METHODOLOGY FOR DEVELOPMENT OF MYPARD – GAME DEVELOPMENT FRAMEWORK FOR REHABILITATION OF PATIENT WITH PARKINSON DISEASE

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Abstract. MyPard is a framework designed for game developers to create games tailored for patients with Parkinson's Disease. The aim of the game is to facilitate the rehabilitation process while providing an enjoyable experience. The chosen methodology for this research is an embedded mixed-method approach. The development of MyPard progresses through four phases: analysis, design, development, and validation and testing. During the analysis phase, a comprehensive literature review and expert interviews are conducted to identify key issues. In the design phase, several frameworks are studied to gain insights into the essential elements for MyPard. The subsequent development phase involves the actual construction of MyPard. Finally, the validation and testing phase engages both experts and patients for evaluation purposes.

Keywords: Methodology, Framework, Game Development, Parkinson

1 INTRODUCTION

MyPard is a framework that can be used by game developer to develop a game, tailor made for patient with Parkinson Disease to carry out rehabilitation. Past research has used rehabilitation frameworks to serve the underserved community in Malaysia and even in some other countries (Fairuz, 2023). Research for MyPard uses Mixed Method approach as it involves integrating qualitative and quantitative research to resolve the weakness of both methods when done individually (Creswell, 2013). There are many types of Mixed Methods available, however, the method chosen for this research is the Embedded Mixed Methods. This method provides an understand-

ing of the Parkinson Disease (PD) patient's views within the context of the game developed (Creswell, 2013). Table 1 shows different types of Mixed Methods.

Table 1. Mixed Methods, Expected Outcomes, and Recommended Design (Creswell, 2013)

Reasons for Choosing Mixed Methods	Expected Outcomes	Recommended Mixed Methods Design
Comparing different perspectives drawn from quantitative and qualitative data	Merging the two databases to show how the data is convergent or divergent	Convergent parallel mixed methods design
Explaining quantitative results with qualitative data	A more in-depth understanding of the quantitative results (often cultural relevance)	Explanatory sequential mixed methods design
Developing better measurement instruments	A test of better measures for a sample of a population	Exploratory sequential mixed methods design
Understanding experimental results by incorporating perspectives of individuals	An understanding of participant views within the context of an experimental intervention	Embedded mixed methods design
Developing an understanding of needed changes for a marginalized group	A call for action	Transformative mixed methods design
Understanding the need for an impact of an intervention program	A formative and summative evaluation	Multiphase mixed methods design

There are many types of mixed design methods. The chosen mixed method design for this research is Embedded Mixed Method. This is to gain a better understanding of the results of the PD rehabilitation game development framework through the PD patient's gameplay and view of the game-based rehabilitation game installed in their homes. The incorporated results will be mapped onto interview questions and its results will be discussed fully into an enhancement of current knowledge.

2 PHASES IN RESEARCH METHODOLOGY

In order to obtain the outcome of this research, phases in each research methodology have to be designed. Figure 1 shows the research flow and activity.

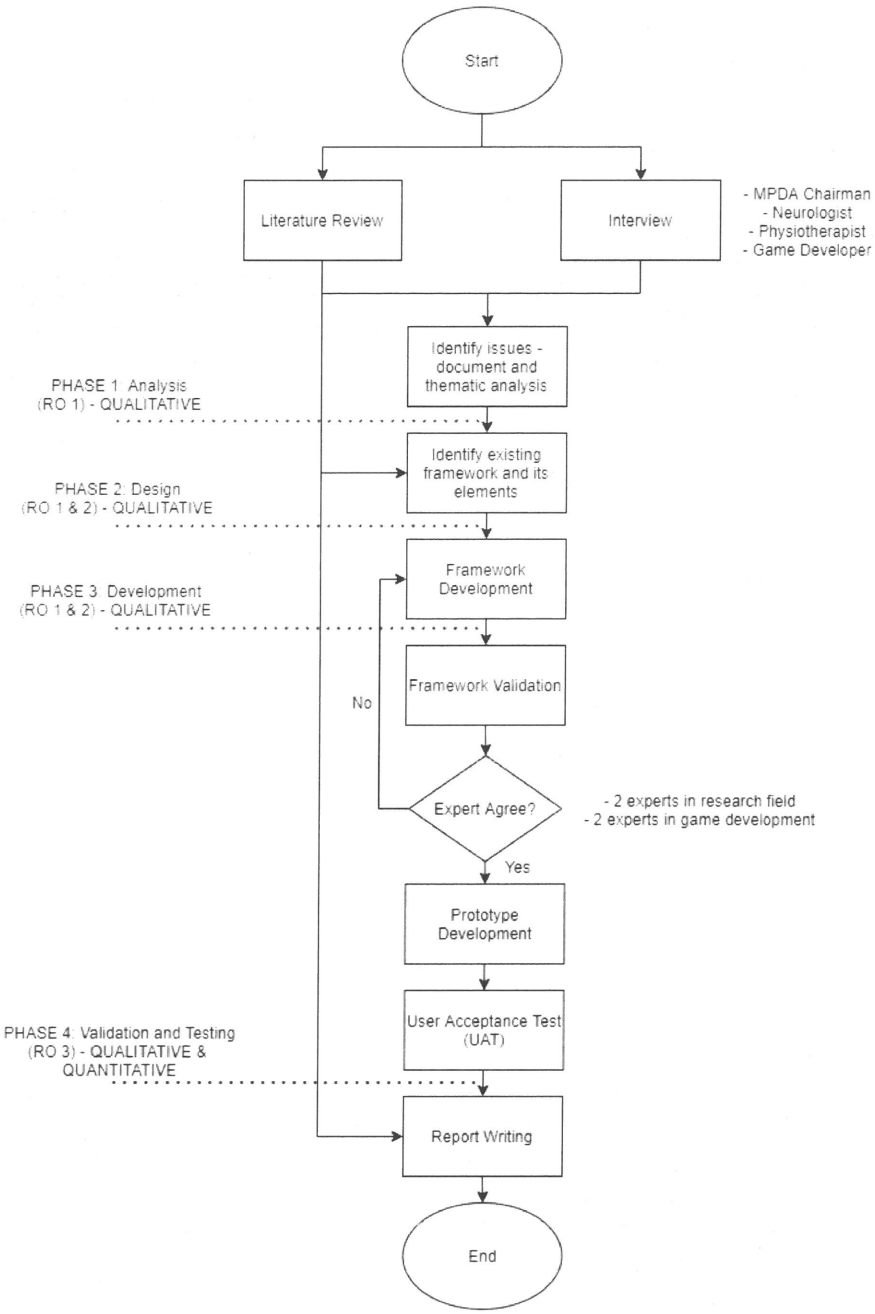

Figure 1 Research flow and activity

Research flow and activity in figure 1 can be mapped into four phases which are analysis, design, development and validation and testing. Table 2 provides an overview for each phase.

Table 2. Research method mapping

Phase & Research Process	Research Method & Instrument	Research Output
PHASE 1: Analysis **- Qualitative**	1. Documentation Analysis – Journal and Thesis Review 2. Conceptual Study - Expert Interview	1. Thematic Analysis of Journal & Expert 2. Comparison of Journal & Expert Thematic Analysis
PHASE 2: Design **- Qualitative**	1. Documentation Analysis – Journal and Thesis Review 2. Conceptual Study - Expert Interview	1.Comparison Ranking, Main Framework Concept & Issue 2. Primary Framework Element
PHASE 3: Development **- Qualitative**	1. Framework Development – From Primary Element	1. Conceptual Framework
PHASE 4: Validation and Testing **- Qualitative And Quantitative**	1. Element Validation – Analysis Result Mapping 2. Framework Validation – Expert Interview 3. Game Testing - User Acceptance Test	1. Game Prototype 2. Validated Framework

Each phase produced a different outcome and at the end of the research, contributes to the body of knowledge in the related field.

2.1 Analysis Phase

Analysis is the first phase of this research. The expected outcome of this stage is to identify a gap in the field of this study. A total of 183 documents which include journals and conference papers have been analyzed using the software Publish and Perish. These documents focus on previous work on this research. These documents also provide details on PD which include causes, symptoms, treatment and rehabilitation, stages in PD and quality of life for PD patient. Apart from PD related research, these documents provide rehabilitation methods for PD from a computer science point of view. Besides that, treatment for a patient with PD is also identified at this stage

which includes drugs, surgery, and rehabilitation. Rehabilitation for PD patients can be done in various ways. Another area of knowledge that is explored at this stage includes the best tools for rehabilitation for PD patients, which is Kinect. Apart from that, more information was obtained regarding serious games, exergames and game design.

Interviews with a few experts have been carried out as well. Experts that involved in early study are PD community expert (COM_01), neurologist (NEU_01), physio-therapists (PHYS_01, PHYS_02, PHYS_03 and PHYS_04) and game developer (DEV_01, DEV_02 and DEV_03). Research interview questions are developed using either past journal questions or own questions, where past journal questions have a validity and reliability index via qualitative reliability and validity analysis, and own questions need to be pilot tested in order to test its validity and reliability index via Cronbach's Alpha value (Creswell, 2013; Sekaran & Bougie, 2016). Summary of analytical induction of past interview questions is shown in table 3.

Table 3. Summary of Analytical Induction of past interview questions

Tag	Phenomenon	Hypothesis	Expert Questions	User Questions	Game Development Questions	Main Paper References Author, Year
AI01	Parkinson's Disease patients have their own description, stage, and suitable rehabilitation process	It is a movement disorder type disease with both physical and psychological factors affecting the patients with physical and psychological impact	What is the description of a Parkinson's Disease patient?	What is your experience as a Parkinson's patient?	Can a movement limited user play a gesture-based game?	(Andersen et al., 2019; Damasevicius, 2018; S. B. Dias et al., 2017; Fairuz et al., 2016; Garcia-Agundez et al., 2019; Hadjidimitriou, 2016; Hallin & Vilic, 2017; Idriss et al., 2017; Kongcharoen et al., 2019; Lind & Mikko, 2017; Maroni, 2016; Mogen, 2018; Muñoz et al., 2019; Ren et al., 2020; Stütz et al., 2017; Szücs et al., 2020; Triandafilou et al., 2018; Zheng, 2016)
		The stages of Parkinson's Disease are on a scale and evaluation forms according to the patient's age and	What are the symptoms and stages of a Parkinson's Disease patient?	What do you feel physically and psychologically as your Parkinson's Disease progresses?	What level structures best fit movement limited players?	(Cikajlo et al., 2018; Gray, 2018; Ibañez et al., 2014; Janatova et al., 2019; Javaid, 2018; Jonsdottir, Klein, et al., 2018; Keary, 2018; McLaughlin et al., 2018; Nam et al., 2018; Örücü & Selek, 2020; Pachoulakis et al.,

		progress of the disease				2016; Salcuni, 2017; Tadayon, 2020; Vogiatzaki & Krukowski, 2015)
A102	Parkinson's Disease patients have unique and catered lifestyle	The Parkinson's Disease patient has a lifestyle with social rights protecting each patient's social relationships, job security and physical environmental interactions	Do the symptoms affect a Parkinson's Disease patient's lifestyle and its social interactions?	Do the symptoms prohibit you from doing your daily routine?	What are the tolerance settings needed to calibrate the device to the player's movements?	(Andersen et al., 2019; Cikajlo et al., 2018; Gray, 2018; Hadjidimitriou, 2016; Ibrahim & Money, 2019; McLaughlin et al., 2018; Örücü & Selek, 2020; Planinc et al., 2016; Pöhlmann et al., 2016; Sahiba Kohli & Ravinder Chadha, 2017; Singla et al., 2017; Soltani et al., 2016; Vogiatzaki & Krukowski, 2015; A. I. Wang et al., 2018)
		Parkinson's Disease patients are physically active and plays games	How active are Parkinson's Disease patients?	How often do you exercise/play games?	Do physically fit and active gamers play better and achieve better scores?	(de Moraes Lopes et al., 2020; Ibrahim & Money, 2019; Janatova et al., 2019; Javaid, 2018; Pachoulakis et al., 2016; Rahman et al., 2019; Singla et al., 2017; Tadayon, 2020; Tannous et al., 2016)

		Parkinson's Disease patients are socially active within society	How often do Parkinson's Disease patients join community groups?	Do you join any community support group?	Are unique players socially competitive?	(Åberg et al., 2017; Ibrahim & Money, 2019; Javaid, 2018; Keary, 2018; Konstantinidis et al., 2016; Mogen, 2018; Örücü & Selek, 2020; Pachoulakis, 2016; Planinc et al., 2016; Rahman et al., 2019; Salcuni, 2017; Sayma et al., 2020; Sielużycki et al., 2019; Vogiatzaki & Krukowski, 2015)
		The public is very aware and knowledgeable of Parkinson's Disease and how to manage it	What is the awareness of the public on Parkinson's Disease?	How are you treated publicly?	Do unique players play alone to avoid social reprimand?	(Åberg et al., 2017; Cikajlo et al., 2018; González-González et al., 2019; Hadjidimitriou, 2016; Ibrahim & Money, 2019; Janatova et al., 2019; Javaid, 2018; Keary, 2018; Konstantinidis et al., 2016; Mogen, 2018; Rahman et al., 2019; Salcuni, 2017; Sielużycki et al., 2019; Tadayon, 2020; Vogiatzaki & Krukowski, 2015)
AI03	Current rehabilitation process and its adequacy	The current rehabilitation process and evaluation method is adequate, standardized, and accurate	What is the process to rehabilitate a Parkinson's Disease patient?	What is the task given during a rehabilitation activity?	What are the game tasks that can increase a player's motor skills?	(Åberg et al., 2017; Cikajlo et al., 2018; Gray, 2018; Ibrahim & Money, 2019; Janatova et al., 2019; Jonsdottir, Klein, et al., 2018; Mogen, 2018; Örücü & Selek, 2020; Pachoulakis et al., 2016; Rahman et al., 2019; Sayma et al., 2020; Sielużycki et al., 2019; Singla et al., 2017;

						Tadayon, 2020; Tannous et al., 2016; Unbehaun et al., 2020; Vallati et al., 2019)
			What are the forms involved before, during, and after the rehabilitation of a Parkinson's Disease patient?	How do your medical officer and caretaker review your progress?	What are the score settings and other evaluation methods that can best review a player's motor skills?	(Åberg et al., 2017; Cikajlo et al., 2018; Gray, 2018; Ibrahim & Money, 2019; Janatova et al., 2019; Jonsdottir, Klein, et al., 2018; Mogen, 2018; Örücü & Selek, 2020; Pachoulakis et al., 2016; Rahman et al., 2019; Sayma et al., 2020; Sielużycki et al., 2019; Singla et al., 2017; Tadayon, 2020; Tannous et al., 2016; Unbehaun et al., 2020; Vallati et al., 2019)
			How consistent are Parkinson's Disease patient able to come to the rehabilitation centre?	How often do you go to the rehabilitation centre?	How consistently does a player need to play to increase their motor skills?	(Andersen et al., 2019; de Moraes Lopes et al., 2020; Hadjidimitriou, 2016; Heloir et al., 2019; Ibrahim & Money, 2019; Janatova et al., 2019; Keary, 2018; McLaughlin et al., 2018; Mogen, 2018; Oña, Balaguer, Cano-De La Cuerda, et al., 2018; Pachoulakis et al., 2016; Rajagopalan et al., 2017; Salcuni, 2017; Skjæret et al., 2016; Soltani et al., 2016; Teo et al., 2016)

			Which rehabilitation task is suitable and best targets a Parkinson's Disease patient's problematic area?	Are the rehabilitation tasks helpful in reducing your pain, tremors, or cramps?	How does a unique player feel during gameplay?	(de Moraes Lopes et al., 2020; Ibrahim & Money, 2019; Janatova et al., 2019; Javaid, 2018; Pachoulakis et al., 2016; Rahman et al., 2019; Singla et al., 2017; Tadayon, 2020; Tannous et al., 2016)

Table 4 shows the interview questions formulated from analytical induction based on findings in table 3.

Table 4. Interview questions formulated from Analytical Induction

Sample of Interview Questions		
Expert	**User Requirement**	**User Post-Gameplay**
1. What is the description of a Parkinson's Disease patient? 2. What are the symptoms and stages of a Parkinson's Disease patient?	1. What is your experience as a Parkinson's Disease patient? 2. What do you feel physically and psychologically as your Parkinson's Disease progresses?	1. What is the severity of your Parkinson's Disease? 2. Do the severity limits your movement, rate of pain, and rate of enjoyment of the gameplay?
1. Do the symptoms affect a Parkinson's Disease patient's lifestyle and its social interactions? 2. How active are Parkinson's Disease patients? 3. How often do Parkinson's Disease patients join community groups? 4. What is the awareness of the public on Parkinson's Disease?	1. Do the symptoms prohibit you from doing your daily routine? 2. How often do you exercise/play games? 3. Do you join any community support group? 4. How are you treated publicly?	1. What type of games do you play at home and how often? 2. Whom do you play with and where? 3. How often do you exercise and with whom? 4. What type of exercise do you do at home? 5. Are you self-motivated to exercise?
1. What is the process to rehabilitate a Parkinson's Disease patient? 2. What are the forms involved before, during, and after the rehabilitation of a Parkinson's Disease patient? 3. How consistent are Parkinson's Disease patient able to come to the rehabilitation centre? 4. Which rehabilitation task is suitable and best	1. What is the task given during a rehabilitation activity? 2. How do your medical officer and caretaker review your progress? 3. How often do you go to the rehabilitation centre? 4. Are the rehabilitation tasks helpful in reducing your pain, tremors, or cramps?	1. Is the game you played an exercise game for rehabilitation? 2. Did the game provide the right kind of exercise support for you? 3. Can you imagine playing it at home? 4. Did you feel safe playing the game? 5. How successful is the game and would you buy it?

targets a Parkinson's Disease patient's problematic area?		

For this research, documents which include journals and previous theses have been studied. Focus is to understand about PD, PD rehabilitation and previous framework. Eight frameworks have been studied and a comparison table has been produced is produced. These elements are then verified by experts before the framework is developed. Results of the interview is analyze using thematic analysis. In this research, the literature review produces a list of elements, which is then classified into elements and their related sub-elements. These elements are the main conceptual element used to compare each result further into the research, which is then be tabulated and further analyzed using Maximum Qualitative and Mixed Method Data Analysis (MAXQDA) Software Thematic Analysis, Code Mapping, Word Cloud, and Code Configuration.

2.2 Design Phase

This stage requires elements for the framework to be identified. Through literature review and expert interview in the previous phase, few frameworks have been identified. These frameworks are being compared to identify key elements of each framework. Result of interview provides crucial input as well such as issues with the current rehabilitation method and process. At this stage, seven elements have been identified. These elements are then validated through interview with few experts which consists of PD community expert, neurology, and physiotherapists. These experts are identified based on analysis of 112 documents. Interview questions have been constructed through various LR to ensure that each element can be validated and to accommodate any gap or issues within the research field. Research on the background of each field is carried out to ensure maximum understanding of the research that is carried out.

2.3 Development Phase

Framework is developed based on elements that have been verified by expert. Findings through interview and LR is being integrated in the framework as well. At this stage, a total of 183 documents were analyzed and filtered. The frameworks which are related to this research were further analyzed and tabulated. Various frameworks that relate to the rehabilitation of PD or brain injury which are almost all related to PD were studied. A direct comparison between each framework is carried out to identify elements of the proposed framework. Elements such as player/patient, therapist, game engine, game design, game mechanics, results and database were identified as a component for the proposed framework. Sub-elements were also identified at this stage. Then, the sub-element of the highest-ranking element was used as a basis for the framework's gamification into a game prototype. Efficacy, evaluation method, motivation and safety are all crucial elements of a game design, the highest-ranking element, especially for PD patients. Based on initial findings in phase one, a

new framework is proposed, or the existing framework is updated. Then, three game developers, DEV_01, DEV_02, and DEV_03 were interviewed to understand and map out the gamification of the framework, as well as validate the type of Game Engine and Game Mechanics that needs to be used for the game development phase.

2.4 Validation and Testing Phase

This phase covers framework validation, prototype development and User Acceptance Test (UAT) of the prototype that have been developed. Research interview after the framework has been developed, interview questions have been constructed to validate the framework. Four experts have been chosen to validate the framework. Expert review has been chosen as method of validation since it involves experts from different fields and point of view hence provide view from different perspective. The framework will be improvised based on the comments made by these experts. This is an ongoing process until the framework is validated. This is to ensure the reliability of the framework. There are two validation sessions, which are element validation and overall framework validation. For element validation, an expert review has been chosen as the methodology to do the validation process. A group from various backgrounds are engaged and the session is conducted online on 21st July 2018. The group that is called upon to carry out expert review includes COM_01, NEU_01, PHYS_01, PHYS_02, PHYS_03, PHYS_04, DEV_01, DEV_02, and DEV_03. Each element of the framework is validated, and the framework's primary structure was obtained.

Next was the overall framework validation. For this session, four framework experts have individually presented the findings of the framework via virtual meeting on Google Meet and their responses were used as justification of the framework's updated structure, layout, and element mapping. The framework experts are one academician, ACD_01, and three industry experts, IND_01, IND_02, and IND_03. Each expert provided a unique assessment of the framework's validity. Table 5 identify the experts for framework validation process.

Table 5. List of experts and outcome types based on previous research.

Experts	Description	Interview Expected Outcome	Outcome Type
ACD_01, IND_01, IND_02, IND_03	• Academicians and industrial experts in the field of Information Technology and Computer Science • Expertise: Framework Development	Framework Development Elements	Research Topic, Subject, Methodology, Technicality and Overall Research Design Output

The framework is validated, and the resulting framework is then used for the next phase which is prototype development. The prototype development will accommodate each element and design principles that have been identified previously. After the prototype has been developed, it needs to be tested. User Acceptance Test (UAT) process is required to ensure that the game met the requirement set by user and achieve its main objective which is to verify that the framework is capable to assist in the development of game.

3 SUMMARY

This research uses both qualitative and quantitative research methodology via Embedded Mixed Method design to produce an understanding of PD patient's views within the context of their PD rehabilitation's assessment and its successes through game development framework and prototype game justification. The framework and game prototype have also both been validated and resulted in 100% success with a few future recommendations by both experts and users. The detailed results of the analysis, game development framework and the prototype game development will be discussed in future publication.

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