CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter presents the study of research methodology that the applies research approach and design, proposing a research model, population sampling and the result of the pilot study. The research design is based on a survey design and a quantitative-based method. The case study is selected in SOCSO Tun Abdul Razak Rehabilitation Centre in Malaysia which is equipped with three assistive technology that use serious games as tools for persons with disabilities to undergo exercises and therapies. The procedures and steps taken in the pilot study are well explained in the subtopic. The research instruments and data collection are based on survey design and quantitative based. At the end of the topic, the data analysis method will be briefly explained.

3.2 Research Framework and Design

This section explains precisely works in each phase. The research design will explain the chosen type of method used meanwhile the research framework will show the proposed structure for this research. The subsections 3.2.1 and 3.2.2 below will determine the whole process for this study in terms of research design and framework.

3.2.1 Research Design

In this subsection, the researcher is focusing on deciding the design that will be used to study the user experience factors through motivation and usability and their relationship with one another in serious games for rehabilitation. This research is using an approach that can deal with numbers and anything that measurable in systematic ways of investigation and their relationships (Rajagopal & Bojin, 2003). As the purpose of the research is to measure the user experience attributes by identifying them through motivation and usability factors, the type of data collection that is selected to be used in this research is quantitative.

The quantitative method is defined as social research that employs empirical methods and statements (KamolsonSu, 2007). It is important to have an intention in exploring, explaining, predicting, and controlling the measurable variables in each relationship. Thus, the research hypothesis is made to discover the relationship of user experience factors between motivation and usability in serious games. The significance of each relationship is shown in the following section which later is explained by the figures and tables of data.

As the researcher has decided to use the quantitative method for this study, a survey design is used for collection of data from questionnaires. The survey is aimed to answer the questions that have been raised in research questions, to solve problems that have been posed or observed and to assess the needs and to establish baselines against the comparisons made in the future (Glasow, 2005). Thus, the information gathering from the problem statements, objectives and hypothesis are leading to the action of this research.

A survey is simply a tool that is capable to obtain information from large a sample of the population (KamolsonSu, 2007). However, for this research this tool is applied within a smaller size. Though there are two types of survey, the verbal survey and written, yet for this study, the researcher is using the written survey design using questionnaires to collect and measure the data. Before the distribution of the questionnaire to the respondents take place, there are two steps in designing the survey. The sampling plan is done to select the sample from the targeted population. As for this research, the population is selected among patients in one rehabilitation in Malaysia.

The sampling plan precisely describe the group from the population, the sample size and the choice of media used to run the survey. Secondly, another step in designing the survey is by obtaining the population number from the sample data and identifying the desired responses from the estimated data. Hence, survey design and quantitative based are essential in relying on hypotheses testing where the clear objectives and methodology are needed (Daniel, 2016).

3.2.2 Research Framework

This subsection explains precisely on works that take in each phase of this research. There are four main phases: identification, development, analysis, and model testing, where each phase discusses and shows different works. Figure 3.1 shows the framework and flows of this research.

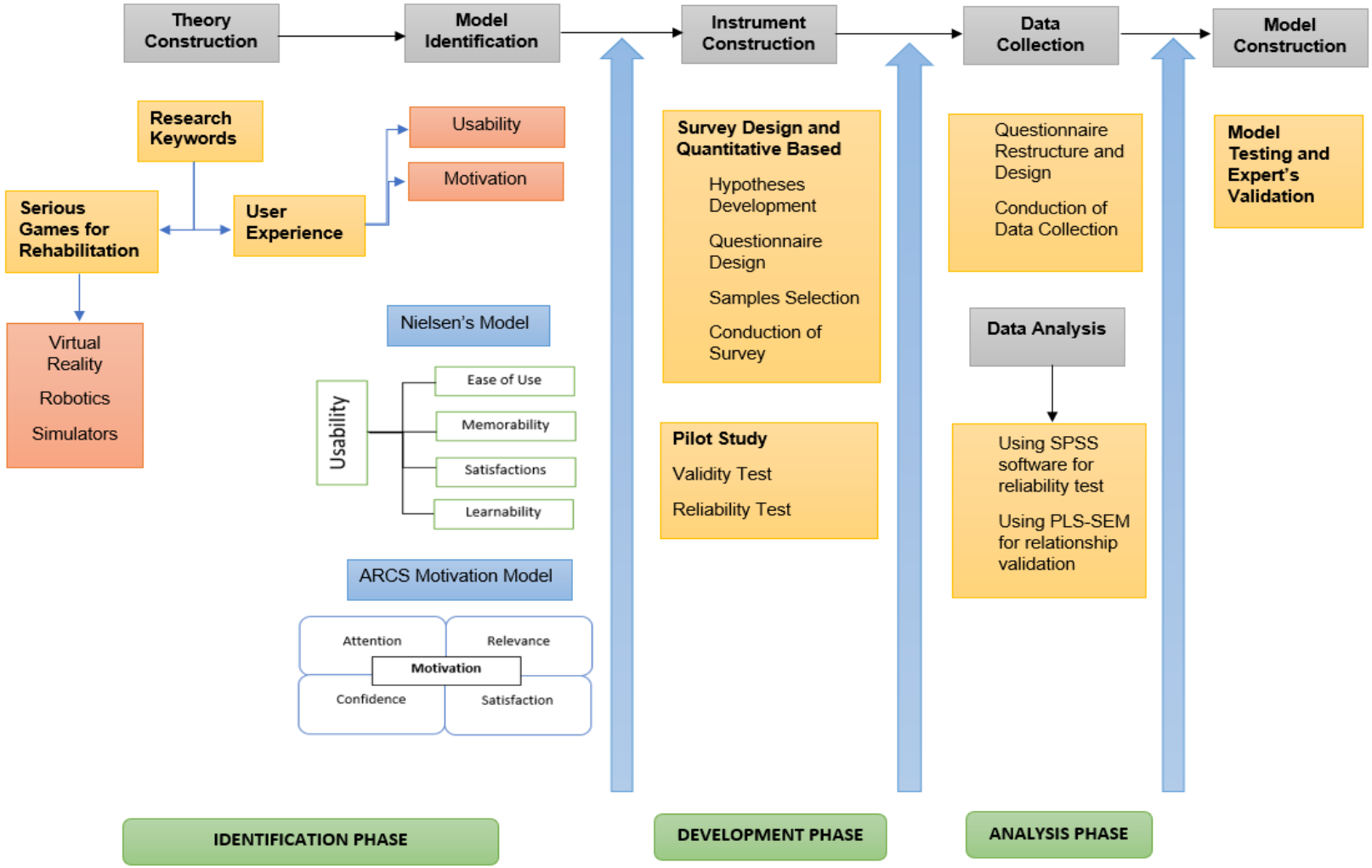

Figure 3.1: Proposed Research Framework

The framework shown in Figure 3.1 is the working flow of this research. There are six steps according to the basic approach of structural modelling equation (SEM) where theory construction is the first step to start. In this research, the theory construction is started by determining the keywords of the research objectives: user experience and serious games. The keywords of serious games are divided into three main technologies that have been used in the rehabilitation field as the assistive technology. The three assistive technologies selected for this research are virtual reality, robotics, and simulators. Meanwhile for user experience, there are two main factors that will be explored in this research: usability and motivation.

User experience is discussed on two different models that shows different priorities and focus. The ARCS Motivation Model is used for identifying feelings and some attributes in Nielsen's Usability Model that focus on the use of a product and its quality. The researcher has come out with eight (8) user experience attributes based on the systematic review method. Hence, this remarks on the second steps in SEM which is model identification and shows the first phase in this research is completed when two steps are applied. The second phase of this research is continued with the development phase for this study is including the instrument construction in SEM basic approach. In this phase and step, there will be two main works which play big roles in this research.

Quantitative based is the chosen method to be used for the whole research. The research design using survey is precisely explained in the previous subsection where the hypothesis is the main instrument to be developed and started the questionnaire design. The next step will be focused on the sampling plan where the sample selection and conduction of the survey take place. By distributing the questionnaire for the first time to the respondents, the reliability and validity test is conducted. Thus, the pilot study is the second main work for this phase and step. The justification for collecting and analysing the results of the pilot study is to see the reliability and validity of the questionnaire. The pilot study is using different respondents from the actual respondents involved in the research.

The fourth and fifth steps are continued to be done in the next phase of research, the analysis phase. The fourth step is questionnaire restructure after getting the results from the pilot study. The need to redesign the questionnaire is based on the recommendations and suggestions from the expert and results from the two tests. There are two types of software used for this research: SPSS for reliability tests and PLS-SEM for relationship calculation and validation. The data collection is held once the questionnaire is well prepared. At the end of this research, there will be an enhancement of the user experience model through motivation and usability factors in serious games for rehabilitation.

The enhancement of the user experience model is the result of the calculation and expert's suggestions and recommendations while in the analysing phase. As for this research focusing on rehabilitation, the assessment from the professionals is important in achieving the goals of every person with disabilities who undergo the therapies. Hence, the last phase of this research and the last step in the SEM basic approach is to test and validate the new model from the expert's point of view. The result of the enhancement is discussed in the following chapter.

3.3 Population and Sampling

This section is the continuity of the research design which discussed on survey design and quantitative-based approach. A population is the group of individuals restricted to a geographical region such as living in the same place or working in a certain institution like a healthcare centre, and that is a set of individuals who have at least one characteristic in common (Martínez-Mesa et al., 2014) . The population of respondents for this research is based in SOCSO Tun Abdul Razak Rehabilitation Centre and the type of sampling plan for choosing the respondents is explained thoroughly in the forms of tables and figures.

As highlighted in chapter 1, the reason for choosing SOCSO Tun Abdul Razak Rehabilitation Centre is mainly referring to the equipment offered to undergo rehabilitation using serious games as an assistive tool. There was a total of approximately 300 patients during the pandemic who undergo therapy and there are only four groups of diagnoses selected to take part in this research. The specific groups are taken as the sample. Persons with stroke, spinal cord injury, traumatic brain injury, and amputee are the chosen sample recommended by the experts in the rehabilitation centre.

These respondent groups are the selected person who is using assistive technology and serious games for rehabilitation therapies and exercises. The outlined Table 3.1 is generated from the therapist in choosing patients to be the respondents for this research as not all group of sample data can use and play serious games using the selected assistive technology. The patients who will be selected as respondents must be chosen by the therapists, can do sit-to-stand movement and understand English. Hence, there is a quick interview between the researcher and the therapist on the chosen sample group.

The interview is focuses on asking the therapist about their patient's diagnosis and their readiness for technology and rehabilitation therapy. Table 3.1 shows the results of the quick interview with the therapists and Figure 3.2 shows the type of assistive technology that can be played by the sample.

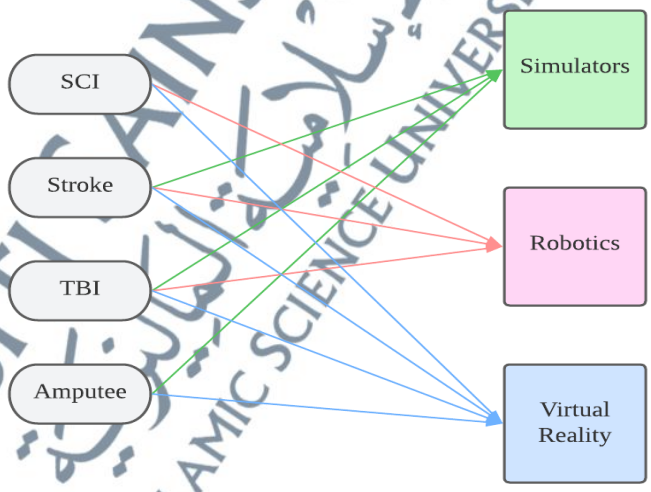

Figure 3.2: Allocation of Respondents to Serious Games

Table 3.1: Results on Quick Interview with Therapists

Serious Games	Diagnosis	Comments
Simulator	Stroke, Amputee, Traumatic Brain Injury	The simulator of driving a car is aimed to identify a patient's focus and attention while driving. Hence, this is not suitable for traumatic brain injury who has a cognitive impairment to play the games. As this physical therapy need lots of movement, patients with this diagnosis are the one we consider using the simulator as their daily exercise
Robotic	Stroke, Spinal Cord Injury, Traumatic Brain Injury	The robotic games is focusing on sit-to-stand and walking exercises. Hence, patients with this diagnosis are the ones who will be considered to back to work and start to walk with or without walking aids. There are also a sfew exercises such as knee frontal flexion and hip flexion involve as part of the exercise to increase their range of motion (ROM) on balancing while walking
Virtual Reality	Stroke, Amputee, Traumatic Brain Injury, Spinal Cord Injury	Virtual reality is made for all patients to play but it is not necessary for amputee patients as they do not have cognitive impairment. For spinal cord injury patients, most of them are advisable to use robotic support to avoid falling as they have lower limb disabilities.

Hence, in SOCSO Tun Abdul Razak Rehabilitation Centre, there are 230 total number of population for the research according to the inclusion criteria. Table 3.2 shows the number of participants in each group before the selection of respondent is made.

Table 3.2: Number of Population for Each Group

Respondent Group	Total Number of Sample for Each Group
Stroke	110
Spinal Cord Injury	50
Traumatic Brain Injury	40
Amputee	30
Total	**230**

Next, the step of selecting respondents is outlined based on the response from the therapists. Figure 3.3 shows the steps of selecting respondents for the sample in this research.

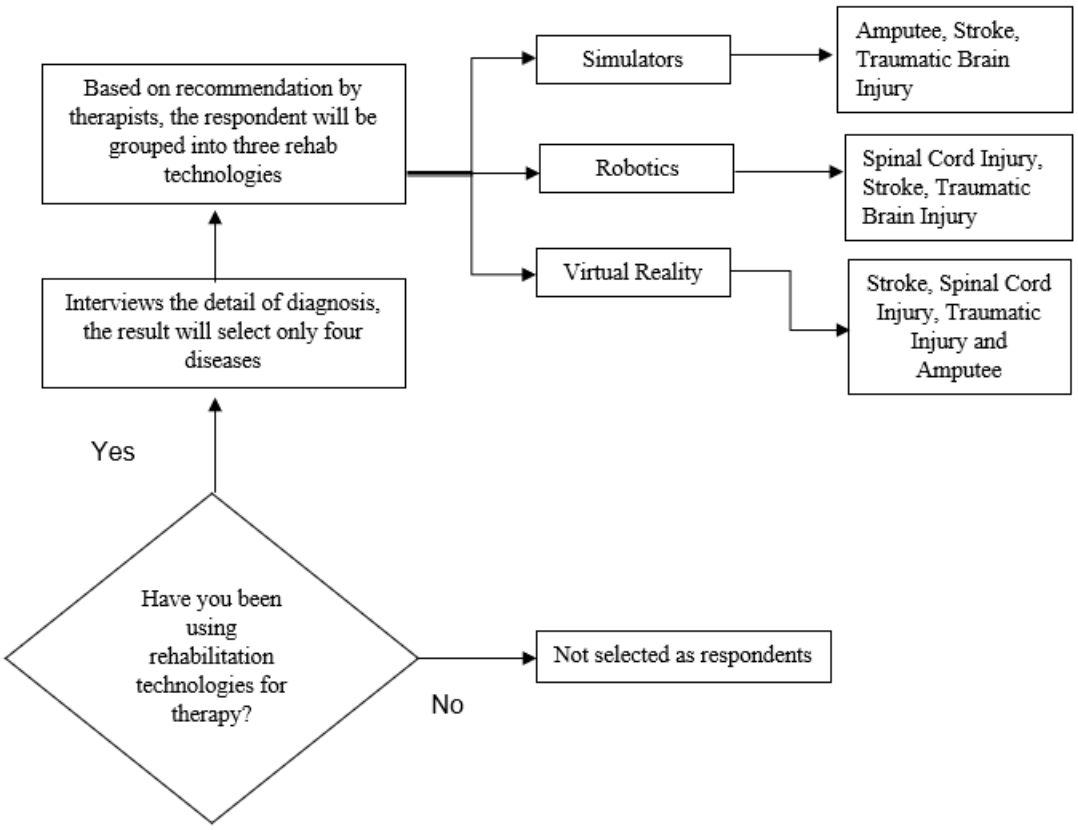

Figure 3.3: Steps of Selecting Respondents

Figure 3.4 shows the selection of the sample is started with the general interview on basic information. The interview is aimed to get the information on the respondents who have been used assistive technology as one of their therapies. If the response is yes, there will be another question in the interview in making sure the diagnosis background of the respondents. Respondents only will be grouped together based on four selected diseases: spinal cord injury, stroke, amputee and traumatic brain injury as differential diagnoses and diseases will have different rehabilitation technologies to be used in the therapy session. Next, with the recommendation of the therapist, the selected respondents

with different diagnosis groups will be placed in three group of technologies: simulator, robotic, and virtual reality.

As for the selection to be in the assistive technology group, the respondent will undergo an interview assessment from the therapist before starting the therapy session. The simulator only focuses on amputee, stroke and traumatic brain injury individuals who have a goal to drive the actual car at the end of rehabilitation. The criteria for choosing the respondents are totally depending on their ability of learning and understanding the instructions as the simulator is done in an immersive environment through games to get pictured of a real situation while driving, and Figure 3.4 shows the situation of car driving simulation as the assistive technology.

Figure 3.4: Car Driving Simulator

For the robotic, Figure 3.5 will show the equipment used in rehabilitation for assisting patients. The group of diagnoses is focusing on spinal cord injury, stroke, and traumatic brain injury individuals in the rehabilitation centre. The purpose of the therapy using serious games in robotic is to facilitate the individual to walk with the support of full-body equipment.

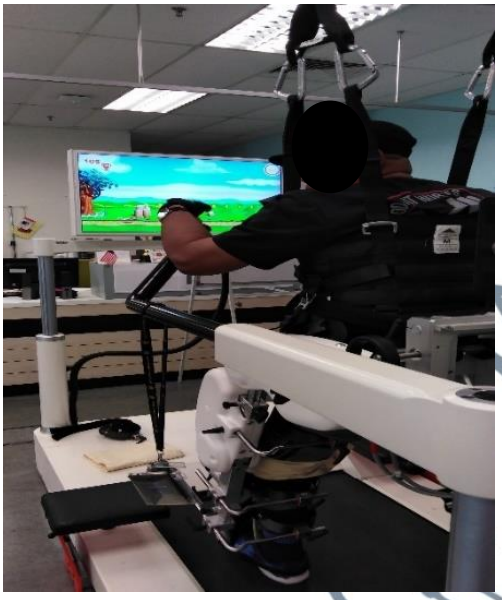

Figure 3.5: Robotic Serious Games using Lokomat

Next, the last group of respondents that will be selected come from individuals who are using games in virtual reality. They are the individual with all types of selected diagnosis: stroke, spinal cord injury, amputee and traumatic brain injury is welcomed to play serious games for rehabilitation therapies and exercises. The criteria for choosing respondents are based only on their ability to understand, learn, and memorize the instructions and steps of the exercises. The following Figure 3.6 shows the virtual reality that help patients to exercise while playing the games.

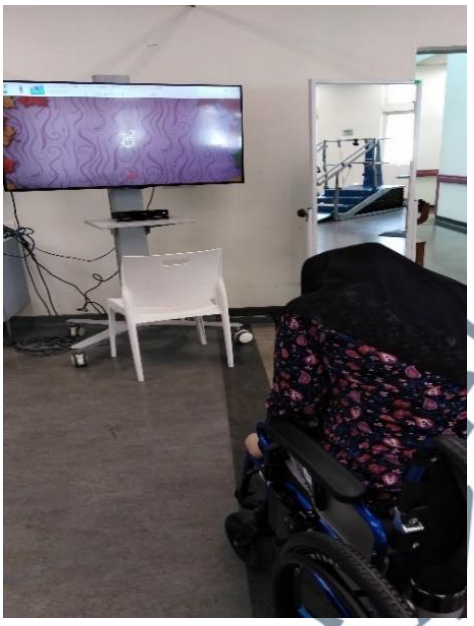

Figure 3.6: Virtual Reality Session

Though there are 230 number of populations according to the selected group and diagnosis, there is a limited number of samples that can be taken as respondents for this research according to the capacity given by SOCSO Tun Abdul Razak Rehabilitation Centre and the new intake of patients based on the needs. Hence, the researcher is using the purposive sampling technique to gain, gather, and analysed the data from the respondents. As the respondents are selected from the observations and recommendations of the therapist, it can be said that the judgment made by the expert is purposeful in sampling the data.

In the steps of survey design and quantitative based, the sampling plan is an important in ensuring the series of strategic choices about with whom, where, and how the research will be carried out. The statement implies the way of research sample that should be tied with the research objectives (Palys, 2008). This sampling represents a group of different non-probability sampling which relies on the subject and judgement of

the researcher when it comes to selecting the sample units (Rai & Thapa, 2015). Thus, the purposive sampling is chosen method of data collection and analysis for this research.

In purposive sampling, there are a few essential criteria that need to be highlighted before starting to collect the data. The first criteria are to categorize the selected group of respondents based on the specific characteristic mentioned in Table 3.3 above. The second one is deciding the number of samples for this research from the selected respondents. The number of patients in SOCSO Tun Abdul Razak Rehabilitation Centre is changing over times, and after three months of therapy sessions, there are huge changes in the number of patients, hence the researcher has decided to have 45 respondents in total.

The sample size plays an important role in determining the accuracy of the results at the end of the research, hence the significance of having 45 total number of respondents are based on the recommendation of (Hair et al., 2019; Ringle et al., 2018). The power analysis recommended for sample size calculation is effectively appropriate (Memon et al., 2020). The factor of estimating the appropriate sample size for this research is referring to the time and completion rate as it is depending on the number of respondents in SOCSO Tun Abdul Razak Rehabilitation Centre.

It is commonly understood that covariance-based structural equation modelling (CB-SEM) such as AMOS requires a larger sample size, however this research is using partial least square structural modelling equation (PLS-SEM) such as SmartPLS to analyse the data (Memon et al., 2020). PLS-SEM requires a smaller sample size compared to CB-SEM (Hair et al., 2019; Rigdon et al., 2020; Ringle et al., 2018). The main goal of choosing purposive sampling with smaller sample size is to focus on the

characteristics of the selected respondents. The following Table 3.3 shows the proposition of respondents according to diagnosis and types of assistive technology used.

Table 3.3: Proposition of Respondents

Assistive technology	Respondent Groups	Sample Size
Simulator	Stroke, Amputee, Traumatic Brain Injury	15
Robotic	Stroke, Spinal Cord Injury, Traumatic Brain Injury	15
Virtual Reality	Stroke, Spinal Cord Injury, Traumatic Brain Injury, Amputee	15

3.4 Research Instruments

In this phase, the data is collected by the specific requirements explained in the steps of selecting respondents to run the needs of research and are reliable information. The data are collected for a pilot study by the researcher to get the problem at hand so thus it is factual and original in character. In this research, the researcher is distributing the questionnaire to the current targeted population and aims to obtain several pieces of information from respondents. After the results of the pilot study, the data collection using survey design and quantitative based is held.

The content of the questionnaires is targeted for approximately 20-30 minutes using English language. The instrument used in this study is six-page questionnaire consisting of four (4) sections: Section A, Section B, Section C and Section D. The

questionnaire is using Likert-scale questions in section A, B and C meanwhile there are two types of questions in section D: Likert-scale and Open-ended questions. Figure 3.7 shows the distribution of data collection in the questionnaire with the number of questions for each subtopic.

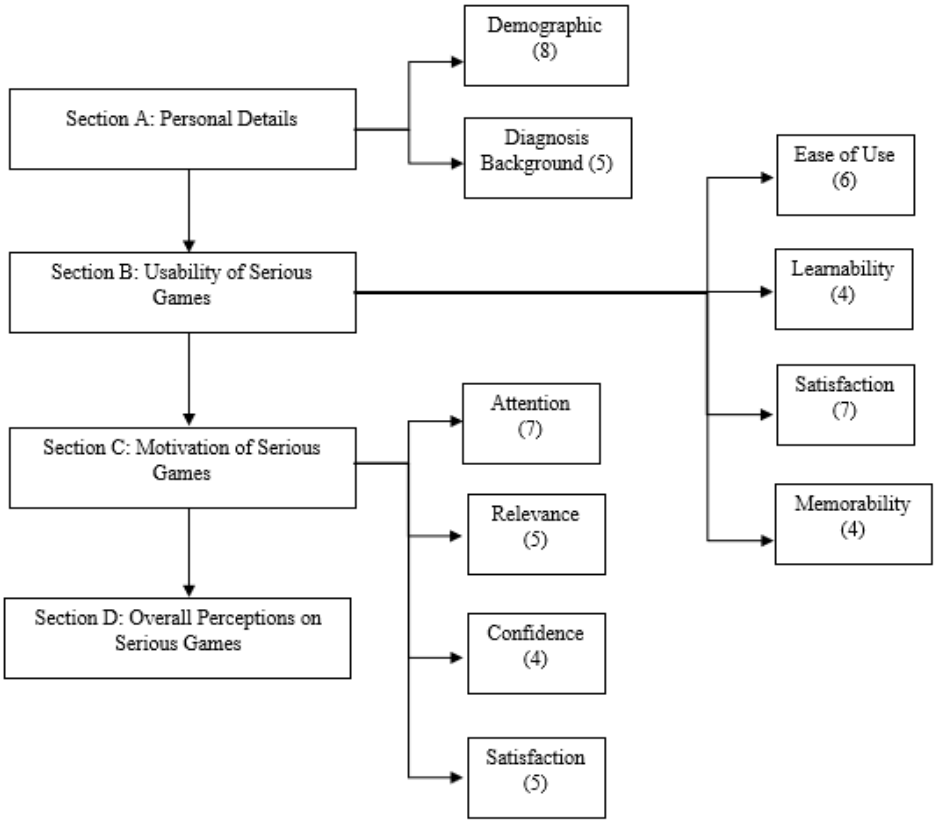

Figure 3.7: Distribution of Data Collection in Questionnaire

Table 3.4 below shows the 5-point Likert scales answers used to range from one to five serving as choices of answers in section A, B, C, and half part of section D.

Table 3.4: Likert Scale Measurement Answers

Answer	Scale

Strongly Agree	5
Agree	4
Neither agree nor disagree	3
Disagree	2
Strongly Disagree	1

The first section of the questionnaire named as Section A, consists of thirteen (13) questions on the respondent's background. The focus of this section is on the respondent's demographics and diagnosis background and medical histories such as gender, age group, highest educational attainment, job and occupation, diagnosis, and duration of treatment before and after being admitted to the location of sampling. This section used to be the overall background of respondents. Table 3.5 below shows tabulate questions for Section A.

Table 3.5: Summary of Question in Section A

Type of Questions	Definition
- Gender - Age - Race - Religion - Marital Status - Academic Qualification - Job - Working Period	To collect the demographic information from respondents
- Diagnosis	To know the respondent's medical history and treatment background such

- Duration of Disease Before Rehabilitation - Duration of Treatment Before Admitted to The Rehabilitation Centre - Duration of Treatment in Rehabilitation Centre	as duration of disease before admitted to rehab, side of injuries and duration of treatment before admitted to rehab
Side of Injuries	To identify the effect side of respondents

The second section which is Section B has twenty-one (21) questions in total. This section is focusing on usability questions which involve a general understanding of learnability, satisfaction, and factors for respondents to memorize the assistive technology of serious games for rehabilitation. The usability of serious games also measures the current ease of use during the rehabilitation session involving Likert scale answers. Figure 3.8 shows the summary of questions in section B.

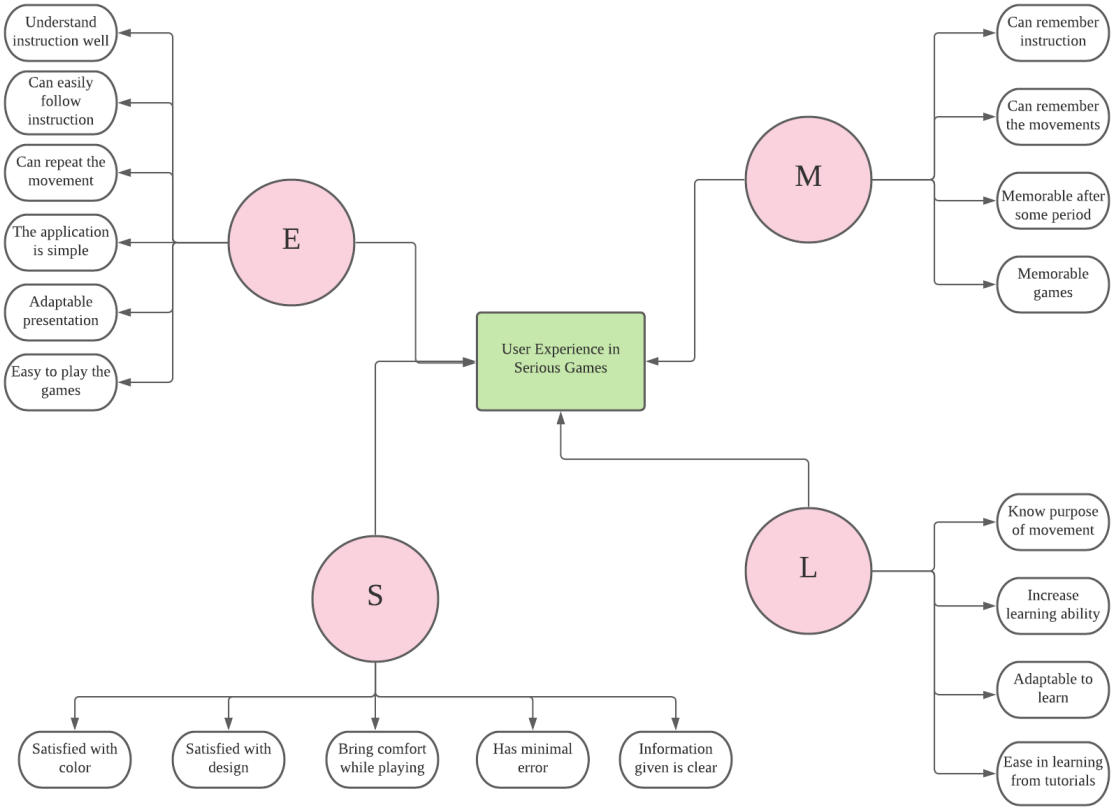

Figure 3.8: Summary of Questions in Section B

The following Table 3.8 is the summary of each attribute in section B together with references. Table 3.6 shows the summary of questions based on each attribute in the usability of serious games which was taken and referred by previous researchers. From (Baur et al., 2018; Merilampi et al., 2019; Pramana et al., 2018) they have described serious games are performing the understandable, interactive, and simple attributes that should be highlighted. The usability attributes which have been selected to be the main in this section are ease of use, learnability, satisfaction, and memorability. These four attributes have the same purpose which to make ease the functionality of serious games for respondents to experience low risk and user-friendly gaming environment.

Table 3.6: Summary of Questions in Section B

Items	Factors	Reference	Year
I can understand the instruction well	Ease of Use	Merilampi et al., Ling et al., Fernandez et al.,	2017, 2018, 2019
I can easily follow the tutorials given	Ease of Use	Chen et al., Ammann et al., Hughes et.al	2013, 2014, 2017
I can easily repeat movements whenever I make mistakes	Ease of Use	Baur et al, Jercie et.al, Vugts et.al, Quilis etl.al, Rego et.al, Pramma et.al	2017, 2018
The presentations of the application are simple	Ease of Use	Merilampi et.al, Ling et.al, Fernandez et.al	2017,2018
The presentations are practically adaptable	Ease of Use	Georgiou et.al, Jercie et.al	2017
Overall application is easy to use	Ease of Use	Merilampi et.al, Quilis et.al, Ammann et.al	2014, 2018, 2019
I can understand the purpose of the movements shows	Ease of Use	Pramma et.al, Vugts et.al	2017, 2018
I find ease in learning the movements through tutorials	Learnability	Hughes et.al, Chen et.al, Ammann et.al	2013, 2017
The application raises my learning ability in my daily activities	Learnability	Merilampi et.al, Tan et.al, Hoogland et.al, Idriss et.al	2017, 2018, 2019
I can adapt with the application	Learnability	Quilis et.al, Ammann et.al, Merilampi et.al	2014, 2017, 2019
I am satisfied with the color used in the application	Satisfaction	Hughes et.al, Merilampi et.al, Fernandez et.al	2017, 2018
The application used an appropriate design	Satisfaction	Vugts et.al, Idriss et.al	2017

I am satisfied as the application is simple	Satisfaction	Merilampi et.al, Ling et.al, Fernandez et.al	2017, 2018, 2019
I feel comfortable while using the application	Satisfaction	Merilampi et.al,Pramma et.al, Dhawan et.al, Chen et.al, Ling et.al, Mubin et.al, Hughes et.al	2017, 2018, 2019
The application has minimal error	Satisfaction	Merilampi et.al, Prahm et.al, Ammann et.al	2014, 2017, 2018
The presentation information is clear and appropriate for users	Satisfaction	Merilampi et.al	2019
Overall application is good	Satisfaction	Hughes et.al, Merilampi et.al, Ammann et.al	2017, 2019
I can understand clearly the instructions given	Memorability	Baur et.al, Jercie et.al, Vugts et.al, Quilis et.al, Rego et.al, Pramma et.al	2017, 2018, 2019
I can remember every steps of the instructions in the tutorial while playing the game	Memorability	Gorsic et.al, Merilampi et.al, Jercie et.al, Dhawan et.al	2017, 2018
Even after some time, I still can remember the instructions and steps	Memorability	Merilampi et.al, Ling et.al, Fernandez et.al	2017, 2018
Overall application is easy to remember	Memorability	Jercie et.al, Chen et.al, Ling et.al, Mubin et.al	2013, 2017

The third section has a total of twenty-one (21) Likert scale questions. This section is focusing on respondents' motivation for attention, relevance, confidence, and satisfaction with serious games for rehabilitation and the relevance of the serious games for respondents. It is developed to know the effect of four attributes on respondents who

are playing the serious games using rehabilitation technologies. Figure 3.9 shows the summary of questions in section C.

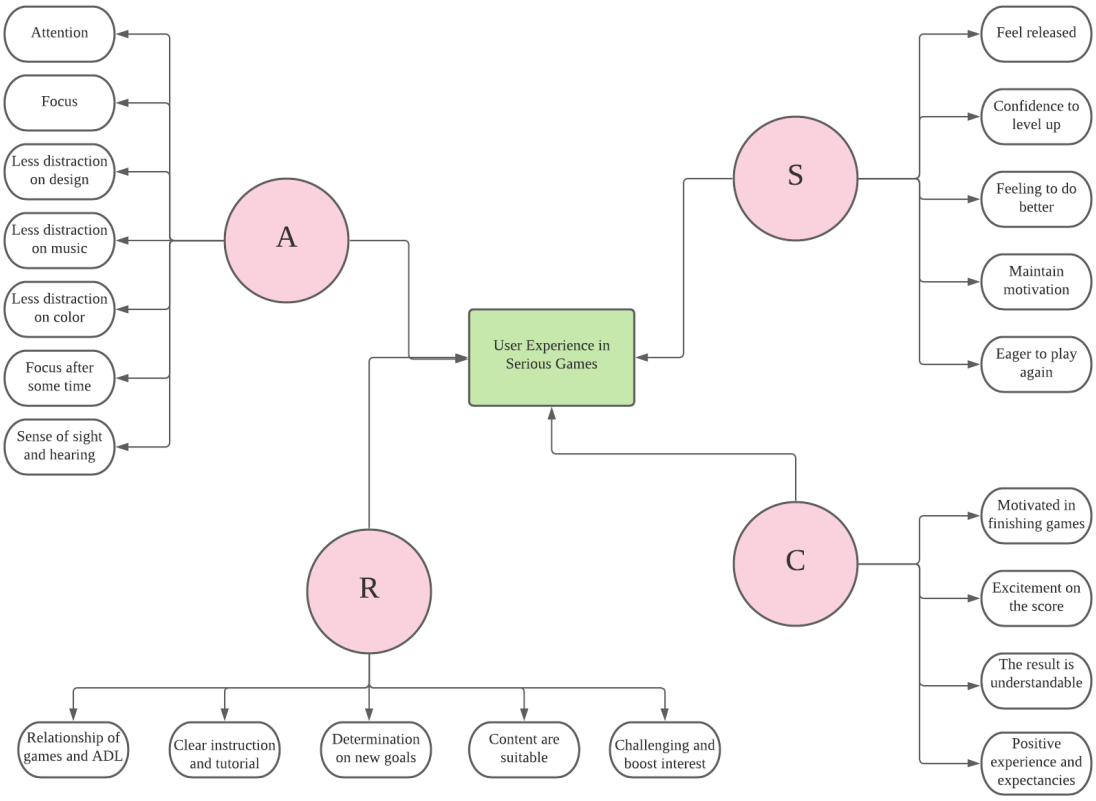

Figure 3.9: Summary of Questions in Section C

The following Table 3.7 is showing the summary of questions based on the selected attributes in the section are tabulated together with references. As far from (Georgiou & Demiris, 2017; Ling et al., 2017), the most mentioned attributes which have been selected to be the main in this section are confidence, satisfactions, relevance, and attention. These four attributes are bringing out different functionalities yet have the same

focus and purposes which to measure and improve motivational appeal in one's motivation.

Table 3.7: Summary of Questions in Section C

Items	Factors	Reference	Year
I can pay attention to the instructions given	Attention	Georgiu et.al, Ling et.al, Brox et.al	2017
I can focus on the movement while playing the games	Attention	Gorsic et.al	2014
I get less distraction from the design while playing the games	Attention	Idriss et.al, Merilampi et.al, Ling et.al, Fernandez et.al	2017, 2018
The color used on the application can give me focus	Attention	Jercie et.al	2017
I get less distraction with the music used while playing the games	Attention	Merilampi et.al, Baur et.al, Gorsic et.al, Ling et.al	2014, 2017
I can stay focused after 15 to 30 minutes playing the games	Attention	Georgiu et.al, Ling et.al, Brox et.al	2017
I can do the movement by focusing my sight and hearing while playing the games	Attention	Merilampi et.al, Jercie et.al, Dhawan et.al	2017, 2018, 2019
I can feel the relationship between playing the games and daily living	Relevance	Jercie et.al, Tan et.al, Chen et.al, Ling et.al, Mubin et.al	2013, 2014, 2017
I get clear instructions from the games	Relevance	Brox et.al, Rego et.al, Baur et.al	2014, 2017
I can set up new goals for the next session after playing the previous games	Relevance	Georgiou et.al, Idriss et.al	2017

I find the content of the games are is suitable for me to play	Relevance	Merilampi et.al	2019
I can boost my interest up by choosing any types of games	Relevance	Merilampi et.al, Jonsdottir et.al	2017, 2019
I feel motivated after seeing my final scores at the end of the games	Confidence	Merilampi et.al, Baur et.al, Gorsic et.al, Ling et.al, Idriss et.al, Brox et.al, Vugts et.al Dhawan et.al, Rego et.al, Pramma et.al, Jonsdottir et.al, Chen et.al, Mubin et.al	2013, 2014, 2017, 2018, 2019
I feel excited when I can do the movement and follow the instructions correctly	Confidence	Merilampi et.al, Baur et.al, Gorsic et.al, Ling et.al	2017, 2018
I can understand the scoring result after playing the games	Confidence	Merilampi et.al, Pramma et.al, Dhawan et.al, Rego et.al	2017, 2018
I have had positive experiences while playing the games	Confidence	Georgiou et.al, Hoogland et.al	2017, 2019
I feel released when I can complete the games successfully	Satisfaction	Pramma et.al	2018
I can sense my confidence level up after seeing my final score	Satisfaction	Hughes et.al, Merilampi et.al, Ammann et.al	2014, 2017, 2018
I think I can do better for the next sessions while playing the games	Satisfaction	Idriss et.al, Georgiou et.al	2017
I can maintain my motivation while playing and after getting my final score	Satisfaction	Merilampi et.al, Baur et.al, Gorsic et.al, Ling et.al, Idriss et.al, Brox et.al, Vugts et.al Dhawan et.al, Rego et.al, Pramma	2013, 2017, 2018, 2019

		et.al, Jonsdottir et.al, Chen et.al, Mubin et.al	
I feel eager to play the games continuously	Satisfaction	Chen et.al, Ling et.al, Mubin et.al	2013, 2017

The last section is Section D combines the Likert scale and open-ended questions which focusing on respondents' preferences in assistive technology on serious games for rehabilitation. The open-ended questions are aimed to get to know users' preferences and opinions after playing serious games. Table 3.8 provides a summary of questions in Section D.

Table 3.8: Summary of Questions in Section D

Items	Type of Questions	Reference	Year
The interface design of serious games is attractive	Likert-scale	Quilis et.al, Ammann et.al, Idriss et.al	2017
The way of giving instruction is understandable in serious games	Likert-scale	Rego et.al, Baur et.al, Pramma et.al	2017
The color chosen in the serious games are suitable	Likert-scale	Hughes et.al, Merilampi et.al	2014, 2018
The scoring details in serious games are shown clearly to the user	Likert-scale	Merilampi et.al, Pramma et.al, Dhawan et.al	2017, 2018, 2019
The serious games helping in improving your disease	Likert-scale	Pramma et.al, Tan et.al, Chen et.al,	2013, 2017, 2019

		Ling et.al, Mubin et.al
The overall used of serious games is good for rehabilitation	Likert-scale	Merilampi et.al, 2017, 2018 Baur et.al, Gorsic et.al, Ling et.al
Do you think serious games for rehabilitation are effective in helping you to increase your motivation?	Open-ended	-
Do you think serious games can be deployed at home? If Yes, why? If No, what is the limitation?	Open-ended	-
Overall feeling using serious games in rehabilitation. You can pick more than one.	Open-ended	-
If you are playing more than one serious games for rehabilitation, which one is the best to play? Why?	Open-ended	-
Select the types of rehabilitation technologies that implement serious games by numbering the best as 1 followed by 2 and 3	Open-ended	-

The summary of questions in Section D questions is divided into two parts: Likert-scale questions and open-ended questions. As the main data for further analysis is from the Likert-scale questions, the open-ended questions are not meant to be a mixture

in the quantitative method. The aim of having open-ended questions in the questionnaire is to support the result of the data analysis. It is an additional support that the researcher needed to refer to the preferences of respondents while using serious games for rehabilitation. Hence, the open-ended questions in the questionnaire are formed.

The references of Likert-scale questions are based on previous research meanwhile the open-ended questions are referring to small interviews beforehand. The small interview was held to get some additional information on the most preferable serious games for users. As for the small interview, the user's preferences are chosen based on their motivation level, feelings, preferences, and suggestions after playing serious games from different platforms: robotic, simulator, and virtual reality.

Few selected respondents who undergo rehabilitation therapies with two platforms suggested by therapists. Some are combining virtual reality-simulator for therapy sessions, and some are using virtual reality-robotic. The small interview held with therapists and respondents, it shows the therapists and user's feedback on serious games that respondents have played during their rehabilitation sessions.

3.5 Pilot Study

A pilot study is an important element for this research to get a genuine view of the study based on physiotherapists suggestions and recommendations. Hence, the significance of this pilot study is shown as follows:

1) In this research motivation and usability are chosen to be the main factors for persons with disabilities to undergo rehabilitation and keep doing the exercise with the help of serious games in assistive technologies: simulator, robotic, and

virtual reality. The pilot study was conducted to establish the research practice and enable changes in addition or removal of relevant factors found in the literatures.

2) The data collection process is explained in another section 3.6 below from the beginning of choosing people to be in the group until the serious games that can be played based on the therapist concerned. However, through this process the researcher needs to acquire knowledge and certainty from the focus-group according to their selected assistive technologies: simulator, robotic, and virtual reality. The undertaken steps are required to ensure the questions are relevant.
3) The pilot study is aimed to explore knowledge on the results gained from the questionnaire and open-ended questions answered by the focus group. These have allowed the understanding of the real-life situation and can be practically implemented.

The pilot study is aimed to get the feedback and impressions of playing serious games for rehabilitation therapies in the selected group of people. The steps of collecting the data in the pilot study are the same as collecting the real data. Table 3.9 shows the criteria for the selected group for the pilot study.

Table 3.9: Summary of Pilot Study

Assistive Technology	Sample Unit	Sample Size	Criteria
Simulator		3	-First time playing
Robotic		3	

Virtual Reality	Stroke, Amputee, Spinal Cord Injury, Traumatic Brain Injury	3	-15 to 30 minutes duration -Less than 50 years old -Male and female

The following bar Chart 3.1 shows the demographic results of the pilot study. Out of the total of nine, there are 3 male and 6 female respondents at the age of 20 to 50 years old. The respondent who is at the age of 20 to 30 years old is the first criteria highlighted for age. The second and third criteria are 31 to 40 years old and 41 to 50 years old. As for the race, there are only three main races selected as the respondent for the pilot study: Malays, Chinese, and Indians. Lastly, the demographic results on the duration of diseases and the three criteria are: 1 year, 2 to 4 years, and more than 4 years.

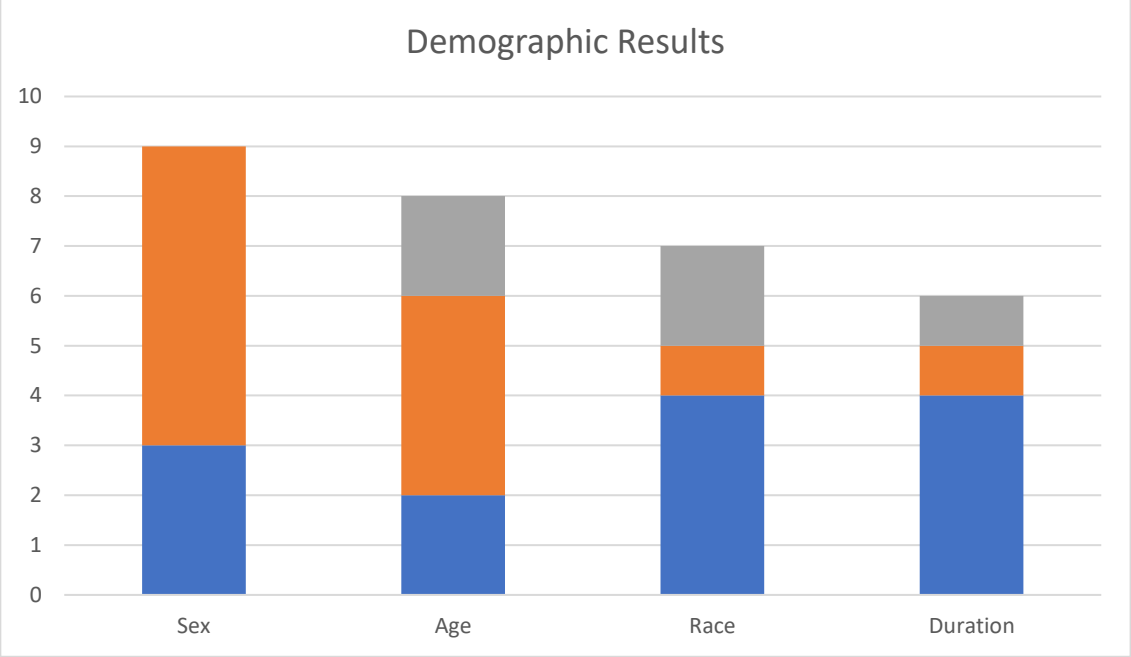

Chart 3.1: Demographic Results Chart

3.5.1 Validity Test

In this section, the criteria that will be used for evaluating the quality of the research is by validity. It is an evaluation that includes all phases of the research, the conceptualization, and the design to the way the data will be collected, analysed, and interpreted. The validity of the research is enhanced through multiple sources of data and multiple collection methods. The results from questionnaires and opinions given during the interview session are consistently strengthening the validity of the research.

As for questionnaire validation for the quantitative method chosen, this research is referring to an expert with more than 5 years of experiences to validate the questions and identify the suitability of the questions according to their attributes. The validation is done through a validity test by an expert panel, a senior lecturer from Universiti Sains Islam Malaysia. The comments on additional and corrections are corrected in the finalized questionnaire and attached in the appendices. After the validity test, there are a few corrections and suggestions to improve the quality of attributes in the questionnaire. The corrections to the questionnaire are made before the research is started.

3.5.2 Reliability Test

Reliability is one of the important elements of a quality test as it is a step in which comparable results are generated at different times. In this section, the reliability test will tell the consistency of the test scores based on the questionnaires answered

by a total of nine respondents in Tun Abdul Razak Rehabilitation Centre. Every three serious games in assistive technology are played according to the group diagnosis and physiotherapists suggestions. The reliability test is measured using SPSS software. Table 3.11 shows the overall reliability statistics using Cronbach's Alpha following internal consistency in Table 3.10.

Table 3.10: Crobach's Alpha Internal Consistency

Crobach's Alpha	Internal Consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable

Source: (Mohajan, 2017)

Table 3.11: Overall Reliability Statistics

	Cronbach's Alpha Based on Standardized Items	N of items	Section
0.675	0.738	5	A
0.918	0.916	21	B
0.947	0.949	21	C
0.758	0.750	6	D
0.902	0.950	54	Overall

The reliability test is following the Cronbach's Alpha where the coefficient of reliability falls in between 0 and 1. The general rule of Cronbach's Alpha for the reliability test is depending on the value generated as if it has a closer value to 1,

the measurement of research instruments is reliable (Hair et al., 2019; Lett et al., 2014; Rigdon et al., 2020). Table 3.9 shows the measurement of Cronbach's Alpha value for overall questions in the pilot study. The data interpretation shows an excellent value with more than 0.90 for Cronbach's Alpha and 0.950 for the standardized items in the overall questions (N=54). The same data have been tested using Cronbach's Alpha for section A, B, C, and D.

Section A is demographic questions asked to the respondents. There is a variety of answers which affect the reliability of the data. The measurement of Cronbach's Alpha is showing 0.675 which is below the accepted value however based on the standardized items the value of 0.738 is acceptable to be used in the questionnaire. The total number of items for this section is five. The value of Cronbach's Alpha for section B is showing 0.918 meanwhile section C is resulting a 0.947 value. Both sections with total questions of 21 (N=21), have an excellent internal consistency value and Cronbach's Alpha for standardized items.

The reliability statistics in section D is focuses on the Likert-scale questions (N=6). The value of Cronbach's Alpha for this section is above 0.700 minimal requirement to be reliable data. The value of section D with a total of six questions and the value of Cronbach's Alpha based on their standardized items are 0.758 and 0.750 each.

3.6 Research Procedures

In research procedures, the researchers is explain the data collecting process in detailed starting from getting the permission in conducting the research in a rehabilitation centre

to the data collection until the verification of the model from the experts. As model validation from the experts is vital to fulfilling the last objective of this research, the formation of the new model through motivation and usability factors in user experience towards serious games is validated in this section. The selection of the experts is based on their experiences as physiotherapists who have handled serious games for rehabilitation. The experience of more than 5 years working has been the main factor in the selection.

The procedures of collecting data are done in eight different steps. The first step in getting the permission to do the data collection is by preparing a proposal research which consists of the research background, objectives, methodology and steps taken to do the purposive sampling. The next step after preparing the proposal research, the permission of collecting the data must be proposed to the Faculty of Science and Technology, USIM in advance before submitting to SOCSO Rehabilitation Centre.

After getting the approval to run the research, the research proposal is submitted together with the workflow. Thus, the research is started once it has been approved by the Chairman of Research and Development Department. The admission letter is attached in the appendices. The forth step right before collecting the data is getting the permission from Research Ethics Committee, USIM to distribute the questionnaire. Few documents that need to be submitted and corrected before the data collection take place. The important documents such as steps of sharing information and explaining the main details of the research to the respondents in the simplest way.

The finalized questionnaire was also submitted to the committee to get the approval for distributing the questionnaire in SOCSO Rehabilitation Centre. Hence, after

getting the approval, the selected respondent will played serious games for exercising for 15 to 30 minutes until they completed a total of 5 sessions. The significance of having 5 sessions is suggested after a few discussions made by the researchers and the expert therapists in the rehabilitation centre.

As the respondents are the majority come with neurological impairment, tedious and repeated exercises will make them out of focus. Besides, the time taken for each respondent to have their rehabilitation therapy is a maximum of three months and some of them have lesser than the estimated month. Yet, the choice of 5-time sessions playing serious games with a similar type of movement is the final decision for the research.

Lastly, the sixth step of data collection is by answering the finalized questionnaire. As the questionnaire is using simple English, the researcher is fully ready with the help to assist the respondents who are in the need. Thus, the data is collected. The following Figure 3.10 shows the steps of collecting data for this research.

Figure 3.10: Steps for Collecting Data

3.7 PLS-SEM and Calculation Method

Structural equation modelling (SEM) is one of the multivariate statistical techniques that is used to examine the direct and indirect relationships between one or more latent

variables known as independent variable and dependent variable (Gefen et al., 2000). The model is used to test the overall fit of a model and evaluate the hypotheses linkage with the respective measures. SEM is used broadly in behavioural science research for complex and multivariate data sets in which researchers gather the multiple measures into a proposed construct (Gefen et al., 2000).

SEM consists of two types of analysis: Covariance and Partial Least Square which for this research, the researcher has chosen the PLS model to be used in analysing the hypotheses. Though the number of appropriate reporting of covariance-based SEM (CB-SEM) analysis has been us widely but never less so for Partial Least Square SEM (PLS-SEM) as it has the same following steps and procedures (Chin, 2014a). However, the used of covariance matrix data in CB-SEM is considering the common variance, in contrast with the PLS-SEM which is referred to as variance-based, but it accounts for total variance and uses the total variance to estimate the parameters (Hair et al., 2019).

PLS-SEM was invented in the year of 1960s and has been widely used as one of the structural equation modelling techniques in variance-based analysis. It is used as the alternative algorithms which extends the correlation analysis using two sets of linear equations known as the measurement model and the structural model (Ringle & Sinkovics, 2009). The steps below shows the basic implementation using SEM which are applies to be used in PLS.

Step 1: Theory Construction – Identify user experience and serious games for rehabilitation and the interception of motivation and usability that affect patients while doing the therapy session

Step 2: Model Identification – The model is constructed to analyse the relationship between both correlation with the intervention of indicator variables

Step 3: Instrument Construction – Research instruments and procedures are made to gather and collect information from patients in the rehabilitation centre

Step 4: Data Collection and Analysis– Collection of data is done by using a quantitative method through questionnaire distributions and the analysis for this research is using SPSS for reliability test and PLS-SEM for relationship analysis and validation

Step 5: Model Testing – The proposed model is tested using PLS-SEM and the relationship is being analysed

Step 6: Results – The analysis results are ready to be interpreted

Step 7: Interpretation – The interpretation will answer the theory and hypothesis made at the beginning of the research

PLS-SEM using SmartPLS software brings an open-source environment together with the set of procedures for the out-of-sample prediction that involves estimating the model on an analysis sample. It evaluates predictive performance on data other than analysis samples known as sample-based prediction (Hair et al., 2019). SmartPLS is one of the model testing software used to test and analyse data with a small sample size (Yaakop et al., 2020). As the user-friendly software, PLS-SEM packages with technical knowledge on methods and it combines with more complex packages for statistical computing software environments such as R (Ringle et al., 2018).

The first step of analysing PLS-SEM results is by evaluating the measurement models. Researchers need to identify the criteria and differ the relevant constructs on reflective and formative. If the measurement models required are meeting all the criteria, then the researcher needs to assess on the structural model. In this step, reliability and validity assessments are used to ensure that multiple indicators in each latent variable is converge. Reliability makes researchers more confident if the measurements are consistently based on the individual indicator.

Hence, PLS-SEM is chosen to be the model analyser as it is capable of handling both formative and reflective constructs with a least and great number that can be applied to the complex structural equation modelling (Urbach, 2014). There are several types to assess the reliability and validity of construct measures. Internal Consistency, Indicator Reliability, Convergent Validity, and Discriminant Validity. Table 3.12 shows the measurement model assessment procedures for this study.

Table 3.12 : Lists of Research Hypotheses and Their Relationship

Validity Type	Technique	Description	Acceptable Results
Internal Consistency Reliability	Cronbach's Alpha	The composite internal consistency should be above 0.60 for exploratory research and 0.70 for confirmatory research (Gefen et al., 2000)	The values ranged from 0.715 to 0.934
Indicator Reliability	Indicator Loadings	Absolute standardized outer loadings should be higher than 0.7 (Hair et al., 2019)	The values ranged from 0.703 to 0.935 but three data that

			have lower than the suggested values
Convergent Validity	Average Variance Extracted (AVE)	The average variance extracted should be higher than the 0.5 value (Yaakop et al., 2020)	The values ranged from 0.550 to 0.803
Discriminant Validity	Fornell-Larcker Criterion	This method compares the square roots of the AVE with the correlation of the latent construct. The square root of each construct's AVE should have a greater value than the correlations with other latent constructs (Izdihar et al., 2017)	The values of AVE square higher than the squared correlations with all other latent variables

Internal consistency reliability is the first criterion to evaluate the measurement model. Cronbach's Alpha is used to scale and estimate the individual reliability. Composite reliability varies between value 0 to 1, yet the higher values indicate the higher levels of reliability. The composite reliability should be above than 0.60 for exploratory research and 0.70 for confirmatory research (Gefen et al., 2000).

Measurement model results from indicator loading shows that the standardize outer loadings is absolutely should be higher than 0.7 (Hair et al., 2019). From the data analysis, all the items in the measurement model the outer loadings are exceeding 0.700, ranging from value 0.272 to 0.934 and all items are significant as the P values in the

bootstrapping is 0.000 except Learnability-2 ← Learnability. Table 4.4 shows the values of indicator loading for each item. Based on the results, all the items used for this research demonstrated as indicator reliability.

Convergent validity is a measurement technique which use to correlate the construct. The assessment is to measure the level of correlation of multiple indicators are in the agreement. A common measure used in convergent validity is Average Variance Extracted (AVE). PLS-SEM is a preferred approach when formative constructs are included in the structural model (Hair et al., 2019). Before heading to the structural model evaluation and assessment, the need of evaluating the formative measurement model is to assess the construct based on convergent validity, indicator collinearity, statistical significance, and relevance to the indicator weights (Ringle et al., 2018).

Convergent validity has been assessed in the previous chapter by using the Average Variance Extractor (AVE). This procedure is used as the redundancy analysis for determining the correlation construct with the alternative measure. Variance inflation factor (VIF) is often used to evaluate the collinearity of the formative indicators (Hair et al., 2019; Publications, 2014). VIF with a value of 5 or above is indicating critical collinearity issues among indicators. Hence, ideally the VIF values should be close to and below than 3 (Lett et al., 2014). Table 4.8 shows the VIF values for each indicator.

The adequate value ranges from 0 to 1, the AVE should exceed and higher than 0.50 (Izdihar et al., 2017; Yaakop et al., 2020). Discriminant validity is referring to the extent to which the construct is differs from one to another, empirically. Fornell & Larcker criterion is a method that compares the square root of the AVE with the

correlation of latent constructs (Izdihar et al., 2017). The assessments evaluate on how accurate the measure is and their convergent and discriminant validities (Chin, 2014b).

Fornell-Larcker is a discriminant validity method is used to assess and compares the square root of the AVE with the correlation constructs. Hence, the square root of each construct's AVE should have a greater value than the correlations with other latent variables. AVE was originally proposed to measure the amount of variance that the latent variable component captures from its indicators relative to the amount due to measurement error. (Chin, 2014b).

In summary, all results shown in the Tables 3.13 are the reflective measurement model which has been compared using two measurement tests: reliability and validity. For reliability test, composite reliability, Cronbach's Alpha, and indicator reliability are the medium used to identify the satisfactory evidence for model fit. On the other hand, the validity test is depending on convergent and discriminant validity using AVE and Fornell-Larcker techniques. AVE values have supported the model and discriminant validity is used to examine the squared correlations among the latent variables

3.8 Summary

In this chapter, the researcher explained on the method and software that has been used to identify, analyse, and recognize the theory, model, instrument, data, and relationship. The theory construction and model identification during the identification phase has successfully determined in the previous chapter. The instrument construction started with hypotheses development and questionnaire design ended with a survey and pilot study. The result of the validity test in the pilot study shows that the questionnaire should be

restructured with the new attribute suggested by the panel. The reliability test result is showing an excellent value of internal consistency using Cronbach's Alpha on usability and motivation sections in the questionnaire. Hence, the researcher decided to restructure and design the questionnaire before distributing it to the selected respondent.

Data collection and analysis are held in the same line for the pilot study. As patients from rehabilitation centres are have only three months of therapy trial, the requirement for them to complete five sessions each with four different movements using virtual reality, four sessions using the simulator and five sessions using robotics is a must. The data collection is using SPSS software to analyse the reliability meanwhile for the validity and relationship recognition using PLS-SEM. This software is used to find the correlation between two main variables: user experience and serious games for rehabilitation with the intervention of indicator variables: motivation and usability.