to navigate,	(Andrade et al., 2016; Chen et al., 2013; Fernandez-Cervantes & Stroutia, 2019; Fitz-walter et al., 2017; Georgiou & Demiris, 2017; Hoogland et al., 2019; Hughes et

		al., 2014; Ling et al., 2017; Merilampi et al., 2017, 2018; Mubin et al., 2020; Tobler-Ammann et al., 2017)
Learnability	Adaptive, cooperative, useful, interactive, reachable, dynamic movement, feasible, learning, understandable, engaging	(Andrade et al., 2016; Baur et al., 2018; Chen et al., 2013; Dhawan et al., 2019; Gómez et al., 2018; Jerčić et al., 2018; Lozano-Quilis et al., 2014; Merilampi et al., 2019; Pramana et al., 2018; Rego et al., 2017; Tan & Zary, 2019; Vugts et al., 2016)
Memorability	Meaningful, variety, the complexity of UI, illustrative, in detail, simultaneous	(Brox et al., 2017; Fernandez-Cervantes & Stroutia, 2019; Merilampi et al., 2018; Mubin et al., 2020; Prahm et al., 2017; Tobler-Ammann et al., 2017; Vugts et al., 2016)
Satisfaction of Usability	Enjoyable, fun, freedom of choosing, positive feelings, comfortable, entertaining, attractive, user-friendly, suitable	(Andrade et al., 2016; Baur et al., 2018; Fitz-walter et al., 2017; Goršič et al., 2017; Hughes et al., 2014; Idriss et al., 2017; Jonsdottir et al., 2018; Ling et al., 2017; Lozano-Quilis et al., 2014; Merilampi et al., 2017, 2018, 2019; Novak et al., 2014; Tobler-Ammann et al., 2017)
Attention	Attention, interesting, real, evidently catching, immersive, focus	(Brox et al., 2017; Chen et al., 2013; Georgiou & Demiris, 2017; Idriss et al., 2017; Ling et al.,

		2017; Merilampi et al., 2017, 2019; Mubin et al., 2019; Tan & Zary, 2019)
Relevance	Validity, reliable, presence, home-based task, engaging	(Dhawan et al., 2019; Gómez et al., 2018; Jerčić et al., 2018; Pramana et al., 2018)
Confidence	Exercise intensity, fast, challenging, competitive, reward, digital reward, quick, dexterity	(Andrade et al., 2016; Goršič et al., 2017; Hoogland et al., 2019; Idriss et al., 2017; Mubin et al., 2019, 2020; Novak et al., 2014; Prahm et al., 2017; Pramana et al., 2018; Rego et al., 2017; Wittmann et al., 2015)
Satisfaction of Motivation	Motivating, satisfaction, excitment, reducing anxiety, self-assessment, feedback	(Baur et al., 2018; Brox et al., 2017; Chen et al., 2013; Dhawan et al., 2019; Goršič et al., 2017; Hughes et al., 2014; Idriss et al., 2017; Jonsdottir et al., 2018; Ling et al., 2017; Merilampi et al., 2017, 2018; Mubin et al., 2019, 2020; Novak et al., 2014; Pramana et al., 2018; Rego et al., 2017; Tan & Zary, 2019; Vugts et al., 2016)

There are eight (8) quality attributes in user experience factors through motivation and usability from this research. Ease of use in usability factor explains on the efficiency of serious games to help users feel at ease while using and playing the games for rehabilitation. The keywords highlighted in recent studies are showing the importance on developing the low risk, simple and easy to set up, navigate and start serious games. Since

serious games are developed to be one of the platforms for assistive technology in rehabilitation, ease of use is a must-have attribute to assist persons with disabilities to undergo exercises and therapies.

Next, learnability and memorability attributes are focusing on giving ease in learning and memorizing to users. As rehabilitation exercises are repeated and tedious therapies, persons with disabilities require an adaptive, interactive, and meaningful serious games to undergo the sessions according to previous research. Satisfaction is another usability attributes that brings freedom and pleasant feelings towards persons with disabilities who played serious games for rehabilitation. Enjoyable, fun, and feeling comfortable are the keywords highlighted by the recent researchers.

On the other hand, quality attributes from motivation factor are focusing on the continuity of persons with disabilities' motivation. Attention is the first motivation attribute that stresses on perceptual of users while playing serious games. Immersive is one of the keywords in attention that shows the importance of getting involved in real-life experiences to stay focused. Next, relevance and confidence attributes which depending on one another. Relevance is based on goal orientation and motive matching meanwhile confidence is grounded on competition, reward, and challenges.

Goal orientation in relevance is important while playing serious games for rehabilitation, as persons with disabilities are facing competitive and challenging games to achieve rewards. Hence, the validity and engaging serious games helped them to raise confidence through exercise intensity, challenges and reward offered. The last attribute of this research is satisfaction in achievement and self-expressions. Motivating is the most highlighted keyword in the previous research to emphasize the importance of

motivation in developing serious games for rehabilitation. Thus, it brings positive feedback and excitement to users' experiences.

2.6 Conceptual Framework

A conceptual framework helps in clarifying the research questions and objectives and fulfilling the role of providing theoretical clarification for readers to have a clear vision (Leshem et al., 2007). Hence, Figure 2.10 shows an interpretation of the second objective of the research which is to determine the relationship between user experience factors and serious games for rehabilitation that lead to the idea of a conceptual framework. It is the continuity of the research hypothesis in chapter 1.

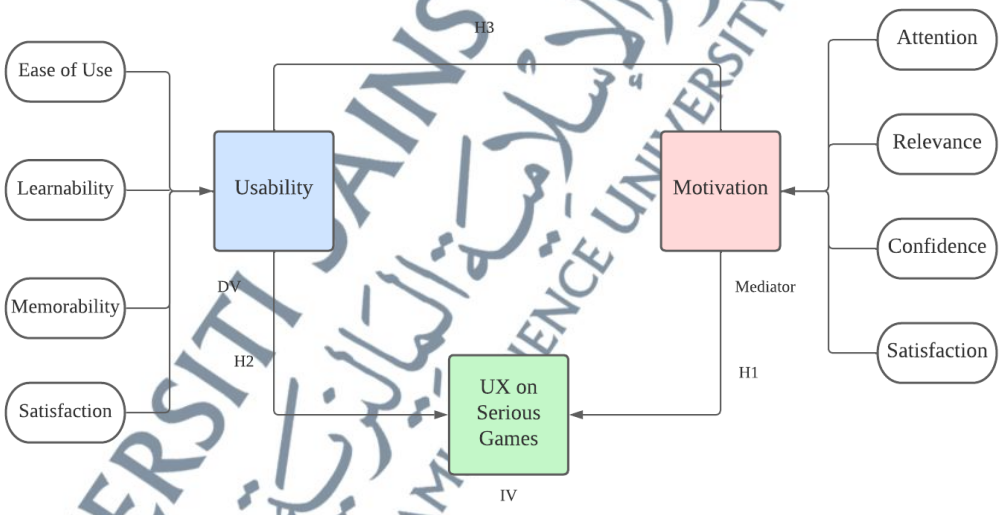

Figure 2.11: Relationship between Usability and Motivation Factors

Figure 2.11 shows the conceptual framework where usability act as the dependent variable for this research. According to the relationships in the research

hypothesis subsection, there are three (3) main hypotheses that need to be discussed: (1) The relationship of motivation factor towards user experience in serious games, (2) The relationship of usability factor towards user experience in serious games and (3) The relationship between usability factor as the dependent variable towards user experience in serious games as the independent variable through motivation factor as the mediator.

For the first and second hypotheses, the relationships are involving one-to-one relationships where there is no intervention of other factors. On the other hand, the third hypothesis is involving the motivation factor as the mediator to discover the effect of the intervention of motivation in usability towards user experience in serious games. The attributes of usability factor are depending on attributes in motivation factor which resulted from the relationship with user experience. Figure 2.12 and 2.13 show how the relationship are drawn.

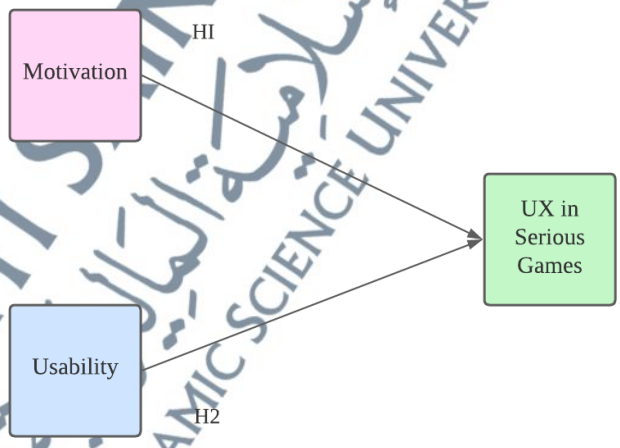

Figure 2.12: H1 and H2 One-To-One Relationship

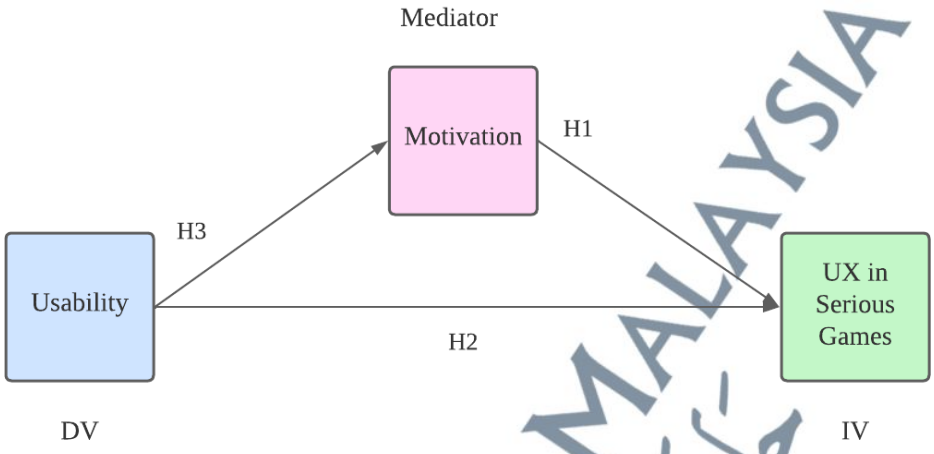

Figure 2.13: H3 Relationship Between DV and IV

The relationship Figures in 2.12 and 2.13 are generated from the idea of conceptual framework in Figure 2.11 which shows all three hypotheses. With the information from Figure 2.13, it is clear that the relationship on the third hypothesis is using mediator analysis. Hence, the analysis of each hypothesis from this research is discussed in the next chapters.

2.7 Summary

Assistive technology is one of the important tools for persons with disabilities to stay healthy. As time changes, there are lots of games invented in the gamification field for this population which are immersive, educating, and enjoyable. The immersive games are known as serious games. Serious games are commonly used in physical rehabilitation therapy processes and become one of the assistive technology platforms in the research area as the games are more advanced in terms of game development. Hence, serious

games become a world wide medium used in assistive technology that benefit people around the world.

User experience is an essential field of study to ensure the relationship of emotions and behaviours in users in continuing. As user experience is a study to emphasize users' feelings in terms of quality, context, and relationship with other people, it is important to highlight the effect of using serious games for rehabilitation. In this research, there are two user experience factors that the researcher is focusing on. Usability is a quality factor that measures the extent of simplicity that affect the receiver's success in a system and preferences meanwhile motivation aims to motivation is an improving factor to enhance motivation to learn and developing motivational attributes in persons with disabilities who undergo rehabilitation.

Usability and motivation factors consist of eight (8) attributes that have been discussed in the chapter and the attributes are; ease of use, learnability, memorability, satisfaction in usability, attention, relevance, confidence, and satisfaction in motivation. In this chapter, further discussion on keywords used in previous research has been conducted. Some tables that explaining the previous research with keywords that refer to user experience while playing serious games for rehabilitation. The mapping table on classifying the keywords into each attribute is also been discussed in the subsection. Hence, the first objective to identify attributes in user experience through usability and motivation factors has been achieved.

The following subsection is discussed on conceptual framework focusing on the research hypotheses. The discussion explained on variables and future analysis in chapter 3. The dependent and independent variables are based on the mediator analysis and the

usability factor has become the dependent variable using the motivation factor as a mediator towards user experience in serious games as the independent variable. Thus, at the end of the chapter, researchers have found that usability and motivation factors in user experience that affect persons with disabilities who played serious games for rehabilitation.