UNIVERSITI TEKNOLOGI MARA

BRIDGING GAME DESIGN AND BEHAVIOURAL THEORY: A SERIOUS GAME FRAMEWORK FOR CHILDHOOD OBESITY AWARENESS

NOOR IZDHORA BINTI MOHD BAZID

PhD

June 2026

UNIVERSITI TEKNOLOGI MARA

BRIDGING GAME DESIGN AND BEHAVIOURAL THEORY: A SERIOUS GAME FRAMEWORK FOR CHILDHOOD OBESITY AWARENESS

NOOR IZDHORA BINTI MOHD BAZID

Thesis submitted in fulfilment
of the requirements for the degree of
Doctor of Philosophy
(Computer Science)

Faculty of Computer and Mathematical Sciences

June 2026

CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 8 December 2025 to conduct the final examination of Noor Izdhora binti Mohd Bazid on her Doctors of Philosophy thesis entitled "Bridging Game Design and Behavioural Theory: A Serious Game Framework for Childhood Obesity Awareness" in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The Panel of Examiners was as follows:

Nor Azizah M Yacob, PhD
Associate Professor
Faculty of Computer and Mathematical Sciences
Universiti Teknologi MARA
(Chairman)

Suraya Masrom, PhD
Associate Professor
Faculty of Computer and Mathematical Sciences
Universiti Teknologi MARA
(Internal Examiner)

Ariffin Abdul Mutalib, PhD
Professor
School of Arts and Sciences
Universiti Utara Malaysia
(External Examiner)

PROF DR HJH ZURAEDA IBRAHIM
Dean
Institute of Postgraduates Studies
Universiti Teknologi MARA

Date: 30 June 2026

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Noor Izdhora binti Mohd Bazid
Student ID. No.	:	2017794475
Programme	:	Doctor of Philosophy (Computer Science) – CS950
Faculty	:	Computer and Mathematical Sciences
Thesis Title	:	Bridging Game Design and Behavioural Theory: A Serious Game Framework for Childhood Obesity Awareness
Signature of Student	:	……..
Date	:	June 2026

ABSTRACT

Obesity has become a significant public health concern, particularly among children in Malaysia and globally. It is driven by sedentary lifestyles, unhealthy dietary patterns, and persistent misconceptions that excess weight is merely cosmetic, underscoring the need for engaging, developmentally appropriate health-promotion interventions. Serious games have emerged as a promising approach to promote obesity awareness and encourage healthy lifestyle habits. This study aimed to bridge game design and behavioural theory by proposing a structured, reusable serious game framework to promote obesity awareness among children, addressing gaps in existing interventions that are often single-domain and insufficiently grounded in behaviour change theory and robust evaluation. The research methodology consists of three phases: problem identification, solution design, and evaluation. In the first phase, a literature review and expert interviews were conducted to identify the research problem. The second phase involved the construction of a serious game framework based on a review of existing frameworks, models, and game elements, followed by an expert review to initial-validate the proposed framework. The final phase focused on the development of a game prototype based on the framework and an experimental study to validate and evaluate its effectiveness in promoting obesity awareness. The framework was anchored in the Information-Motivation-Behavioural Skills (IMB) model and operationalised through systematic extraction and synthesis of components from established game frameworks and models, while game elements were organized using Werbach and Hunter's taxonomy (components, mechanics, dynamics). Expert review informed iterative revision, yielding a refined IMB-based framework with explicit mappings between game context (information), motivational design, behavioural skill support, and intended outcomes. A corresponding prototype, *FitFuel Frenzy*, was developed to embed obesity-related knowledge, nutrition and physical activity emphasis. Evaluation with children aged 7–18 assessed usability, player experience, and perceived learning, supported by reliability analysis, descriptive statistics, and correlation analysis among quality domains. The study concludes that a theory-driven, taxonomically structured framework can guide coherent serious game design for childhood obesity awareness and provides a practical foundation for designers, educators, and researchers, while highlighting needs for larger samples and longitudinal assessment of sustained behaviour change and real-world lifestyle outcomes.

ACKNOWLEDGEMENT

First and foremost, I give my utmost gratitude to Allah (SWT) for granting me the opportunity to embark on this PhD journey and for guiding me to its successful completion. Alhamdulillah.

I am deeply grateful to my supervisors, Assoc. Prof Dr. Suzana Ahmad and Assoc. Prof Dr. Norizan Mat Diah, whose unwavering support, guidance, and encouragement carried me through some of the most challenging moments of my research. Your belief in me, especially during times when I felt on the brink of giving up, has been instrumental in pushing me forward. Thank you for helping me navigate through the toughest phases and for empowering me to continue progressing confidently on my academic journey.

I also wish to express my sincere appreciation to Assoc. Prof Dr. Siti Sabariah Buhari, who was one of the first to guide me in laying the foundation of my research. Your invaluable insights and support, particularly given that my field is not directly health-related, enabled me to find my footing and set the stage for my work to move forward.

To my parents, and Mohd Bazid Abd Kahar. You have always been there for me through every challenge, and I know that your prayers have been the source of my strength. Your love and guidance continue to inspire me every day.

To my husband, Muhd Daniel. Words cannot fully express my gratitude for your unwavering support. Thank you for being my pillar during this journey, for helping me balance my responsibilities, and for always being there, especially during the most intense moments of my writing phase. Your sacrifices have lightened my burdens, and for that, I am forever grateful.

Finally, to my beloved children, Dian Kalila and Muhammad Seth. Both of you are my light at the end of every long day. Both of your smile have the power to erase the fatigue and worries of my academic journey, allowing me to face each new day with renewed energy and determination. This achievement is as much yours as it is mine.

My heartfelt thanks go to those who helped me in completing this journey, whose words of encouragement and silent prayers have been a source of strength. Your moral support, both near and far, has meant more to me than words can express.

This victory means the world to me, and it is dedicated to everyone who has stood by me throughout this journey. Alhamdulillah (Praise be to Allah SWT).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviations

ADDIE	Analysis-Design-Development-Implementation-Evaluation
AR	Augmented Reality
BMI	Body Mass Index
CBGD	Cognitive Behavioural Game Design
CPG	Clinical Practice Guideline
HBM	Health Belief Model
HCI	Human Computer Interaction
IMB	Information-Motivation-Behavioural Skills
KAB	Knowledge-Attitude-Behaviour
MASO	Malaysian Association for the Study of Obesity
MDA	Mechanics, Dynamics, and Aesthetics
MEEGA	Model for the Evaluation of Educational Games
MHP	Malaysian Healthy Plate
NHMS	National Health Morbidity Survey
NHSI	National Health Screening Initiatives
NIH	National Institutes of Health
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SCT	Social Cognitive Theory

SDG	Sustainable Development Goals
SDT	Self-Determination Theory
SGDA	Serious Game Design Assessment
SPSS	Statistical Package for the Social Sciences
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TTM	Transtheoretical Model
VR	Virtual Reality
WHO	World Health Organization

CHAPTER 1
INTRODUCTION

1.1 Research Background

In recent years, health and obesity issues have become a growing concern, not only in Malaysia but also globally. This concern pertains to not only adult obesity but also childhood obesity. The increased prevalence of overweight and obesity among individuals were attributed to the sedentary lifestyles of many working adults, which is often necessitated by the nature of their occupations requiring prolonged periods of sitting in office environments. This sedentary behaviour influences their lifestyle habits, leading individuals to opt for easily accessible and unhealthy foods that are widely available throughout Malaysia. In addition to poor dietary choices, reduced physical activity exacerbates the situation, ultimately resulting in an unhealthy lifestyle that contributes to overweight and obesity (World Health Organization, 2024). Although most individuals are aware of the consequences of obesity, some still perceive it as merely a cosmetic issue with no detrimental health effects (Tee, 2017). However, it is a serious health concern. This misconception regarding obesity demonstrates a lack of awareness among the public regarding the issue. Consequently, there is a need to increase public awareness through health promotion initiatives to improve the overall health and quality of life.

In today's modern era, numerous engaging methods, particularly those based on technology, can enhance awareness of health and obesity. These approaches are essential for effectively conveying health messages, especially to the younger generation. Furthermore, children and young people are the most concerning demographic groups, given the rising trend of overweight and obesity within this population (Mahari, 2024). Digital interactive technology such as digital game has gained popularity among the younger generation. This phenomenon is attributed to the entertainment value, with fun and engaging features that games typically offer to players. Currently, a diverse range of digital games exists, each serving distinct purposes for their target audience. Serious games have gained increasing attention as digital approach that extends beyond entertainment. It is designed to simultaneously provide educational content and entertainment with the primary objective of learning

(D. Michael & Chen, 2006). Moreover, serious games have the potential to engage the young people in fun learning and playing, while imparting valuable knowledge. Furthermore, serious games have demonstrated effectiveness in enhancing knowledge acquisition and cognitive skills as well as potentially promoting behavioural changes (Wouters et al., 2009). Therefore, the implementation of serious games to increase obesity awareness may potentially benefit users in various aspects, specifically in learning, knowledge acquisition, and facilitating behavioural change.

In today's world, technological advancements offer numerous opportunities to address the increasing prevalence of overweight and obesity. Serious games have been extensively utilised in health education to promote positive health behaviours and raise awareness of various health issues, such as vaccine knowledge, diabetes, drug intake, and dengue (Ihsan et al., 2020; Lee & Lau, 2018; Lima et al., 2017; Małgorzata & Joanna, 2015). Locally, serious game interventions have been developed across various social awareness aspects, for example games that focused on cleanliness awareness (Aris et al., 2024), cancer awareness (Chai et al., 2022), antibiotic resistance awareness (Mohamad et al., 2020), diabetes awareness (Ihsan et al., 2020), and body mass index awareness (Nasharuddin et al., 2019). Furthermore, diverse technological platforms with social awareness purposes have been developed, including through mobile and desktop applications, 2D and 3D virtual and augmented reality, Kinect, and robotic technology (Alnaqbi et al., 2021; Kalimuthu et al., 2023; Ma et al., 2020; Mack et al., 2020; Randall et al., 2018; Robles et al., 2020). The integration of social awareness aspects and technological platforms creates opportunities for the innovative design and development of serious games that can enhance players' social awareness and promote health behaviour change. Consequently, serious games that focused on health and obesity awareness are potentially effective for learners to cognitively acquire knowledge and improve their affective state, including attitudes and behaviours.

In addition, various game frameworks have been developed to aid the game design process, such as by Thompson et al. (2010), Starks (2014), Mitgutsch & Alvarado (2012), Yusoff et al. (2009), Ibrahim & Jaafar (2009), and Garris et al. (2002). These frameworks and models offer guidance and serve as tools to create, enhance, and improve the game development process. Despite promising results, existing serious game interventions often lack comprehensive frameworks that integrate evidence-based behaviour change theories and robust evaluation methods (Belghali et al., 2021; Calcaterra et al., 2023; Chow et al., 2020; Dias et al., 2018; Lamas et al., 2023; Limone

et al., 2022; M. Liu et al., 2024; Vondikakis, Politi, Chronis, et al., 2025; Vondikakis, Politi, Goulis, et al., 2025). There is a recognized need for the development of a structured, theoretically grounded framework to guide design, implementation, and evaluation of serious games targeting childhood obesity prevention (Belghali et al., 2021; Calcaterra et al., 2023; Chow et al., 2020; Lamas et al., 2023; Limone et al., 2022; M. Liu et al., 2024; Vondikakis, Politi, Chronis, et al., 2025; Vondikakis, Politi, Goulis, et al., 2025). Implementing serious game interventions necessitates comprehensive guidelines in the game design process to ensure that the knowledge and objectives of the game effectively reach the players, thereby enhancing awareness, influencing behavioural intentions, and ideally leading to long-term behaviour change. Therefore, while multiple models and design taxonomies exist, the field lacks a validated, comprehensive, and practically reusable framework for serious game design specifically aimed at obesity awareness and sustained behaviour change, as well as provide better insights and guidelines for designers, developers, researchers and educators.

1.2 Problem Statement

This research study has identified few problems. The problem to be addressed is the (1) children lack engaging tools to understand obesity risks and healthy habits, (2) many serious games focus on narrow and single-domain aims, and (3) few structured, theory-based and integrated behaviour change frameworks exist specifically for obesity awareness games for children. These problems are explained as follows:

a) Children lack engaging tools to understand obesity risks and healthy habits

Obesity is on the rise both nationally and globally, posing a significant public health challenge worldwide, leading to higher risks of chronic diseases and early mortality (Lamas et al., 2023). Additionally, a news article reported an increasing prevalence of overweight and obesity among children under five and those aged between 10 to 17 years old (Mahari, 2024). Furthermore, based on the National Health Morbidity Survey (NHMS) 2019, 27% of the adult population exhibit low health literacy in health promotion and healthy lifestyle practices (National Institutes of Health (NIH), 2019). Besides that, many children lack adequate knowledge about healthy

eating habits and physical activity (Oliveira et al., 2022). This lack of awareness can contribute to future obesity and other related health issues. Educating people, particularly children, about this issue could enhance awareness, as children are particularly receptive to knowledge and information at a young age (S. Liu et al., 2024). Although health education has been implemented through various technological platforms, digital interventions like serious games have proven to be effective and engaging tools for children (Vondikakis, Politi, Chronis, et al., 2025). A systematic review of playful health literacy interventions highlights the need to explore methods for enhancing children's health knowledge, even though evidence on long-term behaviour change and the adoption of healthy lifestyles remains inconclusive (Ribeiro et al., 2023). Additionally, a review of school-based interventions identifies obesity as a significant challenge and underscores the importance of combining structured lessons with activities to improve knowledge and behaviour, suggesting that standard approaches alone are insufficient (Balderas-Arteaga et al., 2024). Consequently, employing serious games to raise awareness about obesity and promote healthy habits could serve as an effective intervention to enhance individuals' knowledge and influence perceived behaviour change. There is also consensus on the necessity and utility of more engaging tools to educate children about the risks of obesity and healthy habits. Furthermore, such tools could help prevent future obesity and improve eating habits and physical activity.

b) Many serious games focus on narrow and single-domain aims

Serious games have shown to improve nutrition knowledge, awareness, and few behaviour change (Limone et al., 2022). However, current reviews suggest that numerous serious games related to health focus on narrow, single-domain aims, such as enhancing nutrition knowledge or encouraging physical activity independently, rather than tackling multiple lifestyle behaviours in an integrated way (Adaji, 2022; Baranowski et al., 2019; Lamas et al., 2023; Limone et al., 2022). Most interventions focus on narrow aims such as nutrition knowledge rather than holistic awareness or multi-faceted behaviour change (Chow et al., 2020). Furthermore, Belghali et al. (2021) also mentioned that serious games designed for children on obesity often focus on nutrition knowledge and dietary change but may not consider other factors such as

physical activity, genetics, and environmental factors. Experts in a preliminary study concurred that exercise and healthy eating are key to losing weight. Whereas, the World Health Organization (WHO) also highlights the importance of these two factors in weight loss. Therefore, given the narrow aims of many serious game designed, it is imperative to establish guidelines that provide a comprehensive framework and incorporate knowledge pertaining to obesity awareness which includes both nutrition knowledge and physical activity.

c) Few structured, theory-based, and integrated behaviour change frameworks exist specifically for obesity awareness games for children

Methodologies, frameworks, and models serve as crucial navigational tools in the creation of artifacts or products. This holds true in the domain of serious game development, where the availability of such guidelines can significantly enhance the overall quality and coherence of the resulting products. Reviews highlight lack of clear design frameworks, standardized game elements, and validated methodologies in serious game for health (Verschueren et al., 2019). Besides that, there are not many games that are theory-driven or systematically designed (Aster et al., 2024; Maxim & Arnedo-Moreno, 2025). In addition, many games are developed without systematic integration of behavioural change techniques or user-centred design principles (Asadzadeh et al., 2024). Lamas et al. (2023) noted that most games are designed around small set of behavioural change theories with the emphasize to design game with different theoretical perspectives to advance the field which shows that current theory use in game development is narrow and that more diverse, structured frameworks are lacking. According to Brynen (2022), there is a significant gap in the comprehensive articulation of these behavioural design elements, which are crucial for guiding interventions. Since the concept of behaviour change is integral to awareness games, incorporating behaviour change theories and elements of behavioural design is essential in creating a framework. This gap also encompasses the absence of established processes and guidelines. Walters et al. (2020) posit that the implementation of health literacy interventions in the game design process can lead to improved health literacy and enhanced health-behaviour change among individuals. Thus, it is essential to develop a comprehensive framework that incorporates structured, validated, and

integrated behaviour change models to achieve a balanced and effective design for health-related or obesity awareness games.

1.3 Research Question

To build this research study, there are a few research questions that need to be identified. The following are the research questions formed:

a) What are the suitable components and elements for a serious game framework promoting obesity awareness?
b) How to construct a serious game framework promoting obesity awareness?
c) To what extent does the game prototype developed based on serious game framework meet the multi-dimensional quality factors of usability, player experience, and perceived learning for obesity awareness?

1.4 Research Objectives

The main objective of this study is to propose a serious game framework for obesity awareness promotion. The following are the research objectives:

a) To determine the suitable components and elements for a serious game framework promoting obesity awareness.
b) To construct a serious game framework promoting obesity awareness.
c) To evaluate the effectiveness of game prototype based on serious game framework in meeting the multi-dimensional quality factors of usability, player experience, and perceived learning for obesity awareness.

1.5 Research Scope and Limitations

This research focused on the development of a serious game framework with general knowledge of health and obesity awareness embedded in the game. The following are the research scope and limitations of this study.

a) This study will develop a serious game framework for an effective obesity awareness intervention for children.

b) A serious game prototype will be designed and developed that aims to promote obesity awareness and encourage healthy lifestyle habits in children. It will incorporate evidence-based game components and elements into the proposed serious game framework.
c) Feedback will be gathered based on expert review to refine and improve the proposed serious game framework. Then, an experimental testing of the serious game prototype with a representative sample of children aged 7 to 18 years will be conducted. The findings will be evaluated on the effectiveness of the serious game prototype in improving obesity awareness to adopt healthier behaviours.
d) The research provides recommendations for further improvement, development, and implementation of the serious game framework. Besides that, this study will identify potential areas for future research, such as long-term behaviour change outcomes, integration with school curriculum, or expanding the game to other health-related topics.
e) This study will focus on development and evaluation of a serious game framework for obesity awareness, which may not be generalizable to other health-related topics.
f) The research will be conducted with a limited sample size of experts and participants, which may limit the broad applicability of the findings.
g) This study will primarily assess the immediate impact of serious game prototype on obesity awareness but may not be able to measure long-term behaviour change outcomes.
h) Besides that, actual changes in participants' dietary habits, physical activity, and overall health-related behaviours are outside of the scope of this study.

1.6 Significance of Study

This study attempts to propose a contribution towards development of a serious game framework supporting obesity awareness in serious game for children. Several expected benefits in this research study are improved in health outcomes. The newly proposed framework bridges the gap between behaviour and design by incorporating the Information-Motivational-Behaviour Skills (IMB) model, which ensures that the domains: Information, Motivation, and Behavioural Skills are directly integrated into

the game mechanics. This framework fills the void by providing foundational taxonomies and mapping specific game components to the IMB model domains, offering a specialized roadmap for obesity awareness intervention in serious game design. In addition, the implementation of serious game for creating obesity awareness among the children will increase the children's awareness of obesity and promote healthy lifestyle choices which lead to an improved health outcomes and reduce the prevalence of childhood obesity. Besides that, serious games have shown to be highly engaging for children, which can help maintain their interest in learning about heath and obesity issue. Serious game in promoting healthy behaviours can also enhanced learning whereby the information provided can be presented in a way that is both entertaining and educational, leading to improved learning outcomes and behaviour change.

Furthermore, serious games offer a cost-effective way to promote health and wellness among children, particularly in communities with limited access to other forms of health education. Digital interventions are especially accessible to the younger populations, making an effective serious game that encourages a healthy lifestyle a valuable tool for enhancing children's knowledge, learning and behaviour change intentions. Moreover, the Malaysia Sustainable Development 2030 Agenda (SDG) (*SDG Roadmap for Malaysia. Phase II: 2021-2025*, 2024), a resolution adopted by the United Nations General Assembly, aims to ensure health and well-being across all age groups and improve quality education. This study contributes to these goals by developing a serious game framework that promotes obesity awareness. Additionally, in alignment with MADANI goals (BERNAMA, 2023), the framework emphasizes well-being and compassion, focusing on the children's health and future selves. It also promotes obesity awareness through the development of framework and games as an early preventive measure to help reduce future burden of non-communicable diseases. Moreover, this study also contributes to lowering health system costs, thereby supporting the sustainable national development. Additionally, the serious game framework for promoting obesity awareness among children serves as a valuable guideline for the designers, developers, researchers and educators.

Consequently, games developed based on the framework may potentially improve health outcomes, increase engagement, enhance learning, and be cost-effective. They can also lead to improvements in children's knowledge, learning, and behaviour change intentions, while offering a reusable framework as guidelines for

designers and developers. Additionally, this study also aims to contribute to the MADANI goals and Sustainable Development Goal (SDG) of ensuring the health and well-being for individuals of all ages.

1.7 Overall Research Framework

In this research study, the process of the overall research framework is represented in Figure 1.1. It contains the research questions, research objectives, methods involved in the study, and research outcomes. Embedded mixed method design was conducted with content and statistical analysis to achieved first objective which is to find suitable components and elements for a serious game framework promoting obesity awareness. Next, to develop the serious game framework and address the second research question, a process of mapping and integration were conducted, followed by an initial validation through expert review. The serious game framework was ultimately validated through an experimental study, utilizing the game prototype developed to fulfil the third objective.

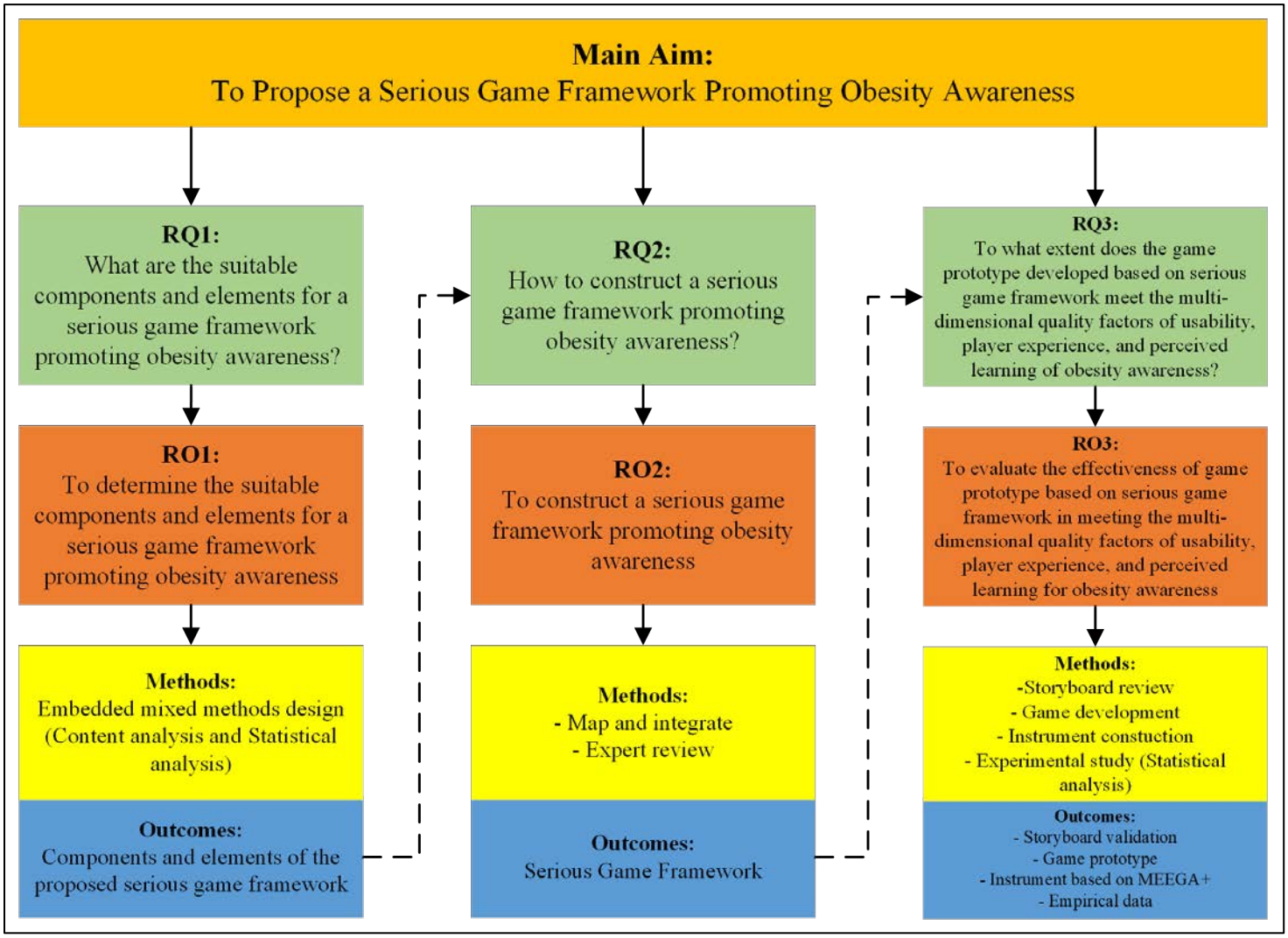


Figure 1.1 Overall Research Flow Based on Research Questions and Objectives

1.8 Thesis Structure

This thesis comprised of six chapters. An overview of content for each chapter is as follows:

a) Chapter 1: Introduction

This chapter serves as the introductory section of the thesis, offering a comprehensive overview of the study. It delves into the research background and problem statements elucidating the key issues and challenges, as well as provide justification for the chosen research topic. Building upon the identified research gap, the chapter articulates the research questions and objectives. Additionally, it delineates the scope and limitations of the study, while also highlighting its significance.

b) Chapter 2: Literature Review

This chapter provides an in-depth exploration of topics such serious games, health education, behavioural models and theories relevant to the research topic, existing game design models and frameworks, game design elements, the integration between the two fields: serious games and obesity prevention, as well as obesity-related health issues and awareness. A comprehensive review of these themes is undertaken to uncover the fundamental aspects and insights pertinent to the overarching research questions. This examination serves to establish connections between the discussed topics and the objectives outlined in Chapter 1, thereby enriching the contextual understanding of the research study.

c) Chapter 3: Methodology

This chapter delineates the sequential processes and activities undertaken throughout the research study. The methodology comprised three phases, which are problem identification, solution design and evaluation. This study culminated in the creation of an artifact, namely, the serious game framework. Subsequently, this framework underwent initial expert reviewing and a developed game prototype that facilitates an evaluation of the game's efficacy. Each phase of the methodology is

thoroughly examined, with an emphasis on elucidating the interconnections between the research questions posited in Chapter 1 and the resultant outcomes.

d) Chapter 4: The Proposed Serious Game Framework for Obesity Awareness and Expert Review Findings

Chapter 4 describes the main contribution of this research study which is the proposed serious game framework. This chapter will answer the first and second research questions of the research study. In addition, this chapter also discussed the activities and procedures entailed in constructing the framework, as well as expert review as an initial validation of the framework. The improved proposed framework constitutes the solution design for the development of serious games that promotes obesity awareness.

e) Chapter 5: Evaluation of Game Prototype

In this chapter, the third research objective will be achieved. A game prototype based on the proposed framework is being developed to test out on the validity of the framework. Besides that, experimental study was also being conducted to assess and evaluate the effectiveness of the game prototype based on the quality factors that are (1) usability, (2) player experience, and (3) perceived learning. The findings are discussed expansively in this chapter.

f) Chapter 6: Discussion and Conclusion

The concluding chapter of the research study provided an overview and summary of the entire research process, revisiting the research questions and research objectives. Moreover, the chapter discussed the contributions and implications of the research study and its limitations. The chapter also offered further recommendations to enhance the contribution highlighted in this study for future research.

1.9 Summary

In this chapter, the research background, problem statement, research questions, objectives, scopes, limitations, and significance of the research study are delineated. The primary aim of this study is to construct a serious game framework that serves as a guide for the development of games aimed at promoting awareness of obesity among children. The subsequent Chapter 2 will delve into the literature review pertinent to this research endeavour.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter offers a comprehensive overview of the literature relevant to this research study, focusing on serious games in health education. It explores the definition and concept of serious games, their effectiveness, existing interventions, key guidelines and features, challenges and limitations, and evaluation methods. Additionally, the chapter delves into behaviour change and health theories and models. It also discusses the strengths and weaknesses of existing frameworks and models commonly used in game design, along with the rationale for extracting components from these frameworks. Furthermore, it examines game design elements, including game taxonomies. The chapter provides essential background knowledge and reviews topics related to health and obesity awareness. It examines the global and local prevalence of obesity among children, explores the causes and risk factors, and discusses current approaches to addressing obesity and promoting health awareness. The chapter concludes with a synthesis of the literature and a summary of this comprehensive literature review.

2.2 Serious Games in Health Education

This section provides a comprehensive overview of serious games in health education. It begins by examining the historical development and evolution of serious games to elucidate their origins. Additionally, the definition of serious games and their intended purpose are explored. Further discussion focuses on the types, genres and technology platforms used in serious games, including their classification and general examples. Then, it examines the effectiveness of serious games, encompassing evidence of their efficacy in educational and health-related contexts. Moreover, an overview of applications designed for health education, as well as their effectiveness in enhancing health literacy and behaviour change, are presented. Given that the primary focus of this research study centres on serious games and health issues such as obesity, it is essential to examine existing studies and examples of applications in health and obesity

awareness. Furthermore, this section also discussed on the key guidelines and features in serious game as well as the common challenges encountered in implementing serious games for health education. This section also delves into Model for the Evaluation of the Educational Games (MEEGA+) model as an instrument tool for evaluation of serious games.

2.2.1 Definition and Concept of Serious Games

Serious games have a long history, with origins dating back to ancient discussions on the purpose of play (Wilkinson, 2016). Back in 1970, Clark C. Abt has already coined the term "serious games" and later been popularized by Ben Sawyer in 2002. Thus, the idea of using games for non-entertainment purposes has existed for centuries (Wilkinson, 2016). In recent years, the trend for serious games, which started in the early 2000s, builds upon a long history of digital games serving serious purposes that can be traced back to the early days of video games (Djaouti et al., 2011). Nowadays, the concept of serious games has integrated non-entertainment purposes with entertainment objectives, such as facilitating learning while simultaneously acquiring knowledge, fostering engagement, and generating motivation.

Based on Michael & Chen (2006), the definition of serious games is learning as the primary purpose, whilst entertainment, enjoyment, and fun are the secondary purpose. Besides that, Susi et al. (2007) defined serious games as emphasizing engagement whereby serious games engage with users for defined purpose rather than pure entertainment. The purpose of serious games extends beyond mere entertainment, as the games focus on delivering engaging learning experiences and imparting valuable knowledge. It is twofold; which is to provide enjoyment and entertainment, while also serving an educational function (Bellotti et al., 2013). Though serious games should have fun and engaging features for entertainment reasoning, their primary goal is to impart valuable knowledge and learning. Although various definitions have been proposed by researchers over the years, there is consensus among scholars that serious games integrate both entertainment and learning, with learning being the primary objective.

As serious games become increasingly prevalent and widely known among users, there may be misunderstanding regarding whether serious games serve the same purpose as conventional entertainment games. However, entertainment games and

serious games are distinct categories. Entertainment games primarily focus on providing enjoyable and engaging gameplay experiences without specific learning objectives, whereas serious games employ a dual approach that integrates entertainment and non-entertainment purposes to enhance knowledge acquisition through the incorporation of engaging and motivating elements for players (Djaouti et al., 2011).

2.2.2 Types, Genres and Technology Platforms of Serious Games

Serious games can be categorized into several types based on their intended purposes and the target audiences. Based on Göbel (2016), serious games application applied in various domains such as educational, training and simulation, health, societal and public awareness, pervasive gaming, cultural heritage and tourism, and marketing. There are various types and genres of serious games that have been developed and applied in diverse domains over the years. For example, some serious games aim to promote health behaviour change, some aim to promote social awareness, there is also serious games that meant to teach and educate complex subjects to targeted audiences. They serve different purposes but meant to achieve the goal of having an intended purposes and learning. According to Prensky (2001), the categorization of games is based on their characteristics and learning outcomes, as some games focus on imparting factual knowledge while others develop skills through persistent state games or role-playing. For example, in educational setting, serious game usually been used as a tool, for teaching and learning particularly for complex subject (de Freitas, 2006). Other domain such as healthcare includes medical health training which provides immersive experiences and scenarios that enhance user's learning experiences (Kayed et al., 2024). Furthermore, in social awareness domain, many serious games have emerged to promote awareness for social impact (Bogost, 2007). As the field of serious games continue to evolve, new applications are constantly emerging, allowing both challenges and opportunities for academic researchers and industry practitioners alike.

Various types and genres of serious games exist, and they can be categorized based on their primary purpose. Educational games, training simulations, health games, and social impact games are several types of serious games. For example, educational games are designed to facilitate the teaching and learning of specific knowledge or skills, typically in educational settings (de Freitas, 2006). This type of game is commonly designed to align with learning objectives and outcomes in subjects such as

mathematics, science, history, programming, or languages. An example of an educational video game is *MathBlaster!* (see Figure 2.1), created by former educator Jan Davidson in 1983, which subsequently led to the production of multiple versions of the game. *MathBlaster!* utilized an arcade-style format with the purpose of enhancing skill-building mathematical exercises.

Figure 2.1 *MathBlaster!* Game

In addition, training simulations represent another type of serious games, developed with the objective of cultivating specific skills within a low-risk, real-world environment. This genre of games is predominantly developed in fields that require specialized skills for particular purposes, such as aviation, military operations, healthcare, or corporate training (Zyda, 2005). A notable example of such a game is *America's Army* (see Figure 2.2), released in 2002. The game's primary functions are to inform, educate, and recruit potential army personnel, effectively serving as a recruitment tool. Over time, *America's Army* has expanded its availability to various platforms, including Xbox, arcade systems, and mobile applications.

Figure 2.2 *America's Army* Game

Moreover, health games are created for health purposes. It constitutes a type of serious games that aim to promote health-related behaviour changes, rehabilitation, or mental health improvement (Baranowski et al., 2008). Engaging in health-related games can lead to various desirable outcomes such as increase in knowledge, attitude changes, behaviour changes, and other health related outcomes. This type of game typically focuses on specific health issues or awareness, such as obesity, diabetes, smoking, or cognitive decline. For example, a game named *Re-Mission* (see Figure 2.3), developed in 2006, exemplifies a health game designed to assist young cancer patients in comprehending the disease and its successful treatment. The game is intended to influence psychological and behavioural outcomes associated with effective cancer treatment.

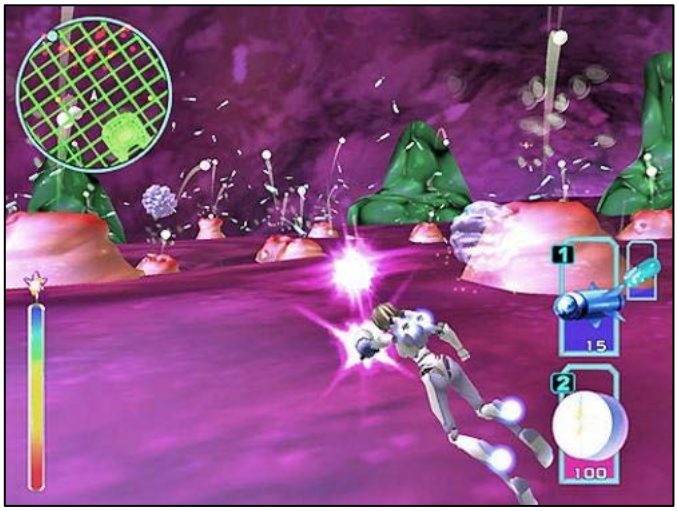


Figure 2.3 *Re-Mission* Game

Furthermore, social impact games represent another type of serious games, designed to promote social change and raise awareness about various societal issues (Bogost, 2007), such as environmental conservation, smoking awareness, conflict resolution, and political activism. An example of such a game is *Darfur is Dying* (see Figure 2.4), released in 2006, which is a narrative-based simulation game. The purpose of this game is to enable players to comprehend and learn about the impact of conflict in Darfur and explore the living conditions of struggling refugees.

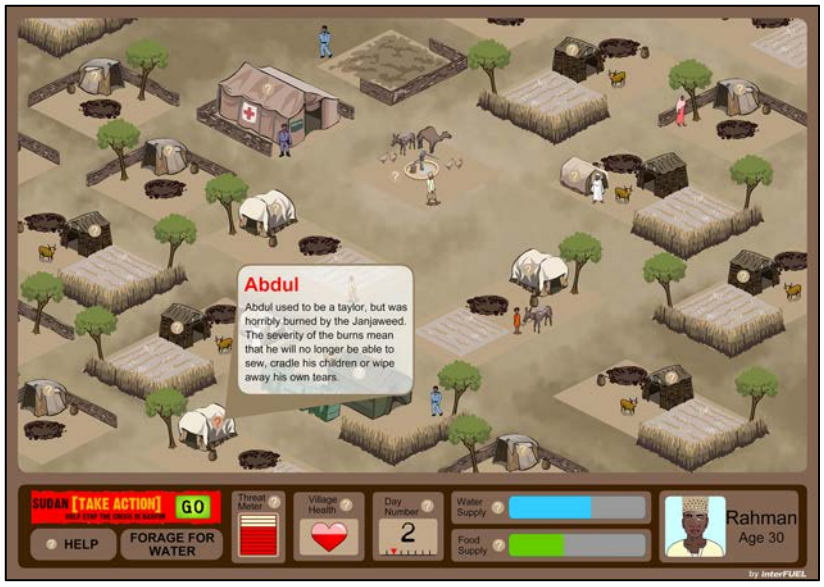


Figure 2.4 *Darfur is Dying* Game

Therefore, it can be shown that each type of game gives different purpose to various intended users. It can also show that certain types of games can have an impact, either on the community as a whole or on individuals. For example, social impact games such as *Darfur is Dying* game can create awareness on societal issue rise. Whereas, health games type can promote health awareness, including the ability to improve desirable outcomes of the players in terms of knowledge increase, attitude and behaviour change, as well the perceived health related outcomes.

In terms of genres, serious games frequently incorporate genres common in entertainment gaming, albeit with the intention of delivering educational or training content. Several common serious game genres can be identified, including simulation, role-playing games (RPGs), puzzle games, strategy games, and platform games. For example, simulations genre is a genre that replicates real-world environments for

players to practice and acquire specific skills or knowledge (Garris et al., 2002). Garris et al. (2002) also mentioned that simulation game is a combination of hybrid format from both games and simulations, which also represent simulation as the reality even though games are not. However, some researchers argue that simulation games are unsuitable and ineffective as standalone tools because individuals often struggle to distinguish general principles from concrete experiences (Winn & Jackson, 1999), even though these games are known to enhance players' interest and motivation in the related subject matter. For example, *Microsoft Flight Simulator X* exemplifies a game designed for the purpose of flight simulation which also represents the purpose of simulation game that depict the real-world environment to improve skills and knowledge learning.

In addition, role-playing games (RPGs) constitute a genre that employs characters or avatars as the primary roles for players. These roles make decisions during gameplay, which subsequently influence the game outcomes or narrative. This genre is frequently utilized in educational settings to impart problem-solving or decision-making skills to players (Barab et al., 2011). In addition, role-playing game through external agents such as avatars create the opportunities for the players to experiment with their actions that they act as appropriate in their virtual perspectives. Moreover, Gee (2003) also mentioned about players in role-playing games usually feels like partly themselves in real world, also partly as an avatar in the virtual world. For example, a game named *Quest Atlantis* which is a role-playing game provides teaching and learning educational tasks to students aged 9 to 12 years old. It involves the use of 3D multi-users environment to allow the children to immerse in the game while being able to role play in the game and engage while learning and gaining knowledge. Another example is *Neverwinter Nights* that has been implemented in educational contexts, wherein it facilitates the teaching of narrative creation and problem-solving. Additionally, the gameplay encompasses learning in terms of reading skills, factual knowledge, spatial cognition, and deductive reasoning.

Furthermore, strategy games genre requires players to utilize decision-making skills to manage resources and achieve objectives within the game environment (Sqire, 2005). It emphasizes on the planning and tactical decision-making of a game design. In the realm of educational games, *Civilization III* is designed to teach players about social studies by allowing them to engage with historical events and societal dynamics (Susi et al., 2007). The original *Civilization* game was first released in 1991 which facilitate indirect educational learning about civilizations within the domains of history and

political science. Sqire (2005) reported in his study that the implementation of *Civilization III* in schools to teach students world history resulted in high levels of student engagement with the game. This engagement facilitated valuable learning experiences, which subsequently led to enhanced historical understanding and improved vocabulary acquisition.

Platform-based games is another game genre that employ a method wherein players control characters by navigating environments through running and jumping to accomplish quests, goals and overcome challenges (McGonigal, 2011). It typically emphasizes fast-action and often involve navigating through levels with various challenges. In the world of gaming, platform games have been instrumental in shaping the industry's culture. Many of the most recognizable figures in video games come from this genre, with characters like *Mario* and *Sonic* standing out as prime examples (Minkkinen, 2016). One of the well-known platform games is *Zombies Run!* which exemplifies a platform-based serious game designed to motivate players to engage in physical activity. Besides that, there is also *BlocklyScript*, an online 2D platform game, designed to introduce programming concepts and foster Computational Thinking (CT) abilities in young learners (Karakasis & Xinogalos, 2020). This shows that this kind of genre can also be applied to games with serious purposes. Based on Karakasis and Xinogalos (2020), platform games allow players to engage with learning environment, indirectly teach practical application of concepts based on the goal of the game and provides aesthetically pleasing visual representation that motivates players to play the game. Besides that, the game also able to progress in learning, allow immediate feedback, improve problem-solving skills, and provide the ability for self-paced learning. Additionally, platform games appeal to individuals across all age groups and are considered simple, uncomplicated with straightforward rules (Galgouranas & Xinogalos, 2018).

Moreover, serious games also have been applied to various technology platforms such as video games, mobile application, 2D, 3D virtual and augmented reality game, kinetic and robotic technology. For example, a well-known and widely played game application globally *Pokémon Go*, indirectly creates awareness on the important of physical activity to the users using the 3D augmented reality platform. Similarly, (Westlin & Laine, 2014) proposed a virtual exergame that utilized a map to facilitate user movement, thereby promoting physical activity. Additionally, Jayachandran et al. (2017) developed a virtual game that provides a simulated shopping

experience for selecting health products while (Randall et al., 2018) employed a robotic technology platform focused on dietary nutrition, specifically a system named Health-e-Eater, which aims to encourage children from low-income families to adopt healthier eating habits. Therefore, various technology platforms used in serious game field allow variety of creativity and leverage the interactive and engaging nature of games to facilitate learning and skill development and improvement across domains.

In conclusion, serious games encompass a diverse range of types, genres, and technology platforms that are designed to engage players with the objective of imparting educational benefits and knowledge acquisition. The variety of types, genres and platforms facilitate the application of these games across multiple domains, including education, health, training, and social awareness. Therefore, to effectively facilitate learning and enhance both cognitive knowledge acquisition and behavioural improvement, it is crucial to incorporate the appropriate game type and genre that align with the intended purpose of the developed serious game.

2.2.3 Effectiveness of Serious Games

Previous studies have demonstrated the efficacy of serious games that serve intended purposes. Most serious games are designed for educational purposes which particularly prevalent in the fields of education and healthcare. Furthermore, research indicates that serious games are also prominent in promoting social awareness and societal impact, addressing issues such as water quality awareness, energy source consumption, wildfire prevention, children's poverty, combating adolescent dating violence, and flood risk and prevention (Abdusselam, 2020; Alhassan et al., 2020; Alvis, 2015; Bowen et al., 2014; Pereira et al., 2015; Rebolledo-Mendez et al., 2009). Additionally, serious games also have been developed to preserve cultural heritage, as exemplified by the study of Isa et al. (2019) focusing on the preservation of Terengganu brassware craft heritage. These serious games, developed for various domains, are equally significant and have proven to be effective and beneficial to individuals, communities, and populations in general, particularly in terms of societal impact.

Furthermore, numerous studies have also shown that serious games can effectively enhance players' cognitive abilities and influence their behaviours. Research suggests that serious games can improve cognitive abilities and knowledge acquisition (Palaus et al., 2020; Sharmin et al., 2023; Wouters et al., 2009) and foster positive

behavioural changes. However, Palaus et al. (2020) pointed out that while certain studies have shown promising results regarding cognitive function improvement, the long-term effect on behaviour change remains unclear, emphasizing the need for additional research in this area. Besides that, there is a notable finding that serious game features contribute significantly to the effectiveness of serious games (Wouters et al., 2013). Additionally, the effectiveness of games is often influenced by their design, which encompasses rich game mechanics and motivating game goals (Roedavan et al., 2023). Therefore, while effective games can lead to enhanced knowledge acquisition, cognitive improvements, and behavioural changes, the outcomes and impacts are influenced by individual factors and the nature of the gameplay and design. Nonetheless, the benefits and effectiveness of serious games generally surpass their limitations and drawbacks.

2.2.4 Applications in Health Education

Health education plays a crucial role in disseminating health information and raising awareness through educational initiatives. Previous studies have demonstrated the effectiveness of serious games in educational contexts. Serious games have been increasingly utilized in health education to promote positive health behaviours and raise awareness on various health issues. For instance, a school-based intervention utilizing serious games to promote healthy lifestyles in children yielded results indicating improvements in dietary knowledge and eating habits among participants (Marchetti et al., 2018). Furthermore, research has focused on employing serious games to enhance understanding and awareness of vaccine knowledge, diabetes, drug intake, dengue, tropical diseases, and depression (Ihsan et al., 2020; Lee & Lau, 2018; Lima et al., 2017; Luz et al., 2016; Małgorzata & Joanna, 2015) which demonstrate these serious games that raise awareness on societal impact issues and the game provides opportunities for the development of self-awareness abilities through gameplay to the users.

Another example, a study conducted by Rebolledo-Mendez et al. (2009) utilized a serious game to address the issue of flooding and found that such games possess the capacity to raise awareness among the population. The implementation of these games to serve the intended purpose of learning and promoting awareness and prevention, facilitates the enhancement of individual knowledge, as well as knowledge improvement among the population engaging with the games. Additionally, such games

have the potential to address specific issues and possess the capacity to raise awareness among the population while improving cognitive knowledge and promoting behavioural change.

Besides that, the effectiveness of serious games has been shown to effectively fosters health literacy and promotes positive behavioural changes in diverse populations. According to Walters et al. (2020), by implementing health literacy interventions, individuals can experience improved health literacy and enhanced health-behaviour change. Thus, to enhance health literacy and promote health-behaviour change, behavioural interventions are implemented through a complex methodology that aims to modify individual actions to achieve improved health outcomes. For example, in a study by Orji (2014), the Model-driven Persuasive Technology (MPT) design approach has been suggested, which involves modelling user motivations and behaviours. These interventions often incorporate a variety of theoretical models and use a range of tactics to impact behaviour in various settings and populations (Stokols, 1996).

Various technologies implemented are increasingly employed to promote favourable health outcomes and lifestyle adjustments. Such technologies encompass a diverse range of platforms, including smartphone applications, wearable devices, and patient portals. These game technologies harness the motivational force of games to encourage favourable behavioural outcomes through employing a variety of tactics including serious games, gamification, and persuasive technologies (Hammady & Arnab, 2022). Moreover, game mechanics and features are essential in fostering behaviour change and designers must consider key theories of behaviour change when creating interventions (Hammady & Arnab, 2022). Thus, effectiveness of developing serious games in improving health literacy and behaviour change consist of various ways including behavioural intervention and behaviour change game technologies.

2.2.5 Existing Serious Games on Health and Obesity Awareness

Serious games addressing obesity awareness and prevention are prevalent in the field of serious games and digital games in general. Numerous games have been developed and implemented in this domain, particularly in promoting awareness of obesity and broader health issues. Previous studies conducted in this field exhibit diversity in terms of design and development, although they serve common objectives,

which are to enhance knowledge acquisition or facilitate perceived behaviour change. For instance, serious games focused on health and obesity awareness primarily emphasize either on the aspects of nutritional intake or physical activity. However, some studies have also addressed both aspects: nutritional intake and physical activities, as recommended by World Health Organization (2024). As stated by World Health Organization (2024), obesity and overweight issues are manageable and preventable. Consequently, these are not solely individual concerns but societal ones. Therefore, solutions are fundamentally rooted in healthy food consumption and regular physical activity, as these two factors are considered easily accessible, available, and affordable for individuals to incorporate into their daily routines. As illustrated in Table 2.1 below, multiple studies have emerged relating to the promotion of obesity awareness and prevention. The development of these games has utilized various technological platforms and focused on different aspects of awareness.

Table 2.1
Summary of Technology Platform and Focus of Awareness of Previous Studies Related to Obesity

Game title	Technology platform	Focus of awareness	Description	Reference
STEM-ARNutri Edu	Augmented reality	Nutrition	An application developed that integrates AR with STEM to enhance learning experiences and improves nutritional education outcomes	(Kalimuthu et al., 2023)
ObeseGo	Desktop application	Nutrition	Educate children and parents the importance of making the right decision of eating healthy and unhealthy foods	(Alnaqbi et al., 2021)
Kids Obesity Prevention	Virtual reality	Nutrition and physical activity	Motion-controlled serious game for children that focused on three aspects: nutrition, physical activity and stress-coping	(Mack et al., 2020)
Qatar Diabetes Game (QDG)	Mobile application	Nutrition and physical activity	Serious game for diabetic children that used arcade-based approach to teach them healthy eating, perform physical movement and manage their health	(Moosa et al., 2020)
Run Boy Go!	Mobile application	Nutrition and physical activity	Serious game for children in Mexico to encourage them to perform physical activity and learn nutrition elements	(Robles et al., 2020)
Barty	Mobile application	Nutrition	Teach children to classify foods based on the level of healthiness and the proper way to choose food meal intake	(Gonçalves et al., 2020)
FitBirds	Mobile desktop application and motion sensing	Physical activity	A multiplayer fitness game to encourage teenagers to perform exercise that are based on their physical intensity level and heart-rate level	(Ma et al., 2020)
FoodRateMaster	Desktop application and motion sensing	Nutrition and physical activity	A game that encourages players to improve food knowledge and promote physical activity	(Espinosa-Curiel et al., 2020)
Exer-Learning Playground Game	Desktop application and motion sensing	Physical activity	Exer-Learning Playground game used Interactive Tag Playground (ITP) based on tag game which integrates learning languages with performing physical activity	(Y. Wang et al., 2020)
NutritionBuddy	Mobile and desktop application	Nutrition	Serious game that promotes healthy balanced nutrition for children based on social cognitive theory principle	(Michael et al., 2018)
GrowHealthy	Mobile and desktop application (web-based)	Nutrition and physical activity	A learning system that encourages children in Qatar to change their eating habits and improve a healthy lifestyle	(Saad et al., 2018)
Health-e-Eater	Robotic	Nutrition	A system named Health-e-Eater that encourage children from low-income families to eat healthily	(Randall et al., 2018)
CiboPoli	Mobile application (chatbots)	Nutrition	Teach primary school students about healthy lifestyle and food waste management using gamified chatbot system	(Fadhil & Villafiorita, 2017)

Virtual Reality Grocery Shopping Game	Virtual reality	Nutrition	A virtual game that offers virtual shopping experience in a grocery shop by choosing the right healthy products	(Jayachandran et al., 2017)
Kids Menu Care	Mobile application	Nutrition	Food menu planning for children and adolescents which provide information in the form of meal schedules and food menu for children	(Yulina & Hajar, 2017)
Running Othello 2 (RO2)	Mobile application and motion sensing	Physical activity	An application that motivates children to perform physical activities and make Physical Exercises (PE) class fun	(Lindberg et al., 2016)
DigesTower	Desktop application	Nutrition and physical activity	Serious game that promotes healthy eating and performing physical activity	(Dias et al., 2016)
Aquamorra	Mobile application	Nutrition and physical activity	Serious game that supports children treatment in with obesity through serious content, facilitate learning and initiate behaviour change	(Mayr et al., 2016)
Technology Based Obesity Prevention Project (TeBOPP)	Desktop and mobile application	Nutrition and physical activity	A video game that applied motivational game-based learning and behaviour change theories for Latino children	(Amresh et al., 2016)
MyFitnessPal (MFP)	Mobile application, web-based and motion-sensing	Nutrition and physical activity	A health and fitness app that helps users to personalized health goals by tracking nutrition, physical activity, and tracks exercise records, dietary habits and weight loss	(Howell et al., 2016)
Spaceship Launch	Web application	Physical activity	A game application to promote physical activity among young children that allows collaboration between parents and children to work together to be more physically active	(Saksono et al., 2015)
MobileKids Monster Manor	Desktop application and motion sensing	Physical activity	A game application to promote voluntary physical exercise among children	(Garde et al., 2015)
Calory Battle AR	Augmented reality	Physical activity	A virtual exergame that used map to allow users to move around and to promote physical activity	(S. L. Kim et al., 2014)
StarsRace	Mobile application	Physical activity	A mobile serious game for obese patients to perform physical activity whereby two players match play at anywhere and anytime	(AL-Qurishi et al., 2014)
Creature-101	Mobile and desktop application	Nutrition and physical activity	A serious videogame to engage with adolescents to motivate in eating healthy foods, performing physical activity, and promote energy balance-related behaviours	(Majumdar et al., 2013)

Currently, the existing games designed for health and obesity awareness incorporate various serious game interventions that engage children and promote health education. These games use game components and elements in the design to create an interactive experience that can influence children's awareness and behaviours regarding obesity and health. Interestingly, while there is a focus on educational and persuasive games, the literature suggests that there is still a need for more research on the social aspects of health games and their design principles (Brox et al., 2011). Furthermore, serious games have been shown to be effective in delivering health promotion and education to children, with studies demonstrating their impact on health behaviours (Lee & Lau, 2018). The design of these games is crucial, as they must be immersive and engaging to successfully promote social behaviours and awareness.

Based on Table 2.1, most studies concentrate on dietary nutrition intake and the significance of engaging in physical activities as suggested by the World Health Organization (2024). Despite the acknowledgment of these two important components, some studies have focused on one aspect to further address the root of the problem and treat it as a comprehensive initiative to overcome obesity. For instance, a game designed named *Barty* teaches children to classify foods based on their level of healthiness and the proper way to choose food meal intake (Gonçalves et al., 2020), focusing solely on nutrition intake awareness. Similarly, other studies such as *STEM-ARNutri Edu, ObeseGo, NutritionBuddy, Health-e-Eater, CiboPoli, Virtual Reality Shopping Grocery Shopping game*, and *Kids Menu Care* (Alnaqbi et al., 2021; Fadhil & Villafiorita, 2017; Jayachandran et al., 2017; Kalimuthu et al., 2023; S. Michael et al., 2018; Randall et al., 2018; Yulina & Hajar, 2017) are examples of games designed focused on diet nutrition awareness.

Nevertheless, games developed to emphasize physical activity also focus on incorporating content related to single aspect related to physical movements and the importance of performing physical activity. Furthermore, this approach allows for a more concentrated effort in achieving the game's designed goal, enabling players to attain their targeted outcomes. *Fitbirds*, for example, encourages teenagers to perform exercises based on their physical intensity and heart rate level (Ma et al., 2020). This allows the players to actively engage in the tasks given in the application without the need to divert their attention elsewhere. Other physical activity-focused games include *Running Othello2, Spaceship Launch, MobileKids Monster Manor, Calory Battle AR,*

and *StarsRace* (AL-Qurishi et al., 2014; Garde et al., 2015; S. L. Kim et al., 2014; Lindberg et al., 2016; Saksono et al., 2015).

Over the years, games have been created with the purpose of preventing obesity by including the two main aspects of diet nutrition and performing physical activities. Despite the focus on single-focused awareness, there are also games developed with the inclusion of two main aspects that are considered important in obesity prevention. *Run Boy Go!* is a serious game created by Robles et al. (2020) for children in Mexico to encourage them to perform physical activity and learn nutrition elements. Learning both important aspects in obesity prevention allows for a comprehensive understanding of how to live a healthy lifestyle, especially in children. Examples of such games include *Kids Obesity Prevention, Qatar Diabetes Game (QDG)*, *FoodRateMaster, GrowHealthy, DigesTower, Technology Based Obesity Prevention Project (TeBOPP),* and *MyFitnessPal (MFP)* (Amresh et al., 2016; Dias et al., 2016; Espinosa-Curiel et al., 2020; Howell et al., 2016; Mack et al., 2020; Moosa et al., 2020; Saad et al., 2018).

Furthermore, there is also an evolution of technology platforms used in the implementation of the games developed in obesity awareness and prevention. Various platforms have been utilized, with desktop and mobile applications being the most employed. Additionally, Augmented Reality (AR) and Virtual Reality (VR) have been incorporated into game development, such as the *Virtual Reality Grocery Shopping Game*, which offers a virtual experience in a grocery store by allowing users to select appropriate healthy products (Jayachandran et al., 2017). Another example is *Calory Battle AR* by Kim et al. (2014), a virtual exergame that utilizes a map to enable users to navigate and promote physical activity. Motion sensing technology is also prevalent, particularly when the focus is on tracking movement and performing physical activity, as it can monitor an individual's physical movements and heart rate, among other parameters. *FitBirds* exemplifies a fitness game that employs motion sensing based on players' physical intensity level and heart rate (Ma et al., 2020). Other platforms, such as the chatbot system *CiboPoli,* present an intriguing approach by educating primary school students about healthy lifestyles and food waste management through a gamified interface (Fadhil & Villafiorita, 2017). Consequently, the integration of diverse platforms in the design and development of games for obesity awareness and prevention facilitates a wide range of creative and engaging learning experiences in serious game interventions.

In summary, the literature indicates that various serious games have been designed and developed to raise health and obesity awareness, with a focus on engaging children through educational content and persuasive elements across diverse technology platforms. Additionally, there are also domain-specific approaches to awareness that concentrate on either dietary nutrition intake or physical activity engagement, allowing for more targeted interventions in game development. However, it is advisable to incorporate both critical aspects of awareness in an application to achieve more comprehensive outcomes, particularly if the objective of the game is to modify the player's behaviour towards adopting a healthier lifestyle.

2.2.6 Key Guidelines and Features in Serious Games for Health Education

The key guidelines and features in serious games for health education indicate the importance of integration of game design elements with outcomes that creates effective serious games. For example, game objectives in serious game should always align with learning outcomes. According to Alonso-Fernandez et al. (2017), serious games must have a clear learning objectives aligned with the overall educational goals. Next, the implementation of game mechanics suitable in the game design process allow to maintain player engagement; such as challenges, rewards, competition and collaboration. This ensures that players achieve the intended learning outcomes while utilizing game mechanics to reinforce learning. Malone & Lepper (1987) mentioned that in a discussion of the theory of flow of state, involving intrinsic motivation that incorporating elements such as curiosity, challenge, and fantasy may enhance engagement in educational contexts. The importance of flow of state where players are fully immersed in the activity, will allow players to be in a state of high motivation and better retention in educational content. Csikszentmihalyi (1990) introduced the concept of flow, whereby players reached this state when the tasks are neither hard nor easy. Besides that, the feedback in serious game also needs to be clear, making the process of learning enjoyable. A study by Kiili (2005) suggested that serious game that is designed with flow principles show an increased in learner engagement and retention of educational material.

Furthermore, incorporating real-world contexts in game design, allow learners to more likely engage and retain the knowledge whereby connecting in-game scenarios to real-world applications fosters deep learning. Gee (2003) stated in his study that

learning through serious games is more effective when players see the relevance of the content to the real-world scenarios. This relevance enhances both engagement and the ability to transfer knowledge to real-life contexts. Besides that, serious games that simulate problems such as environmental or health issues, are encouraged in critical thinking and problem-solving skills. Other guidelines include the balance in fun and educational content. While serious games are played to meet certain objectives, designing it to make it fun and enjoyable are equally important for engagement. Overemphasizing the educational contents at the expense of fun may lead to disengagement, especially in younger audiences. A study by Annetta (2010) found that serious games that are overly focused on education can feel more like "work" than play, which reduce engagement.

In addition, providing constructive feedback and reflection in serious games in terms of immediate feedback allow players to understand their progress and adjust to the gameplay or targeted goal of the game. A study by Wouters et al. (2013) emphasizes that serious games that include both immediate feedback and reflection lead to a greater learning gain. Incorporation of multiple forms of input such as visual, auditory or kinetic can enhance learning especially for younger learners. Multisensory learning experiences make the learning process more engaging and can cater to different learning styles. Research by Mayer (2002) on multimedia learning highlights the importance of combining different sensory inputs to enhance understanding and retention. Clark & Mayer (2003) also stressed the effectiveness of serious games that include a variety of learning modalities, ensuring different preferences and strengths can be benefited. Therefore, it is crucial to comprehend the key guidelines and features that are advantageous to users, as this understanding could lead to enhanced comprehension of the serious game design, its objectives, and intended outcomes. Furthermore, adherence to the suggested guidelines proposed by previous researchers may result in improved outcomes when the game is designed and developed appropriately.

2.2.7 Challenges and Limitations of Serious Game in Health Education

Despite the numerous benefits and efficacy of serious games for users in general, it is also essential to comprehend the common challenges and limitations encountered in the utilization of serious games for health education. Firstly, there is a need to balance educational contents with entertainment. Overemphasis over educational contents can

creates less fun and engagement in the game. Also, it can detract from the original goal of the game (Susi et al., 2007). Similarly, if entertainment is overly emphasized rather than the focus of the contents, players may lose interest and disengage in the game (Wouters et al., 2013). Furthermore, assessing the effectiveness of serious games in delivering health education can be complex. Outcomes from gameplay may result in knowledge acquisition that is beneficial to the players. However, the extent of this benefit remains uncertain. Additionally, it is challenging to capture the depth of learning, including whether behaviour will be improved, which is critical to measure in the short term or quantitatively (Connolly et al., 2012). Moreover, designing serious games for health education presents significant challenges, particularly when the target audience encompasses a broad range of age groups with diverse needs, cognitive abilities, and motivations. DeSmet et al. (2014) posited that games for health should be adaptable to all demographic groups with their respective health literacy levels, which consequently increases the complexity of game design and delivery.

Additionally, serious games may also present challenges in sustaining long-term engagement and impact on behaviour change, despite initially creating engagement with the player. The impact may be short-term rather than long-term. Peng et al. (2012) noted that serious games can initially trigger interest, engagement, and create motivation. However, maintaining these effects over time, especially in promoting behaviour change, is often challenging. Next, Kato et al. (2008) reported in their study that the integration of serious games with healthcare providers often presents a challenge due to the scepticism among healthcare providers, who tend to prefer maintaining conventional methods rather than adopting technological integration. Furthermore, this scepticism may also be attributed to the scarcity of comprehensive studies on the effectiveness and integration of these two fields. Regarding cost and resource constraints, Graafland et al. (2012) asserted that developing high-quality serious games that are both educational and entertaining can be financially demanding, time-intensive, and require significant expertise, which presents a substantial barrier, particularly in public health settings.

Moreover, according to Serrano et al. (2016), the inequalities in population distribution confer disadvantages upon low-income groups or those in rural areas with respect to the benefits of utilizing technology platforms and communication. Consequently, these disparities impede the transfer of knowledge using serious games across various platforms for these demographic groups. In conclusion, various

challenges and limitations have been identified and discussed that could enable designers, developers, researchers, and educators to enhance the implementation of serious games, particularly in the field of health education to achieve improved outcomes for the users who engage with the game for its intended purposes.

2.2.8 MEEGA+ Model as an Instrument Tool for Evaluation of Serious Games

Evaluation tools are essential for assessing and measuring the effectiveness of games that have been designed and developed. In games that emphasize evaluating effectiveness and user satisfaction, several tools, such as MEEGA+ (Petri et al., 2018), the System Usability Scale (SUS) (Jordan et al., 1996), and the Game Experience Questionnaire (GES) (IJsselsteijn et al., 2013), support the measurement of game effectiveness. Despite the widespread use of these tools, each one evaluates and focuses more on specific aspects. For instance, the System Usability Scale (SUS) provides a general usability evaluation, while the Game Experience Questionnaire (GES) assesses player experience, including immersion, challenge, and enjoyment. However, to comprehensively assess the effectiveness of serious games, this research study found that MEEGA+ offers a comprehensive approach to determining game quality and effectiveness, making it suitable for evaluating usability, player experience, and perceived learning in games. Besides that, Daud et al. (2024) also noted that MEEGA+ is currently recognized as one of the most widely used evaluation models.

According to Petri et al. (2016), the MEEGA+ model is a method for evaluating both effectiveness and user satisfaction. Renowned for its practical application, this approach emphasizes efficiency and effectiveness, and it is used to assess the quality of games, particularly focusing on learner usability, the gameplay experience and perceived learning in educational games (Petri et al., 2016). The quantitative and qualitative data gathered through this model offer valuable insights into the success of teaching methods and the degree of learners' engagement, highlighting areas that may require enhancement.

Usability pertains to how effectively and efficiently students can utilize the game to meet learning objectives within any educational setting (Gresse Von Wangenheim et al., 2025; Petri et al., 2018). The MEEGA+ questionnaire identifies the dimensions of usability as aesthetics, learnability, operability, and accessibility. These usability elements significantly impact engagement and user satisfaction in general

technology implementation including digital games (Daud et al., 2024; Osman et al., 2024). Player Experience refers to the learner's profound engagement in the gaming activity, encompassing elements such as motivation, social aspects, and perceived learning (Petri et al., 2018). Within the player experience domain, elements like focused attention, enjoyment, challenge, social interaction, confidence, relevance, satisfaction, and perceived learning are included.

In the MEEGA+ model, Perceived Learning is a domain of the overall player experience, which examines the relationship between learning and experience (Gresse Von Wangenheim et al., 2025; Petri et al., 2018). Some implementations further divide perceived learning into short-term learning and the achievement of learning objectives (Tsiotras & Xinogalos, 2021). These aspects of perceived learning reflect learners' self-evaluated learning progress, supplementing objective assessments and aiding in determining whether enjoyable experiences are also educationally beneficial (Gresse Von Wangenheim et al., 2025; Petri et al., 2018; Tsiotras & Xinogalos, 2021). MEEGA+ also notes that the learning aspect is grounded in Bloom's taxonomy levels of knowledge, comprehension, and application, and it differentiates between short-term and long-term learning (Gresse Von Wangenheim et al., 2025). MEEGA+ includes questionnaires labelled "perceived learning outcomes" that inquire if the game assisted players in grasping key concepts, it reinforced their existing knowledge, and facilitated more efficient learning compared to other methods (Tsiotras & Xinogalos, 2021). Based on Gresse Von Wangenheim et al. (2020), awareness or perceived awareness represents one facet of the knowledge level. Therefore, in MEEGA+, perceived learning pertains to players' self-evaluation of their understanding and ability to apply the targeted content, rather than merely being exposed to it. While perceived awareness can support learning, the domain specifically focuses on achieving a broader comprehension, utility, and attainment of learning objectives. This study suggests that perceived learning can be seen as perceived awareness.

Initially, the MEEGA+ model concentrated on evaluating game quality, effectiveness, and user satisfaction within two primary domains: player experience and perceived learning (Petri et al., 2016). It has since been refined to extract the usability domain, which was previously included under the player experience domain, while still maintaining the player experience domain and incorporating perceived learning within it (Petri et al., 2018). Despite changes and improvements in the model's domains, all dimensions are considered related to the three main domains: usability, player

experience, and perceived learning. Although the recent MEEGA+ model focuses on two main domains: usability and player experience; the perceived learning domain remains important, especially when evaluating games with specific goals and purposes. Besides that, it still encompasses three domains mentioned above that assess and measure the effectiveness of a developed game. Numerous studies have implemented MEEGA+ in their game evaluations (Daud et al., 2024; Fernando et al., 2019; Galgouranas & Xinogalos, 2018; Moosa et al., 2020; Phutela et al., 2022), suggesting that this instrument is the most widely used evaluation method.

In conclusion, within the MEEGA+ model, Usability pertains to how effortlessly and efficiently learners can interact with the game, Player Experience encompasses their engagement, emotions, and motivation, and Perceived Learning indicates the extent to which they believe they have gained knowledge through the game. Collectively, these areas provide a structured approach to assessing both the enjoyment and educational effectiveness of a serious game in practice.

2.3 Behaviour Change and Health Theories and Models

In the realm of promoting behavioural change, various theories and models have been instrumental in guiding the development of serious games focused on health-related behaviour change. For instance, the commonly utilized theories and models in determining health-related behaviour changes such as Transtheoretical Model (TTM), Health Belief Model (HBM), Information-Motivation-Behavioural Skills (IMB) Model, and Knowledge-Attitude-Behaviour (KAB) Model were discussed. Besides that, supplementary theories such as Social Cognitive Theory (SCT), Self-Determination Theory (SDT), and the Theory of Planned Behaviour (TPB) are also well-established theories in explaining intended behaviour relations and are effective in predicting health-related behaviours.

2.3.1 Overview of the Theories and Models

Several models have been previously designed as guidelines for the purpose of health behaviour change; wherein intentional change was required by individuals for the behaviour change to occur. The related theories and models include are the Transtheoretical Model (TTM), Health Belief Model (HBM), Information-Motivation-

Behavioural Skills (IMB) Model, and Knowledge-Attitude-Behaviour (KAB) Model. These theories and models suggest various guidelines for the purpose of individual improvement in health-related change, which could cognitively or behaviourally impact individuals to have the intention to change for the better, whether for short-term or long-term health-reasoning purposes, ultimately leading to a healthy lifestyle as individuals. In addition, Social Cognitive Learning (SCT), Self-Determination Theory (SDT), and the Theory of Planned Behaviour (TPB) were integrated as supplementary theories to offer a more detailed understanding of health behaviour change within the context of developing a game framework. In the development of game design guidelines promoting obesity awareness, the intended behavioural change outcomes through gameplay can be effectively implemented by utilizing theories and models renowned for their role in promoting health-related behaviours.

For example, the Transtheoretical Model (TTM) is recognized for its role in promoting health behaviour modification. This model proposes that individuals progress through six stages of change: precontemplation, contemplation, preparation, action, maintenance (Prochaska & DiClemente, 1983), and termination (Prochaska & Velicer, 1997). The Health Belief Model (HBM) is another well-recognized framework for predicting health behaviours. This model suggests that individuals are more likely to adopt positive health practices when they perceive a health threat as serious and believe they are at risk. Additionally, they must see the benefits of preventive actions as outweighing the barriers to taking those actions (Carpenter, 2010). The Knowledge-Attitude-Behaviour (KAB) model is another widely recognized framework that influences human behaviour. This persuasion model emphasizes the role of knowledge as a crucial factor in intentional health-related actions (Bettinghaus, 1986). According to the KAB model, increased knowledge can trigger intentional attitude shifts, particularly in the health behaviour domain. These attitudinal changes accumulate over time, eventually leading to behavioural modifications. In addition, Information-Motivation-Behavioural Skills (IMB) model is another well-known framework for comprehending and encouraging positive changes in health behaviours. This model posits that the likelihood of adopting health-related behaviours is influenced by three key factors: information, motivation, and behavioural skills (W. A. Fisher et al., 2003). Overall, all these models are primarily designed to facilitate health behaviour change and achieve positive health outcomes. Although each model proposes distinct methods,

components, and guidelines, it all lead to the common objective of fostering positive health interventions.

In health and technology-related intervention implementing behaviour change and health models, there have been few studies that have effectively utilized these models to facilitate health behaviour change and promote health interventions. For example, studies indicate that interventions based on the TTM can effectively promote lifestyle modifications, such as enhancing physical activity and quitting smoking (Ferron & Massa, 2013). Besides that, researchers have also integrated the HBM with technology-focused models to explain health behaviours in digital environments. For instance, the HBM has been combined with the Technology Acceptance Model (TAM) to forecast health-related Internet usage (Ahadzadeh et al., 2015) and the intention to use smartphone apps for stress management (Paganin et al., 2023). These combined models emphasize how perceived usefulness, and attitudes mediate the use of health-related technology. In addition, Wu et al. (2020) suggested incorporating technological self-efficacy and cultural factors into the HBM to better comprehend how culture and technology influence health behaviours. The HBM has also been adapted to examine computer security behaviour, with perceived susceptibility, benefits, and self-efficacy identified as factors influencing email security practices (Ng et al., 2009).

Furthermore, KAB model has also been employed in numerous health and technology-related studies. In the realm of information security research, it has been utilized to examine awareness, with age and education level serving as moderating factors in the relationships between knowledge, attitude, and behaviour (Nguyen & Le, 2024). Additionally, the model has been adapted to explore the impact of knowledge on users' adoption of information security solutions (P. A. Wang, 2010). In the field of health technology acceptance, researchers have developed an extended TAM that incorporates elements from the KAB model to comprehend consumers' behavioural intentions towards health information technology (J. Kim & Park, 2012). Moreover, several studies have also demonstrated the effectiveness of the IMB model in promoting health behaviours. For instance, research on HIV prevention interventions based on the IMB model has shown positive outcomes in improving condom use and reducing sexual risk behaviours (Walsh et al., 2011). Furthermore, there is also research that aimed at promoting awareness in diabetes self-care has been found to be beneficial (Osborn & Egede, 2010). In addition, the model based on IMB has also been utilized to examine security practices among college students (Farooq et al., 2019). The model's constructs

of information, motivation, and behavioural skills have been found to be significant predictors of health behaviours, with behavioural skills often mediating the relationship between motivation and behaviour change (Kalichman et al., 2005; Walsh et al., 2011). These various studies showcase the behaviour change models' adaptability in explaining various health and technology-related behaviours when integrated with other theoretical frameworks and models. The following sections provide further discussion of the theories to behaviour change and health promotion.

2.3.2 The IMB Model: Structure and Application

The Information-Motivation-Behavioural Skills (IMB) model, developed by Fisher & Fisher (1992), is a widely used theoretical framework in health behaviour research. It posits that individuals must possess relevant information, be motivated to act, and have the necessary behavioural skills to perform and maintain health-promoting behaviours. Originally developed to explain HIV-related behaviour change, the IMB model has since been successfully applied to a variety of health and technology-related domains, including adopting online health information, eHealth program, and HIV prevention application (Aliabadi et al., 2015; Tang et al., 2024; Yang et al., 2019).

IMB model is known for its extensive framework in comprehending and encouraging positive changes in health behaviours. This model posits that the likelihood of adopting health-related behaviours is influenced by three key factors: information, motivation, and behavioural skills (see Figure 2.5). Information refers to knowledge about the health behaviour and its consequences, motivation encompasses personal attitudes and social support, and behavioural skills involve the abilities to perform the behaviour (W. A. Fisher et al., 2003). To integrate and align with game components and elements for a proposed game framework, the IMB model offers a clear, actionable structure for identifying what the game should teach (information), how it should engage and encourage players (motivation), and what behavioural competencies it should help them develop (behavioural skills) and finally what leads to perceived health outcomes gained from the information retrieved through game context.

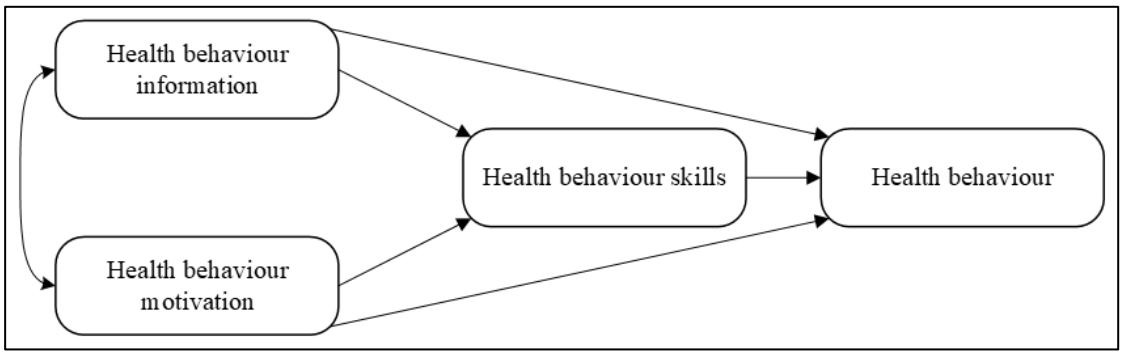


Figure 2.5 Information-Motivational-Behavioural Skills (IMB) Model (W. A. Fisher et al., 2003)

The IMB model has shown significant importance in various health behaviour interventions. Several studies have demonstrated the effectiveness of the IMB model in promoting health behaviours. For instance, research on HIV prevention interventions based on the IMB model has shown positive outcomes in improving condom use and reducing sexual risk behaviours (Walsh et al., 2011). Besides that, it is also beneficial in promoting awareness in diabetes self-care (Osborn & Egede, 2010). Furthermore, the model based on IMB has been utilized to examine security practices among college students (Farooq et al., 2019). Besides that, several other studies also includes adopting online health information, eHealth program, and HIV prevention application (Aliabadi et al., 2015; Tang et al., 2024; Yang et al., 2019). The model's constructs of information, motivation, and behavioural skills have been found to be significant predictors of health behaviours, with behavioural skills often mediating the relationship between motivation and behaviour change (Kalichman et al., 2005; Walsh et al., 2011). The IMB model suggests that information and motivation impact behaviour through behavioural skills and impact the intended outcomes. Across various studies, the IMB model has demonstrated consistency in forecasting and elucidating behaviours, with behavioural skills consistently serving as a mediator between information and motivation and the target behaviour. These outcomes highlight the model's adaptability and its potential to enhance health-related behaviours.

Interestingly, while the IMB model has been extensively used in health behaviours interventions, its role in technology advancement and serious game development remains largely unexplored. This indicates a gap in the research, suggesting that the model's framework could be adapted for designing educational games or health-related applications. Thus, while the IMB model has proven effective

in various health behaviour interventions, its direct application in serious game development is not evident. However, the model's core constructs, and intervention strategies could potentially be adapted to inform the design of educational games or health-related applications, leveraging technology to deliver information, enhance motivation, and improve behavioural skills in an interactive and engaging manner. Additionally, it is also worth noting that IMB model has been applied to diverse range of behaviour, suggesting its potential adaptability to various fields.

2.3.3 Relevance of IMB Model as the Foundation of the Proposed Serious Game Framework

Despite the models and theories discussed regarding their purpose and advantages in preventive behaviour and behaviour change, there remain limitations on the discussed models, particularly in proposing their use as guidelines for this research study. Compared to other well-established models such as the TTM, HBM, and KAB models, the IMB model offers a more streamlined and implementation-oriented structure by focusing on three core constructs: information, motivation, and behavioural skills. The IMB model integrates these constructs into a compact and action-driven framework that is easier to translate into game mechanics and player experiences. Its simplicity and clarity make it especially suitable for digital health education tools, where concepts must be delivered in engaging ways and expected perceived health and learning outcomes. Furthermore, the IMB model has been validated across various health domains; including security information awareness, eHealth, online health information awareness and HIV prevention (Aliabadi et al., 2015; Farooq et al., 2019; Tang et al., 2024; Yang et al., 2019). This demonstrates its flexibility and effectiveness in guiding behavioural interventions.

According to Fisher et al. (2003), individuals who possess knowledge and are well-informed are more likely to be motivated to act and feel competent in doing so effectively. Consequently, acquiring information through mediums such as game interventions, which incorporate appropriate structures, components, and game elements, can facilitate comprehensive learning through play and enhance informed decision-making. The IMB model includes motivation as a construct that can lead to intrinsic motivation among players, potentially resulting in increased perseverance and the ability to overcome obstacles, thereby enhancing the learning process (Daud et al.,

2024). Furthermore, motivation is a critical factor in the learning process (Maxim & Arnedo-Moreno, 2025). In the context of behavioural skills, behaviourism is a learning theory that focuses on shaping behaviour. It is utilized in the design of serious games by offering players immediate feedback and by rewarding or penalizing certain behaviours (Maxim & Arnedo-Moreno, 2025). The health outcomes in the IMB model suggest that perceived health outcomes, along with their purpose and perceived value, may influence players' attitudes, leading to a more positive attitudes towards the game if they perceive it as beneficial (Maxim & Arnedo-Moreno, 2025).

The integration of these theories and models as guidelines to develop a serious game that supports health change and obesity awareness requires comprehensive and suitable components and constructs in its framework for improved results and intended health outcomes. Other supplementary theories for health behavioural intervention are Social Cognitive Theory (SCT), Self-Determination Theory (SDT), and the Theory of Planned Behaviour (TPB). These are all well-established theories in explaining intended behaviour relations and are effective in predicting health-related behaviours. The application of these theories in behaviour changes and their integration into technological advancements have proven effective in altering individuals' behaviours.

Models of behaviour change are also predominantly recognized for their application in behaviour change initiatives. For instance, the Health Belief Model (HBM) elucidates behaviour by examining individuals' perceptions of their risk, the severity of the issue, the benefits, the barriers, and their confidence in taking action (Dsouza et al., 2021). It is frequently employed in health screenings and campaigns to alter perceptions of risks and benefits (Dsouza et al., 2021; Pan, 2024). However, the model predominantly emphasizes beliefs about risks, with limited focus on skill practice or social support. Brewer & Rimer (2008) highlighted that HBM lacks emphasis on behavioural skills, habits, social norms, or environmental factors that facilitate behaviour change. In designing serious games, it is highly effective to integrate established behaviour change methods with elements of enjoyment, autonomy, skill, and social connection to maintain engagement (Buil et al., 2019; Epstein et al., 2021; Hammady & Arnab, 2022). This integration allows the IMB model to encompass both personal and social motivational factors (Ehret et al., 2021), aligning well with common game motivators such as social interaction, competition, cooperation, and meaningful narratives.

In addition. the Knowledge-Attitude-Behaviour (KAB) model posits that knowledge influences attitudes, which subsequently lead to behavioural change. However, studies indicate that models focusing solely on motivation or information, like KAB, do not comprehensively explain behaviour. Models incorporating action and multiple steps are more effective (Dsouza et al., 2021). Furthermore, research on serious games demonstrates that information alone is insufficient. Behavioural change in games necessitates specific feedback, opportunities for practice, and designs that engage emotions (Epstein et al., 2021; Hammady & Arnab, 2022). The IMB model emphasizes action rather than mere cognition. Studies reveal that models incorporating action and skills are more effective than those focusing solely on motivation or cognition (Dsouza et al., 2021). The IMB model also considers behavioural skills as a bridge between information/motivation and action for complex behaviours (Ehret et al., 2021). This aligns more effectively with the interactive nature of games compared to models such as the HBM or KAB model.

Furthermore, the IMB model is both robust and adaptable, facilitating behavioural modifications in domains such as chronic disease management, HIV prevention, weight control during pregnancy, and environmental habit improvement. Programs incorporating skill-building components often demonstrate greater efficacy than those lacking such elements (Chang et al., 2014; Ehret et al., 2021; You et al., 2023). Specifically, in interventions targeting obesity and children, the IMB model's emphasis on knowledge and motivation effectively enhances dietary and exercise habits, with these changes last over time (Bartholmae, 2016). Furthermore, the IMB model supports a structured and theory-driven design approach (Ehret et al., 2021). It employs a methodology akin to advanced digital game design, wherein each game feature is systematically linked to specific behaviour change techniques. This is crucial, as many games are still developed based on intuition rather than explicit theories, complicating the identification of causal factors for change (Epstein et al., 2021; Saleme et al., 2021). Conversely, the Transtheoretical Model (TTM) is extensively utilized and conceptualizes change as a progression through stages with distinct processes (Prochaska & Velicer, 1997). It facilitates the customization of interventions by aligning content with an individual's readiness (Hammady & Arnab, 2022; Prochaska & Velicer, 1997). However, reviews indicate that stage-based interventions do not consistently outperform non-stage-based ones in effecting behaviour change or advancing stages

(Bridle et al., 2005). Additionally, TTM places limited emphasis on the social and environmental determinants of behaviour (Brewer & Rimer, 2008; Sharma, 2015).

In conclusion, the IMB model is considered particularly well-suited for the development of serious games, aligning effectively with the core components of game design and development. Serious games must integrate change mechanisms within their mechanics, dynamics, aesthetics, and emotional elements (Epstein et al., 2021). The IMB model comprises three primary components: the Information component that encompasses the game's content, such as narrative, feedback, and data visualizations. The Motivation and Behavioural Skills components that are intricately linked to the overall game design, establishing a coherent framework that connects each game element to behaviour change. Thus, for game design, the IMB model offers a clear, three-step framework for creating targeted interventions, making it an exemplary foundational model to follow.

2.4 Existing Frameworks and Models for Serious Game Development

Frameworks and models play a crucial role in game design and development, serving as guidelines that steer the process of creating serious games. In the realm of health-related behaviour change and cognitive gain, it is imperative to have comprehensive frameworks and models with well-integrated game components and elements. The following sections delve deeper into the existing frameworks and models of game design processes.

2.4.1 Overview of Existing Game Frameworks and Models

Principles encompass guidelines, heuristics, rules of thumb, and strategic constructs, as noted by Fu et al. (2016). Guidelines were typically referenced for frameworks and models to offer guidance to developers, researchers, and educators in the development of a game. In this study, a framework refers to a structure, overview, outline, system, or plan that includes various descriptive categories (Nilsen, 2015). To develop a serious game that enhances knowledge acquisition, cognitive skills, behaviour change, and promotes positive health outcomes, it is important to consider design principles that lead to a comprehensive and effective game design. Key principles for designing effective game design include fostering knowledge and

abilities, integrating personal growth experiences, and balancing fun with seriousness (Ma et al., 2020). A robust theory and models offer clear explanation of how and why certain relationships result in specific outcomes (Nilsen, 2015). Previous studies have examined and developed frameworks and models for the game design process, primarily focusing on game design learning. The following section provides a brief overview of select prior research.

2.4.1.1 Cognitive Behavioural Game Design (CBGD)

Starks (2014) proposed a model named Cognitive Behavioural Game Design (CBGD) Model. The model incorporates the theories of Social Cognitive Theory (SCT) and Multiple Intelligences (MIs) with game design principles. This model aims to create games that can change behaviour of the player in real world. CBGD model consists of three elements that guide the game design process namely (1) social cognitive elements, which include knowledge, goals, outcome expectations, encouragement, and barriers; (2) multiple intelligence elements, which include graphics, music/ sound, physical movement, humour, space/ positioning, narrative, logic/ patterns, nature, relationships/ role models, math/ numbers, words/ language, personal reflection; (3) enjoyment process that includes engagement, challenge, flow, persistence, and mastery which all interconnected to one another. Thus, CBGD model incorporate both behavioural and cognitive aspects in game design to promote behaviour change. In 2024, Starks employed the CBGD model to develop a tower defence game for promoting COVID-19 prevention measures called *Vaccine Nation* (Starks, 2024). The CBGD model has shown promise in developing games that provide an engaging and enjoyable experience for players, while also conveying public health messages effectively.

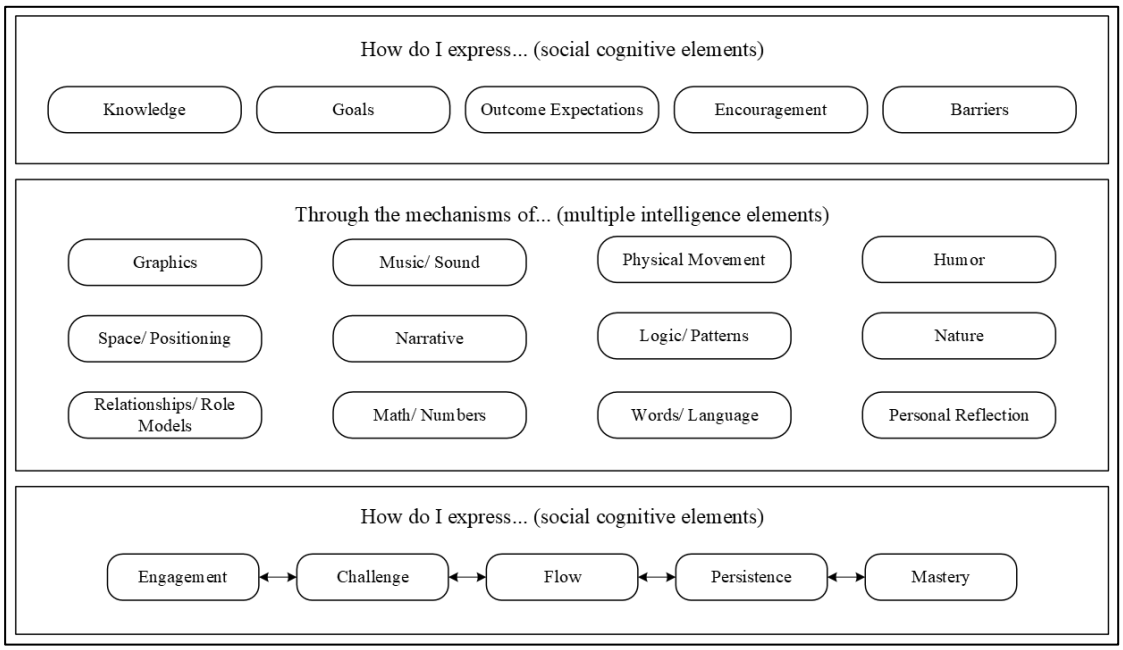


Figure 2.6 Cognitive Behavioural Game Design (CBGD) (Starks, 2014)

2.4.1.2 Serious Game Design Assessment (SGDA)

Mitgutsch and Alvarado developed a framework called Serious Game Design Assessment (SGDA) Framework. The SGDA framework provides an approach to assess serious games in terms of their design quality and effectiveness. This framework has been tested and applied to online games *Sweatshop* (2011) and *ICED* (2008). Besides that, SGDA framework focuses on quality of game content and intention-based design, ensuring that the serious game effectively achieves its intended purpose. The framework consists of a comprehensive structure which are divided into seven components: (1) Purpose, which includes aim and impact, (2) Content/ Information, (3) Framing, (4) Mechanic, (5) Fiction/ Narrative, (6) Aesthetics/ Graphics, and (7) Coherence and Cohesiveness of the game system (Mitgutsch & Alvarado, 2012).

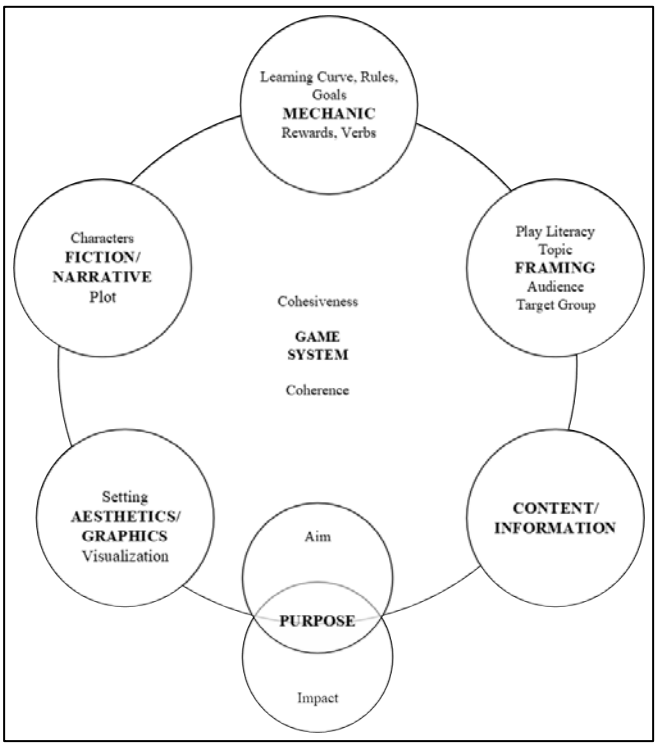


Figure 2.7 Serious Game Design Assessment (SGDA) (Mitgutsch & Alvarado, 2012)

The SGDA framework has been implemented in various fields, including research games in Human Computer Interaction (HCI) (Geerts et al., 2019), healthcare (Wolf & Lenz, 2014), and human rights education (Gabriel, 2018). It has demonstrated its usefulness in evaluating games' ability to meet their intended goals, such as increasing awareness about refugees or poverty (Gabriel, 2018). Moreover, when combined with other models like the Comparative Transformation Model, the SGDA framework can help determine the economic effectiveness of serious games compared to traditional learning methods (Wolf & Lenz, 2014).

2.4.1.3 Cognitive, Motivational, and Self-Regulatory Model

This is a model for the design of a serious video game that promotes self-management behaviours among youth with Type 1 diabetes. It is constructed on principles of behavioural science and underpinned by commercial game design strategies. Besides that, this model also uses Input-Process-Output (IPO) as guides to design the framework. The framework proposed by Thompson et al. (2010) consists of three major component that are (1) Video game, (2) Mediating variable; which involves behaviour specific (knowledge, skills and self-efficacy), self-regulatory (goal setting,

goal monitoring, and problem solving), and motivation (internal motivation), and (3) Outcomes; that is the behavioural change. The sequence of the framework that the video game developed will influence the mediating variables, whereas changes in mediating variable will influence behaviour and then influence health outcomes. The mediating variable component is based on existing theories which are social cognitive theory and self-determination theory. The approach holds potential for preventing diabetes and reducing obesity in young people, as indicated by Thompson et al. (2010).

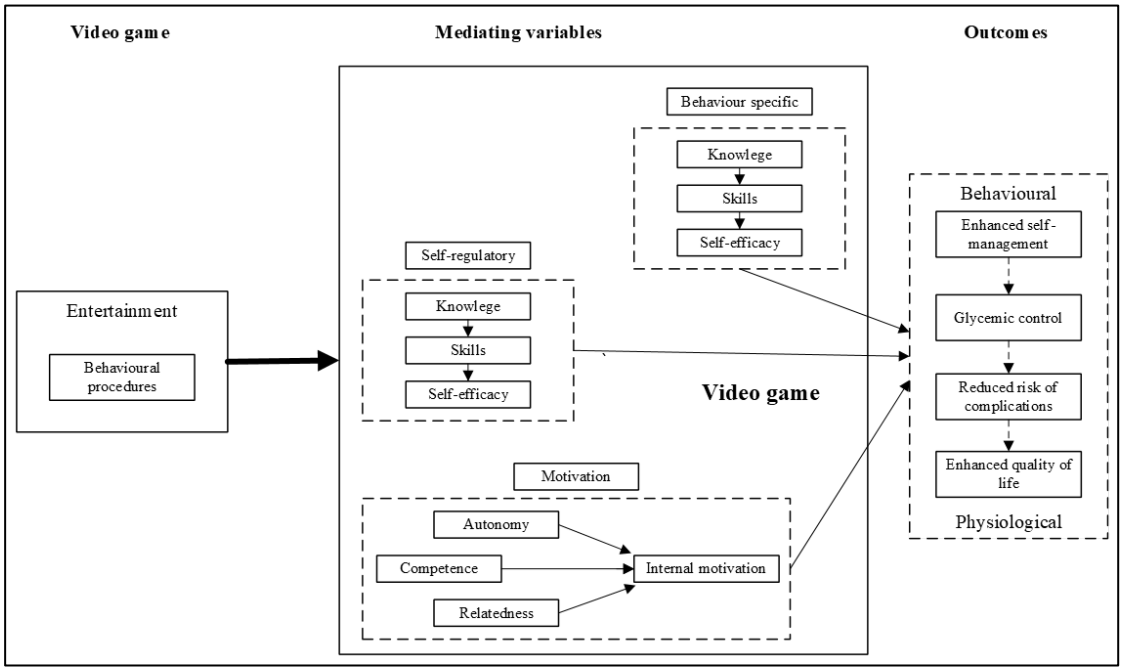


Figure 2.8 A Cognitive, Motivational, and Self-Regulatory Model for the Design of Video Fames Promoting Self-Management Behaviours to Adolescents with Type 1 Diabetes (Thompson, Baranowski, & Buday, 2010)

2.4.1.4 Educational Games Design Model

Educational Games Design Model was proposed by Ibrahim and Jaafar (2009) that aimed to provide framework in educational games design for higher education. The model consists of game design, pedagogy and learning content modelling with emphasis on usability, multimodality, fun, motivation, problem solving and syllabus matching. Initially, the framework was formed by analyzing and comparing the existing frameworks from few frameworks available to look into the point of view of game design and pedagogy such as Adaptive Digital Game-Based Learning Framework

(ADGBL) by Tan et al. (2007), Three Layered Thinking Model that focused on the design of web-based educational games by Fu and Yu (2008), Kiili's Experiential Gaming Model that aids game designers in comprehending the learning processes within games by incorporating educational elements into the game design process (Kiili, 2005), and Model for Educational Game Design by Song and Zhang (2008). The framework proposed by Ibrahim and Jaafar (2009) incorporates game design, pedagogy, and learning content modelling to create educational games for higher education.

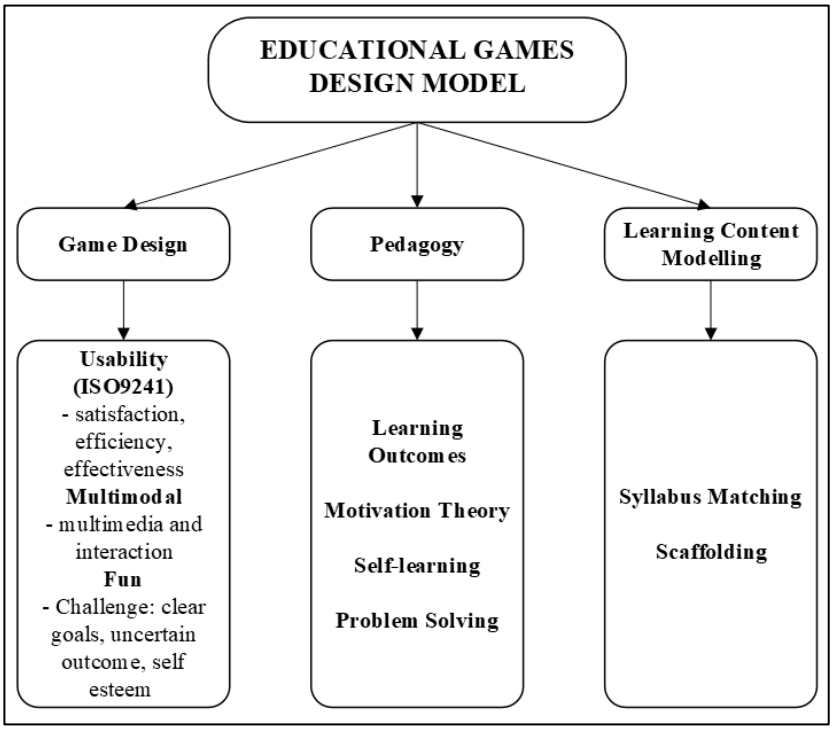


Figure 2.9 Educational Games Design Model (Ibrahim & Jaafar, 2009)

A design model for science and technology classrooms has been developed in the Malaysian context using framework by Ibrahim and Jaafar (2009), with a focus on balancing learning and play components. This model integrates the national curriculum, computer platforms, and teacher and student roles while considering multiple factors for effective educational game design (Rahmat et al., 2012).

2.4.1.5 Input-Process-Outcome Game Model

Garris et al. (2002) framework called Input-Process-Outcome Game Model proposes an input-process-output approach of instructional games and learning. The

three phases' components include Input component that consists of instructional content and game characteristics (fantasy, rules/goals, sensory stimuli, challenge, mystery, and control). The Process component focuses on the game cycle that is user judgements, system feedback, and user behaviour. The Outcome component includes learning outcomes which can be categorized as skill-based learning outcomes, and cognitive learning outcomes. Based on the authors, pairing instructional content with game characteristics in game design can enhance user engagement and accomplish intended learning goals. This framework provides valuable guidelines for game designers to effectively incorporate educational elements, understand the learning processes within games, and achieve the intended learning goals.

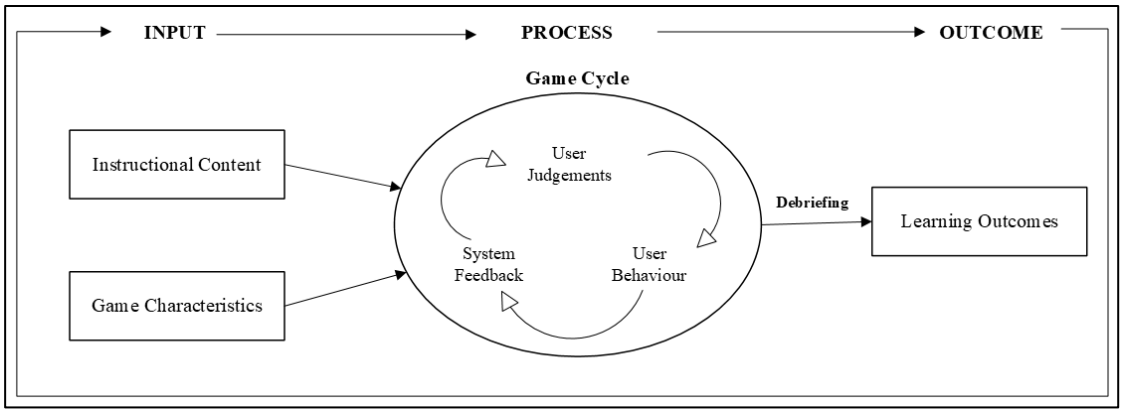


Figure 2.10 Input-Process-Outcome Game Model (Garris et al., 2002)

The model has been implemented and expanded in various situations. For instance, Ren et al. (2022) used it to build a framework for gamifying hazard identification training in construction, concentrating on instructional design, game features, and user characteristics. Additionally, Ghergulescu & Muntean (2014) extended the model to encompass motivation assessment, introducing the MotIPO model that integrates game-focused and player-focused motivation evaluations from the start of gameplay.

2.4.1.6 Conceptual Framework for Serious Games

Yusoff et al. (2009) proposes a Conceptual Framework for Serious Games. The framework is further improved from previous learning model proposed by Garris et al. (2002) and uses Technology Acceptance Model (TAM) for validation purposes. The

framework has been developed to contribute towards the design and achievement of the learning objectives in serious games. This framework consists of nine components that are (1) Capability, (2) Instructional content, (3) Intended learning outcomes, (4) Game attributes, (5) Learning activity, (6) Reflection, (7) Games genre, (8) Game mechanics, and (9) Game achievement. This approach helps to create serious games for efficient learning. The primary objective of this framework is to ensure that learning occurs during gameplay. By following to this framework, designers or developers can demonstrate that their game meets learner requirements and effectively assess learners' achievements through defined learning outcomes Yusoff et al. (2009).

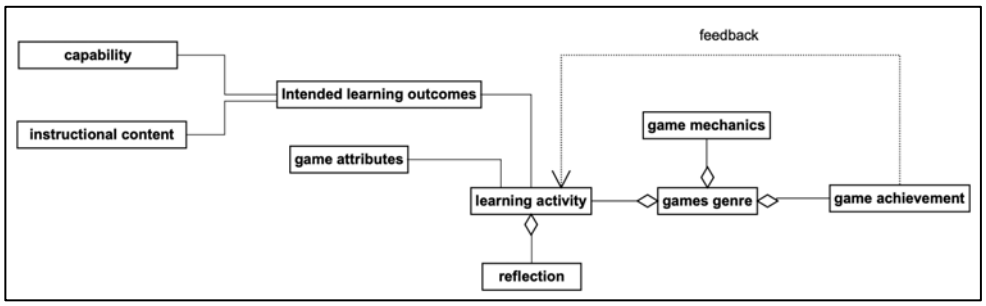


Figure 2.11 Conceptual Framework for Serious Games (Yusoff et al., 2009)

2.4.2 Comparative Analysis of Existing Game Frameworks and Models

Table 2.2 below presents a comparative overview of the strengths and weaknesses of the game development frameworks and models examined. A critical synthesis of these models reveals that although some models prioritize how players learn or modify their behaviour by incorporating complex theories like Social Cognitive Theory (SCT) and Multiple Intelligences (MI) (Starks, 2014; Thompson, Baranowski, & Buday, 2010; Yusoff et al., 2009), they are often criticized for being too abstract to offer specific mechanical guidance. Additionally, while other models focus on the coherence of the game system and the balance between "fun" and educational elements, ensuring the game remains internally consistent and engaging, they frequently lack specific health-behaviour constructs such as self-efficacy or outcome expectancies, which are essential for games aimed at addressing obesity (Ibrahim & Jaafar, 2009; Mitgutsch & Alvarado, 2012).

Table 2.2
Strength and Weaknesses of Existing Frameworks/ Models

Framework/Model	Main focus	Key strengths	Key weaknesses
Cognitive Behavioural Game Design (CBGD) (Starks, 2014)	Behaviour change and learning	-Integrates Social Cognitive Theory and Multiple Intelligences into a unified design blueprint -Aligns with evidence that SCT-based serious games can influence diet and activity related to obesity	-High theoretical load (SCT, MI) can be hard for non-experts to operationalize -Relatively few rigorous outcome evaluations compared to its citation impact
Serious Game Design Assessment (SGDA) (Mitgutsch & Alvarado, 2012)	Structural coherence of serious games	-Widely used meta-framework to analyze purpose-content-mechanics-fiction-aesthetics-framing alignment, helping designers ensure internal consistency and document design decisions	-Analytic more than prescriptive -Does not itself embed health-behaviour theory or specify which mechanics change which behaviours
Cognitive, motivational & self-regulatory model (Thompson, Baranowski, & Buday, 2010)	Link game play with motivation and self-regulated learning	-Highlights how game feedback, challenge, and goals can support self-regulation and learning, in line with later self-regulated-learning and ARCS-based game design work	-Conceptual, with limited concrete guidance on specific mechanics -Originally education-oriented rather than health-behaviour specific
Educational Games Design Model (Ibrahim & Jaafar, 2009)	Balancing education and fun	Addresses the classic t-ension between engagement and learning, similar to later children's educational-game frameworks that specify content, design requirements, and children's preferences	-Focused on general education -Gives little guidance on health behaviour constructs (e.g., self-efficacy, outcome expectancies) that obesity games must target
Input–Process–Outcome Game Model (Garris et al., 2002)	Describing how game features lead to learning	-Clear input-process-outcome loop (game characteristics → user judgments and reactions → learning/transfer), influential in later health-game design guidelines	-Descriptive rather than step-by-step design method -Underplays motivational/affective and contextual factors important in obesity
Conceptual Framework for Serious Games (Yusoff et al., 2009)	Mapping game components to learning outcomes	-One of the early attempts to align serious-game components with instructional outcomes -Anticipated later multi-phase design frameworks	-High-level -Limited detail on behaviour-change theory, affective engagement, or iterative evaluation -Rarely updated in recent health-game work

Furthermore, as indicated in the table above, most frameworks are primarily "education-oriented", meaning they lack the specific markers necessary for facilitating changes in health behaviour. For example, Garris et al. (2002) are criticized for downplaying the motivational and contextual elements crucial for raising obesity awareness. Some frameworks, particularly SGDA, excel at evaluating the coherence of

an existing game but fall short as prescriptive tools. While they can assess whether a game "makes sense", they do not clarify "which mechanics alter which behaviours", Additionally, many of these models present a significant barrier to entry. The CBGD's heavy theoretical content makes it challenging for a typical game development team to apply the guidelines without expert assistance (Starks, 2014). Furthermore, older models like Yusoff et al. (2009) lack detail on affective engagement, which is the emotional component that contemporary research indicates is essential for maintaining long-term behaviour change.

Consequently, while Ibrahim & Jaafar (2009) and Thompson et al. (2010) face criticism for their broad approach, the integrated behavioural theory, such as the IMB model, offers a detailed blueprint for health-related behaviours. Furthermore, the newly proposed framework incorporates integration that bridge theory and mechanics, addressing gaps in existing frameworks by focusing on motivational and emotional factors pertinent to children's nutritional literacy and physical activity. In general, current frameworks present a collection of fragmented tools, with some excelling in instruction, others in design, and some in behaviour change, yet none effectively combine all three within a health-specific context. This shortcoming underscores the need to develop a serious game framework that is more systematic, structured, integrated, and holistic in its design.

2.4.3 Justification for Extracting Components for the Proposed Game Framework

In conclusion, the frameworks proposed above (Garris et al., 2002; Ibrahim & Jaafar, 2009; Mitgutsch & Alvarado, 2012; Starks, 2014; Thompson, Baranowski, & Buday, 2010; Yusoff et al., 2009) provide valuable insights into the design and development of serious games for educational and behavioural purposes. Each framework offers a unique perspective and sets of components that contribute to the successful design of serious games, considering factors such as learning outcomes, motivation, behavioural skills, game mechanics, player experience, and instructional content. These frameworks serve as comprehensive guides for game designers and educators, emphasizing the importance of incorporating educational elements, game components, understanding the learning processes within games, and achieving the intended learning goals. By considering the various components and models outlined in

these frameworks, developers can create engaging and effective serious games that promote learning and behaviour change among players.

Existing game design frameworks and models offer a wealth of well-established components that support effective learning, engagement, and interactivity in serious games. Frameworks such as Input-Process-Outcome Game Model, Educational Games Design Model, and Serious Game Design Assessment (Garris et al., 2002; Ibrahim & Jaafar, 2009; Mitgutsch & Alvarado, 2012) have been applied successfully in diverse educational and health-related contexts, demonstrating the value of structured design principles in guiding game development. However, while these frameworks contribute important insights, many exhibit limitations when applied to complex behaviour change goals such as promoting obesity awareness among children. Existing frameworks often emphasize gameplay mechanics, engagement, and usability, but give insufficient attention to the integration of behavioural theory, health knowledge structuring, or motivational drivers rooted in psychological models. For instance, frameworks like Garris et al. (2002) prioritize user interface and feedback loops but lack structured guidance on how to embed health behaviour constructs such as self-efficacy, motivation, or skill acquisition.

In addition, although Thompson et al. (2010) incorporated diabetes prevention through the implementation of serious games in their framework, no single model fully addresses the unique requirements of designing a serious game focused on promoting obesity awareness and behaviour change among children. As such, this study adopts a selective approach by extracting relevant components such as learning content and information, motivational elements, behaviour skills, and intended outcomes to aligned with the Information-Motivation-Behavioural Skills (IMB) model as the backbone of the proposed game framework, as well as game elements, narrative structures, purpose and aesthetics elements from existing frameworks. These components are then synthesized, mapped, and integrated with the IMB model to construct a new, context-specific game framework.

In conclusion, while the existing frameworks discussed offer valuable starting points for the design of serious educational and behavioural purposes game, it is essential to approach them critically and supplement them with a broader range of considerations to address the complex and diverse landscape of educational game design. Thus, creating serious games that are both engaging and effective remain challenging, necessitating the establishment of best practices and quantifiable measures

of success in game-based learning (Smith & Bowers, 2015). This approach leverages on the strengths of existing models, which are frequently employed in both the game design process and in achieving learning and intended outcomes. Consequently, it underscores the gap and the necessity for a more comprehensive, theory-driven framework that effectively connects serious game design with health objectives.

2.5 Game Design Elements

Design principles are crucial in game design and development as they serve as guidelines for researchers, educators, and game developers to create comprehensive and well-executed interventions that can achieve the intended outcomes. In the context of health-related behaviour change, it is essential to specify the initial objectives of the intervention and adhere to guidelines incorporating relevant theories and taxonomies. Furthermore, game taxonomies, which encompass game elements, are necessary in game design and development to facilitate a seamless gameplay experience while engaging players and fostering motivation to progress. The following sections further elaborate on the game taxonomies applicable to this research study and the relevance of these game taxonomies to serious games.

2.5.1 Game Taxonomies

In designing and developing a serious game, the inclusion of game elements based on game taxonomies is essential for a successful game deployment. Game elements were present in many of the games. They are associated with games and play a crucial role in gameplay (Deterding et al., 2011). According to Ferro (2021), game elements are referred to as components or parts. Game elements can significantly influence people's perceptions of cognitive activity in the game, including affective experience, motivational conflict, and subjective effort. People can be motivated to stay engaged in cognitive pursuits by integrating game elements, which can assist them in attaining greater rewards in the future (Bernecker & Ninaus, 2021).

Game taxonomies provide structured systems for classifying the components of games, allowing designers and researchers to better understand how individual features contribute to the overall player experience. These taxonomies typically group game characteristics into hierarchical categories based on their level of abstraction or

function. By organizing game elements in this way, taxonomies offer a useful lens through which designers can systematically select and combine features to achieve specific goals. In serious games, especially those aimed at health behaviour change, using a taxonomy-based approach ensures that design decisions are purposeful and aligned with motivational and intended outcomes. In this study, the proposed game framework draws from established taxonomies to identify and justify a set of core game elements that support obesity awareness among children.

2.5.1.1 Game Taxonomy by Hunicke et al. (2004)

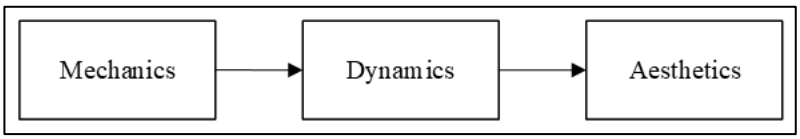


Figure 2.12 MDA Framework by Hunicke et al. (2004)

The Mechanics-Dynamics-Aesthetics (MDA) framework is a structured method for analysing and designing games, which integrates game development, criticism, and research (Hunicke et al., 2004). This framework divides games into three components: mechanics (the actions available), dynamics (the interactions between actions), and aesthetics (the emotional responses evoked in players) (Buttfield-Addison et al., 2016). Additionally, the framework has inspired other classifications, such as the quadripartite taxonomy for collaborative interaction in co-located gameplay, which expands on MDA and Activity Theory to provide analytical dimensions of what, who, when, and how (Baykal et al., 2023). These advancements aim to improve understanding of game design and support systematic approaches in the growing digital games sector.

2.5.1.2 Game Taxonomy by King et al. (2010)

The paper "A New Psychological Taxonomy" written by King et al. (2010) delves into the structural characteristics of video games and their psychological implications. These authors present a classification system that categorizes games based on their design elements and the psychological experiences they elicit in players. This taxonomy is intended to improve comprehension of how various game structures can influence player behaviour and engagement, potentially resulting in both positive and

negative outcomes in gaming experiences (King et al., 2010). Investigations suggest that the structural aspects of video games, such as interactivity, narrative complexity, and reward systems, significantly impact player motivation and emotional responses (Griffiths & Nuyens, 2017; Rehbein et al., 2021). For example, games that offer high interactivity and immersive narratives tend to foster deeper emotional connections, which can enhance enjoyment but may also lead to problematic gaming behaviours (Saini & Hodgins, 2023). The taxonomy proposed by King et al. serves as a foundation for future research to explore these dynamics further, addressing the need for a nuanced understanding of video game design and its psychological consequences (King et al., 2010).

2.5.1.3 Game Taxonomy by Deterding et al. (2011)

Deterding et al. (2011) presented a comprehensive game taxonomy that categorizes games based on their mechanics, dynamics, and aesthetics, which are essential for understanding how games engage players. This framework emphasizes the interplay between game elements and player experiences, highlighting how different genres can evoke varied emotional responses and motivations. The taxonomy serves as a tool for designers to create more engaging and meaningful game experiences by aligning game mechanics with desired player outcomes. However, some studies suggest that the effectiveness of game mechanics may vary significantly across different demographics and contexts, indicating a need for further exploration into how these elements interact with user characteristics (Butt et al., 2023; Higgs & Flowerday, 2024). Overall, Deterding et al.'s framework provides a foundational understanding of game design that can be adapted to diverse applications, though its implementation requires careful consideration of the target audience (Higgs & Flowerday, 2024; Kleinman et al., 2021).

Table 2.3
Levels of Game Taxonomy by Deterding et al. (2011)

Level	Description
Game interface design patterns	Common, successful interaction design components and design solutions for a known problem in a context, including prototypical implementation
Game design patterns and mechanics	Commonly reoccurring parts of the design of a game that concern gameplay
Game design	Evaluative guidelines to approach a design problem or analyze a given

principles and heuristics	design problem or analyze a given design solution
Game models	Conceptual models of the game components of games or game experience
Game design models	Game design-specific practices and processes

2.5.1.4 Game Taxonomy by Werbach and Hunter (2012)

Werbach & Hunter (2012) game taxonomy is a framework for categorizing games based on their mechanics, dynamics, and aesthetics, which provides a means of understanding how games can be designed and applied in various contexts. The taxonomy emphasizes the significance of game mechanics in shaping player experiences and engagement, and it can be applied to both traditional gaming and gamification in non-gaming contexts. Parreiras et al. (2023) highlight that the taxonomy assists in identifying the specific elements that contribute to the effectiveness of games in educational settings, suggesting that different game types can foster various learning outcomes The application of this taxonomy in developing serious games, where comprehending the interplay of game elements is essential for achieving educational objectives. However, Möller et al. (2013) note that while the taxonomy is extensive, it may not fully account for the subjective nature of player experiences, which can vary widely. In summary, Werbach and Hunter's taxonomy serves as a valuable tool for both game designers and educators, facilitating the strategic application of game elements to enhance engagement and learning (A. Toda et al., 2019).

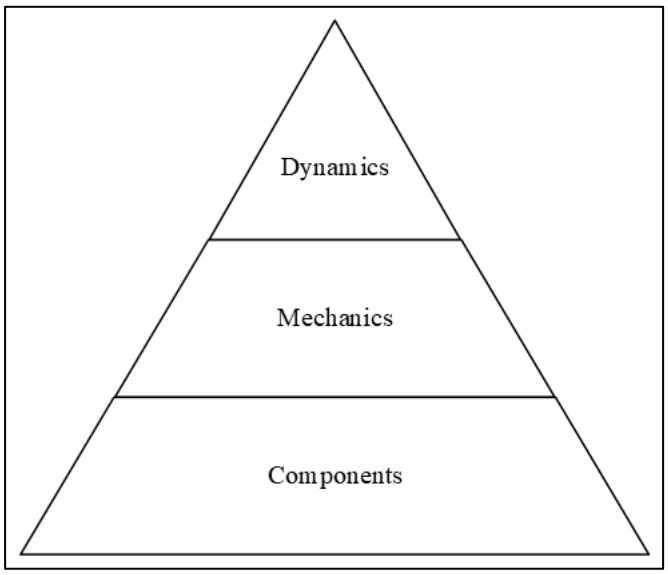


Figure 2.13 Game Taxonomy by Werbach and Hunter (2012)

2.5.2 Justification for Selecting Werbach and Hunter's Taxonomy

In conclusion, Hunicke et al. (2004) proposed a taxonomy based on the Mechanics-Dynamics-Aesthetics (MDA) model. The MDA model is a framework commonly used in game design that is derived from various components of a game. In addition, King et al. (2010) developed a comprehensive taxonomy of structural characteristics in video games. The taxonomy comprises five overarching structural features: social features, manipulation and control features, narrative and identity features, reward and punishment features, and presentation features. These five features are then divided into 24 different sub-features. The authors claimed that this taxonomy has the potential to influence video game playing behaviour. Furthermore, Deterding et al. (2011) proposed a framework that emphasizes the integration of game elements to enhance user engagement, motivation, and overall experience. This framework focuses on the concept of gamification and its application in non-game contexts. It is applicable to systems or tools that implement gamification strategies, rather than being solely intended for use in gaming applications. Next, Werbach & Hunter (2012) presented a framework for creating effective gamification strategies that consists of three categories: components, mechanics, and dynamics. Each category has its own unique elements and meanings. For example, components include tangible elements such as points, rewards, and levels, while mechanics encompass elements that integrate with the gameplay experience, such as rules, win states, and challenges. The dynamics result

from the integration of tangible elements in the game components and game mechanics from the gameplay experience, leading to emergent behaviours and experiences. Although each taxonomy had its own unique elements and functions, all the taxonomies proved to be equally effective in implementing gamification strategies for the development of serious game interventions.

There are also limitations in these game taxonomies, as Schöbel et al. (2020) criticize gamification taxonomies like those of Hunicke et al. (2004) and Werbach & Hunter (2012) for their inconsistent element definitions and encapsulation. These schemes are neither sufficiently comprehensive nor extendible for design and analysis. However, Werbach and Hunter's taxonomy is still considered more practically useful for design due to its comprehensiveness and clarity. In terms of complexity, some frameworks, particularly the King et al. (2010) taxonomy, may be too detailed for practical implementation in simple game designs. Additionally, there is a challenge in translating the taxonomy framework into practical game design. Furthermore, the effectiveness of game elements varies significantly across different contexts and user groups, highlighting context dependency. Based on the game taxonomies discussed above, each provides game elements and components suitable for implementation in game design and development. However, implementing these with the aim of creating health awareness, including the intended behaviour change purpose in the design and development of serious games, could present a challenge.

Werbach and Hunter's game taxonomy is specifically oriented towards gamification. Unlike general game genres or other taxonomies that emphasize domain, platform, or narrative rather than reusable elements (Cormio et al., 2025; De Lope & Medina-Medina, 2017; Klabbers, 2003), this taxonomy presents a clear hierarchy that aligns well with frameworks where the categories; namely components, mechanics, and dynamics would correspond to how subsequent taxonomies structure elements (A. Toda et al., 2019; A. M. Toda et al., 2019). Furthermore, it is widely utilized as a foundational reference in education and information systems, where later taxonomies are explicitly built upon or compared to Werbach and Hunter's work, as it serves as a recognizable "starting list" (Khaldi et al., 2023; A. Toda et al., 2019; A. M. Toda et al., 2019). Moreover, this taxonomy strikes a balance between breadth and simplicity, being more concrete than Deterding's conceptual work, yet less extensive than complex taxonomies that may be challenging to operationalize (A. M. Toda et al., 2019). Overall, Hunicke et al. (2004), Deterding et al. (2011), and King et al. (2010) offer greater conceptual

clarity and domain-specific insights into the taxonomy. In contrast, Werbach & Hunter (2012) provides a practical, hierarchical, and widely recognized catalogue of game elements, rendering it well-suited as an organizing guideline for categorizing elements in a new gamified framework. Therefore, incorporating various game elements within the hierarchical layers of Werbach and Hunter's taxonomy is considered essential for serious games aimed at preventing obesity. Consequently, while these taxonomies provide valuable frameworks for game design and analysis, their practical application requires careful consideration of context, audience, and implementation challenges.

2.6 Health and Obesity Awareness Among Children

This section provides an overview of the global and local prevalence of childhood obesity, encompassing its definitions, causes, and associated risk factors. Additionally, it evaluates current approaches to addressing obesity, with a particular focus on educational programs and interventions aimed at children.

2.6.1 Global and Local Prevalence of Childhood Obesity

Based on Salam et al. (2023), the issue of obesity has become a global public health issue, and the occurrence has been doubling since 1980. Besides that, according to the National Health Screening Initiative (NHSI) 2023, more than half of the population in Malaysia, or 53.5% to be precise, of those screened are overweight and obese, compared to 50.9% in 2019 (CodeBlue, 2023). This shows an increasing number of people being overweight and obese. Prevention strategies are crucial and a comprehensive approach is required to combat this global health issue (Affenito et al., 2012). Hassan et al. (2018) studied the comparison of the people being overweight and obese in Malaysia with other Southeast Asian countries and found that Malaysia rank high among others with an increasing trend. A study of seven ASEAN countries found that overall prevalence of overweight or obesity in these ASEAN countries is of 9.9% among adolescents aged 13-15, with Malaysia rank second-highest rate at 23.7% (Pengpid & Peltzer, 2016). Moreover, another study mentioned that obesity rates in Malaysia increased from 7.9% in the 16-20 age group to 20.9% in the 31-35 age group (Pell et al., 2016). The rising obesity rates in Malaysia indicate an increasing problem

that requires attention. The rapid growth of obesity in the country could potentially hinder Malaysia's ability to compete globally (Hassan et al., 2018).

World Health Organization (WHO) mentioned that being overweight and obese are avoidable (World Health Organization, 2024). However, personal effort to reduce weight were taken lightly because most people perceived overweight and obese as non-communicable diseases. Hassan et al. (2018) noted that the fundamental pillars for reducing body weight are personal initiatives, specifically through controlling excessive food intake and maintaining a routine of physical activities. Therefore, disseminating knowledge about the importance of these two practices is crucial through health education. A study by Ellsworth et al. (2015) indicated that educating children about nutrition can encourage them to adopt healthier habits. However, Taylor et al. (2015) observed that the positive effects of such interventions are typically effective only in the short term. Thus, it would be beneficial if these efforts could foster a long-term healthy lifestyle (Hassan et al., 2018). In Malaysia, many students or children tend to take health education classes lightly because the subject is not considered a core subject and is not required for national examinations (Hassan et al., 2018). Therefore, it is essential to enhance and invest more effort in health education to engage and attract children, enabling them to gain health awareness while enjoying the learning process.

The significant prevalence of overweight and obesity across various age groups, including adolescents, adults, and children, highlights a growing concern about understanding and awareness of obesity in Malaysia. In a study on the mismatch between actual and perceived body weight among adolescents in Malaysia, Zainuddin et al. (2014) emphasizes that there is a significant number of individuals incorrectly assess their weight status. This misperception could have implications for how weight control and management are approached. The research by Muhammad et al. (2021) emphasizes the scarcity of research on interventions promoting healthy eating habits that are culturally and psychologically suitable for Malaysian adolescents. Additionally, Reeves et al. (2018) conducted a study that modified a European intervention for Malaysian preschools, called ToyBox Study Malaysia, which sought to encourage healthy behaviours and prevent excessive weight gain in young children. Besides that, Rune et al. (2015) studied the effectiveness of educational interventions in increasing parental knowledge on childhood obesity, however the change of perception of the parents on their children's weight status are not significant. In conclusion, multifaceted issue on the rates of obesity in Malaysia across different age groups especially in

children, the challenges and gap in the understanding and awareness of the obesity problem through appropriate interventions suggest a need for an increased awareness and education to combat this obesity and health challenge.

Besides that, the prevalence of childhood obesity has been increasing globally which is a concern matter worldwide (Howe et al., 2015). Furthermore, childhood obesity is also increasing rapidly, with the estimation of about 60 million children will be obese globally (Affenito et al., 2012). Besides that, Salam et al. (2023) mentioned that the increasing prevalence of overweight and obese children, and adolescents over time presents a significant risk to both the current and future health of the population. Affenito et al. (2012) said earlier research has indicated that obesity in children tends to persist into adulthood, raising significant concerns. Thus, it is a crucial public health challenge, whereby children with obesity which has excessive body fat can pose risks to their health and well-being (Vajid & Bashir, 2024).

According to the Convention on the Rights of the Child (CRC), a child means any individual under eighteen years of age, except in cases where applicable laws recognize an earlier age of majority for the child (Convention on the Rights of the Child, 1989). Besides that, in terms of psychological or developmental perspective, those who are under 18 years are still considered to be in childhood or adolescence, whereas in medical research and consent viewpoint, individuals who are under the age of 18 years requires parental consent since they are considered minors or children. In addition World Health Organization (2020) set out recommended interventions to promote health and wellbeing of children and adolescents which they considered as those aged below 19 years old.

In childhood obesity, it poses psychological impacts with long-term risks and lasting effects on the individual's life such as reduced self-esteem and social discrimination (Mohamed et al., 2022; Must & Strauss, 1999), which means that childhood obesity can pose various health risks and issues with short-term or long-term health implications. This includes the association with various health risk problems such as non-communicable diseases, psychological issues, and the heightened risk of being obese that continues into adulthood (Mohamed et al., 2022; Must & Strauss, 1999). Therefore, to address childhood obesity requires a comprehensive approach and various bodies responsible that includes healthy eating promotion, performing physical activity, as well as tackling socioeconomic inequalities (Vajid & Bashir, 2024). In addition, there should also be an emphasis on targeting individuals early in life to reduce the risk of

obesity-related health issues in adulthood (Shrestha & Copenhaver, 2015), as it gives the substantial public health implications and potential negative impacts on health, economic, and social aspects (Al-Awamreh et al., 2019).

2.6.2 Causes and Risk Factors of Obesity in Children

Overweight and obesity are defined as being abnormal and an accumulation of excess fat of one's body that may result in health deterioration. As shown in the table 2.1 below, the status of one's weight is being defines through the measurement of body mass index (BMI) whereby BMI greater than or equal to 25 is considered overweight whereas BMI greater than or equal to 30 is categorized as obese (World Health Organization, 2024). As for children above the age of 5 years and below the of 19 years, the BMI measurement is different from the adults when defining underweight, normal weight, overweight or obese because it is interpreted using age and gender specific percentile charts since children's body composition varies with age among boys and girls. Overall, a child is considered underweight if her BMI-for age percentile ranges less than the 5th percentile. It is considered normal weight if it is 5th to less than the 85th percentile, overweight if 85th to less than the 97th percentile, and obese if it is equal to or greater than the 97th percentile (World Health Organization, 2024).

Table 2.4
General Body Mass Index (BMI) Classification (World Health Organization, 2024)

Body weight classification	**BMI (kg/ m^2)**
Underweight	< 18.5
Normal	18.5 – 24.9
Overweight	25 – 29.9
Obese	>= 30

The number of people with obesity has been increasing over the years in Malaysia. Factors that implied to the high number of people being obese are generally because of their high intake of energy-dense foods which contained high fat and lack of physical activity due to their sedentary lifestyle (World Health Organization, 2024). These inactivity and uncontrolled food consumption bring negative consequences and risks to the individuals. Besides that, obesity can pose a major risk in getting non-communicable diseases such as cardiovascular diseases, diabetes, musculoskeletal disorders and cancers (World Health Organization, 2024). In addition, it can also lead

to psychosocial burdens and an increased risk of mortality (World Health Organization, 2024). Thus, the increased number in BMI among the public can affect their body weight and lead to health problems. Even for children of normal health status, obesity may develop in later life if they do not adopt a nutritious diet and engage in regular physical activity.

2.6.3 Current Approaches to Health and Obesity Awareness

In Malaysia, there are many programmes and campaigns held by the government, private sectors and non-governmental organization (NGOs) such as Juara Sihat programme, Malaysian Childhood Obesity Treatment (MASCOT), Nutrition Month, World Obesity Day and Malaysian Association for the Study of Obesity (MASO) 10k Steps Challenge as stated by the experts during preliminary interview of this research study (further discussed in Chapter 3). Furthermore, in order to combat obesity, various methods and initiatives have been conducted, which include lifestyle modification programmes and public health campaigns (Verma et al., 2013). Malaysian Clinical Practice Guideline (CPG) suggested that the initial approach to combat obesity is lifestyle modification (Verma et al., 2013). Initiatives that have been taken by Malaysia also includes 'My Weight My Health' programme that was initiated by the Malaysian Pharmaceutical Society to combat weight issues among Malaysians by having a call centre with the participation of pharmacists, nutritionists and dieticians, to provide counselling and information on health issue (Verma et al., 2013).

Additionally, Malaysian government commenced '10,000 steps a day' campaign to improve healthy lifestyle of the Malaysians by performing movements everyday such as walking, jogging, or running. There is also programme proposed by Malaysian Health Promotion Board called 'MySihat' whereby one of the objectives of the programme is to improve healthy eating habits among the Malaysians (Verma et al., 2013). Besides that, Ministry of Health Malaysia had invented a programme named Malaysian Healthy Plate which focused on the theme "Quarter-Quarter Half" since year 2017 (Che Abdul Rahim et al., 2022). However, implementation of various programmes and campaigns in Malaysia does not stopped Malaysia from being rank top for most people being obese in Southeast Asia region with half of the population are overweight and obese, based on National Health Screening Initiative (NHSI) 2023 (CodeBlue,

2023). This concurred that, the implementation of those programmes is not being well conducted which led to public's lack of awareness on the issue of obesity.

2.7 Synthesis of Literature and Gap Analysis

This chapter's literature review presents a multifaceted view of the role of serious games in health education, the frameworks guiding game design development, and the evaluation of games created using the pre-established framework. The review highlights a clear connection between the escalating global obesity crisis and the potential of serious games as tools for behavioural transformation. Researchers commonly agree that mere information is inadequate for behaviour change (Hammady & Arnab, 2022), but the engaging nature of digital games can enhance health awareness.

However, a critical analysis of existing frameworks and models reveals a fragmentation between game design and behavioural psychology (Asadzadeh et al., 2024; Aster et al., 2024; Brynen, 2022; Maxim & Arnedo-Moreno, 2025). Although many games employ diverse technology platforms and genres, they often lack a solid theoretical base (Aster et al., 2024; Maxim & Arnedo-Moreno, 2025). Additionally, there is a notable gap in articulating these behavioural design elements (Brynen, 2022), which are essential as guidelines. This study addresses this issue by incorporating the Information-Motivation-Behavioural Skills (IMB) model into the game development process. Among various health behaviour change models and frameworks, the IMB model was selected as the foundation of the proposed framework, as it outlines a three-step intervention design process that provides a practical blueprint for tailored interventions, making it well-suited as the primary guiding model in this study. Furthermore, by integrating components from existing game design frameworks and models and synthesizing Werbach and Hunter's Game Taxonomy (Werbach & Hunter, 2012) with the structural components of the IMB model, this research proposes a more comprehensive framework.

Ultimately, the literature emphasizes the need for rigorous measurement of such games' effectiveness. Therefore, by employing the MEEGA+ model (Petri et al., 2018), this study ensures that the proposed framework not only emphasizes "fun" but also meets the educational requirements necessary to address obesity-related risk factors. The evaluation of the game prototype considers three quality factors to assess its effectiveness based on the serious game framework. These quality factors include

usability, player experience, and perceived learning. All three domains are interconnected with the proposed serious game framework, leading to the development of a prototype that is evaluated. This synthesis supports the creation of a new, theoretically grounded serious game framework specifically designed for promoting health and obesity awareness among children.

2.8 Summary

In summary, the literature review presented above offers a comprehensive overview of the topics related to the main aim of this study. The review covered topics of health education which is crucial to children as health awareness is important to deliver during their early stage of life and to make sure that the children able to make a change in health-related behaviour change and knowledge gain. Behaviour change theories were examined, to gain a deeper understanding of the steps involved in perceived behaviour change, highlighting the importance of using the IMB model as the foundation for the proposed game framework. Additionally, existing game design processes were analyzed to justify the extraction of components for the new framework. Furthermore, identifying and addressing the research gap is crucial. Game design elements which encompassed from game taxonomies were discussed to select suitable game taxonomy to be included in the proposed game frameworks. Furthermore, the review provided an overview of health and obesity awareness among children to understand the importance of prevention under the context of information dissemination. Additionally, the literature review discussed serious games for health education, focusing on applications designed for health education and promotion, understanding the guidelines and features used in serious game for health education, addressing the challenges and limitations of using serious games for health education as well as the evaluation tools utilized for serious games. The integration of health and obesity awareness with serious game implementation help to gain a deeper comprehension of the issue of obesity, enabling learning through play and knowledge acquisition, as well as perceived behaviour change. Overall, the review provides a strong rationale for integrating serious game approaches into obesity awareness and prevention initiatives. Therefore, the literature indicates that well-designed serious games, when developed based on a proper and comprehensive game framework, can

serve as a valuable tool for promoting healthy lifestyles and preventing obesity in children.

CHAPTER 3
METHODOLOGY

3.1 Introduction

This chapter describes the research methodology that was used in this study. This section describes the overall approach and design of the study, as well as the various methods and procedures that were employed to collect and analyse data. The research methodology chapter provides a clear understanding of the process that was employed to conduct the study and ensures the reliability and validity of the findings. The processes are described to meet the objectives of the research outlined in Chapter 1. This chapter will elaborate overall research processes method employed in meeting the research objectives.

3.2 Methodology Phases

In this study, we followed a design science research approach that involved three distinct phases: problem identification, solution design, and evaluation (Offermann et al., 2009). Figure 3.1 below shows the research flowchart of this study. According to Denzin & Lincoln (2018), a research methodology or strategy is determined by the nature of the research problem and the research questions.

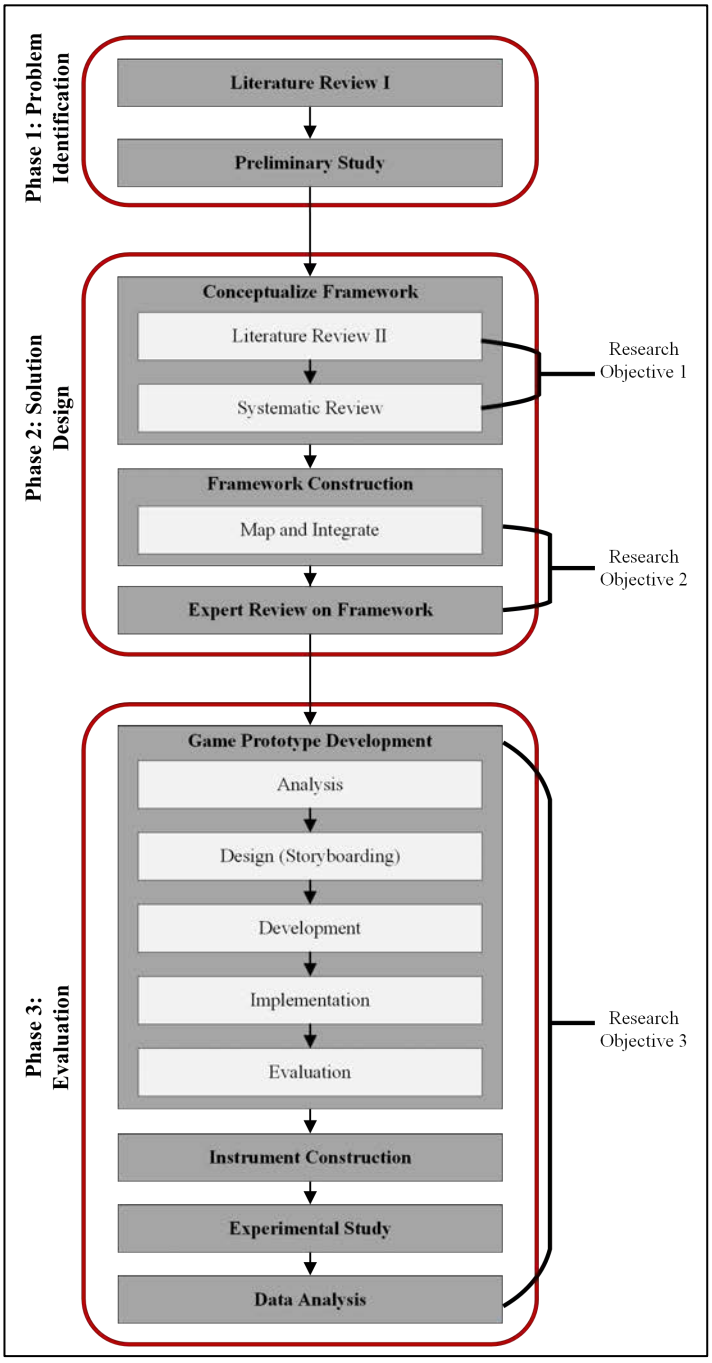


Figure 3.1 Research Methodology Flow

The above Figure 3.1 shows the research methodology flow of this research study based on three phases which are problem identification, followed by solution design, and finally the evaluation phase. Further detailed on the research methodology is explained on Table 3.1 below of this section. The table mentioned on the three phases, methods, activities and the descriptions of the outcomes. The study used a mixed methods approach, combining both qualitative and quantitative data collection and analysis techniques. This approach allowed for a comprehensive understanding of the problem, as well as the development and evaluation of a solution that meets the research objectives.

In the problem identification phase, we conducted a thorough literature review to identify problem in obesity awareness in general whereby we reviewed existing literature on obesity issue and conducted preliminary study through interview with experts in the field. In the solution design phase, we conceptualize framework for serious game design on obesity awareness through few activities that are literature review II, systematic review and finally the framework construction. During the literature review II, previous models and frameworks related to game design process were examined to identify the components and elements that would be relevant in conceptualizing the proposed framework. Besides that, systematic review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline to gather empirical evidence on the suitable and most common game elements in serious games for promoting obesity awareness. The framework construction activity involved the process of mapping and integration as well as synthesis of findings from the literature review and systematic review to develop a cohesive and comprehensive framework for serious game design on obesity awareness. Next, expert review on the developed framework was conducted to gather feedback and suggestions for improvement. Besides that, expert reviews also allow for the initial validation of the proposed solution.

Finally, in the evaluation phase, a few activities were conducted such as game prototype development, instrument construction, and experimental study to evaluate, validate and measure the effectiveness of the serious game in promoting obesity awareness. During the game prototype development, Analysis-Design-Development-Implementation-Evaluation (ADDIE) method was used to guide the iterative design process, ensuring that the game met the specific objectives and requirements identified in the earlier phases. The five phases in ADDIE are (1) analysis, (2) design, (3)

development, (4) implementation, and (5) evaluation. Additionally, instrument construction was involved in the development of experimental study questionnaire. During this phase, data analysis was also conducted to draw conclusions and make recommendations based on the research findings.

Table 3.1
Research Activities

Phases	Methods	Activities	Description of Activities	Description of Outcomes/ Expected Outcomes
Phase 1: Problem identification	Identify Problem	Literature review I	Identify issues and problem in the literatures Come out with possible solutions to the problems	Lack of obesity awareness among the public in Malaysia Children lack engaging tools to understand obesity risks and healthy habits
		Preliminary study	Consult experts in the areas of study	Many serious games focus on narrow and single-domain aims Few structured, theory-based and integrated behaviour change frameworks exists specifically for obesity awareness games for children
Phase 2: Solution design	Artefact Design	**Conceptualize framework** Literature review II	Investigate theories, model, framework and literatures related to serious game and game components and elements	Components of game framework and game elements
		Systematic review	Find out the common game elements in serious game interventions through literatures	Systematic review result on common game elements in serious game interventions for health and obesity awareness
		Framework construction	Construct a framework through mapping and integration as the proposed solution	Removing and adding components and elements based on suggestions from experts
		Expert review on framework	Construction of expert review checklist for the proposed framework Employ the expert review procedures Distribution of the checklist to experts on the proposed conceptual framework for review and validation Analyse and improve on the constructed proposed framework Consult experts based on their expertise for the initial design framework	Checklist for experts on proposed framework Suggestions from experts after the reviewing process Amendments and improvements of the conceptual framework An initial validated and improved serious game framework supporting obesity awareness
Phase 3: Evaluation	Data Collection and Analysis	**Game prototype development** Analysis	Preliminary investigation in components, game elements, proposed framework and learning	Confirmed on the improved game framework and game elements

		content	
	Design (Storyboarding)	Draw sketches and storyboarding Construction of expert review checklist for the storyboard Employ the storyboard review procedures Distribution of the checklist to experts on storyboard game evaluation Consult experts on the storyboard based on their expertise in game design and learning content Analyse and improve on the storyboard design	A storyboard sketches and design before review Checklist for experts on storyboard design Amendments and improvements of the storyboard design based on suggestions from experts An improved storyboard sketches after review
	Development Implementation	Develop a game prototype based on the constructed conceptual framework	A game prototype based on the game framework
	Evaluation	Evaluations for each phase of ADDIE	
	Instrument construction	Construction of experimental study questionnaire	Questionnaire for participants on experimental study Reliability and validity of the questionnaire Suggestions and comments from participants based on the gameplay experience
	Experimental study	Employ the experimental study procedures Distribution of questionnaire to participants about the game prototype	
	Data analysis	Data collection on game's quality and effectiveness of usability, player experience, and learning intentions Analyse the data findings	Empirical results based on the game's quality and effectiveness usability, player experience, and learning intentions

3.3 Phase 1: Problem Identification

Phase one of this research study is to identify problem. This phase involved the process of literature review I and preliminary study. The purpose of this phase was to identify and understand the problem of health and obesity awareness, by gathering insights from existing literature and expert perspectives in the field. The following sections discussed each activity involved in this research study.

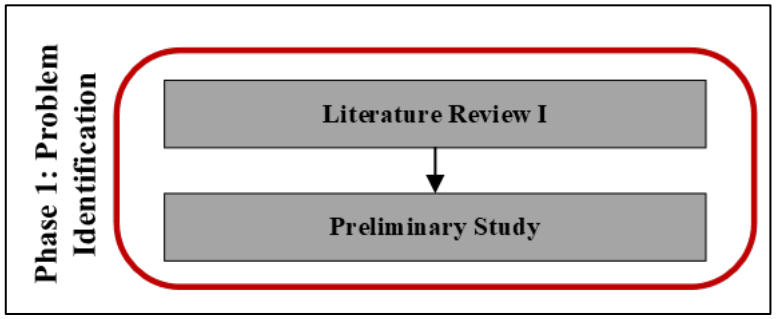


Figure 3.2 Phase 1: Problem Identification

3.3.1 Literature Review I

A comprehensive literature review was conducted to gain better understanding of the current state of research on obesity awareness and serious games. The literature review involved analysing and synthesizing relevant studies, reports and newspaper articles related to obesity, health education and awareness campaigns and programmes. The topics involved during the first look up consists of health issues, awareness, technology platforms and interventions related to obesity. It then evolved and more focused to health and obesity awareness, serious game, game components, elements, and game framework. The purpose of the literature review was to identify gaps in the existing research and to determine the potential for serious games in promoting obesity awareness. The literature review also provided a foundation for the development of the framework for serious game design on obesity awareness.

3.3.2 Preliminary Study

During the preliminary study, expert interviews were conducted to ensure the relevance and validity of the identified problem and its solutions (Offermann et al.,

2009). The interviews were conducted in a preliminary study with experts during the early phase to gather insights, perspectives, and expert opinions on the problem of obesity awareness and potential solutions through serious games. While the primary focus of this research is the development of serious game framework in promoting obesity awareness, this supplementary phase was essential for highlighting the significance of obesity as an issue in Malaysia and the necessity of informing early intervention strategies among the children.

3.3.2.1 Participants and Procedure

The expert selection criteria include that the selected experts came from field of public health. Their expertise and knowledge were valuable in deepening the understanding of the problem and identifying potential challenges and solutions. Five experts were being consulted that came from various background such as (1) nutrition and dietetics, (2) physiotherapy, and (3) nursing (see Table 3.2). The experts were consulted face-to-face at their respective centres to obtain their in-depth insights on the discussed matters. The first expert is a nutritionist and a health science lecturer with sixteen years of experience in nutrition and dietetics field. The second expert is a dietitian and a health science lecturer with ten years of experience in nutrition and dietetics field. Next, the third expert is a health science lecturer with fourteen years of experience in the field of nursing and healthcare, while the fourth and fifth experts are both health science lecturer with eleven and sixteen years of experience in the field of physiotherapy.

Table 3.2
Expert Profiles for Expert Interviews

Expert	Profession	Expertise	Years of experience
A	Nutritionist	Community Nutrition, Childhood Obesity and Interventions	16 years
B	Dietitian	Clinical Nutrition, Dietetics and Nutritional Education	10 years
C	Health Science Lecturer (Nursing)	Nursing, Nutritional Education, Public Health Education, Women and Child Health	14 years
D	Health Science Lecturer (Physiotherapy)	Physiotherapy, Physical Activity, Exercise Physiology, Medical and Health Sciences, Health Care System, Childcare	11 years
E	Health Science Lecturer	Physiotherapy, Medical	16 years

	(Physiotherapy)	and Health Science, and Physiotherapy in Women Health

Discussions with experts involved exploring the context of obesity in Malaysia and understanding the current efforts and challenges in promoting obesity awareness. The expert interviews focused on (1) understanding the issue of obesity, (2) comprehension of health obesity awareness, (3) implications for health, obesity, and the necessities in educating children and the community, and (4) the potential utilization of game technology, such as serious games, in addressing the issue of obesity. The questionnaire and interview were utilized in this preliminary study (see Appendix 1). In this preliminary study, a basic analysis method was employed to gather data. Data were collected through face-to-face interview sessions with the experts. The findings on the preliminary study were discussed in below section.

3.3.2.2 Key Findings and Results

The preliminary revealed that the current landscapes of obesity awareness, focusing specifically on the gaps in health education for children. Through expert interviews, the research identifies primary drivers of obesity such as sedentary lifestyles and urban environments, while highlighting serious health consequences like diabetes and sleep disorders. Although various awareness campaigns and technological tools exist, experts argue that many current methods are too passive or fail to engage younger audiences effectively. Consequently, the findings suggest a critical need for interactive, multimedia interventions that align with a child's cognitive development. The source ultimately advocates for the creation of educational serious games to foster better nutritional literacy and long-term behavioural changes in young people. Table 3.3 below summarizes the expert interviews. Below shows the summary of the expert interviews in Table 3.3.

Table 3.3
Summary of the Expert Interviews

Aspect	**Comments and Recommendations**
Causes and Consequences	Causes: High socioeconomic status, urbanization, lack of ingredient knowledge, and easy access to unhealthy foods. Consequences: Sleep disturbances, excessive daytime sleepiness, and non-communicable diseases (e.g., Type 1 & 2 diabetes, orthopedic

	complications, musculoskeletal disorders, and attentional deficits). Treatments: Focus on physical activity/exercise and dietary modifications.
Previous Research & Programmes	Tools: Deployment of sophisticated feedback-providing instruments to understand obesity progression. Current Methods: Use of informative talks, educational comics, interactive games, and audiovisual resources. NGO Involvement: Organizations like the Malaysian Association for the Study of Obesity (MASO) routinely hold campaigns and conferences.
Current Gaps in Awareness	Target Demographic: Children often lack a comprehensive understanding of obesity-related issues. Systemic Issues: Information dissemination is often limited to nutrition divisions, indicating a need for a more holistic, interdisciplinary approach. Professional Engagement: Healthcare frontliners need better training and incentives to prioritize public health messaging. Nutritional Literacy: There is a widespread lack of understanding regarding calorie intake and nutritional principles.
Education Strategies	Behavioural Changes: Encourage reduced screen time to mitigate sedentary behaviour. Engagement: Implement multimedia-driven programmes tailored specifically to children's interests. Credibility: Ensure all awareness content is evidence-based and drawn from authoritative sources like the Ministry of Health (MoH).
Technological Advancements	Tools & Apps: Integration of feedback-providing tools, reminder-enabled devices, and real-time health information applications. Platforms: Incorporating multimedia elements into educational platforms to create objective-driven technology interventions.
Content Suitability for Children	Core Topics: Focus on energy balance, dietary modification, nutrient education, and food selection. Implementation: Content must consider children's cognitive development levels and integrate guidance for physical activity. Proposed Solution: Development of interactive "serious games" to address gaps in current passive learning methods.

3.3.2.3 Implications for the Main Study

There are several significant implications for the future of obesity awareness, especially concerning children. The primary implication is the identification of a clear gap in current strategies, which are often considered insufficient or too passive for younger demographics. The study concludes that existing methods, such as informative

talks and some technology-based tools, are frequently ‘passive’ and not always designed with a child’s cognitive development in mind. This suggests a need to shift toward interactive and engaging tools to foster genuine understanding. Furthermore, a major outcome of these findings is the justification for developing a serious game. Since children often lack a comprehensive understanding of the causes and consequences of obesity, a game grounded in educational and behavioural theory can bridge this gap by making learning engaging and fun. Additionally, this study supports the creation of a game framework intervention. This framework would serve as a formal guideline for designing future obesity awareness tools specifically tailored to the interests and cognitive levels of young learners. Moreover, the findings highlight that obesity information is currently siloed within nutrition divisions. The study suggests that future efforts must involve a broader range of stakeholders and provide better training for healthcare frontliners to ensure public health messaging is prioritized and effective. Experts also pointed out that many people lack basic knowledge of calorie intake and nutritional principles. Therefore, future awareness content must emphasize practical skills like food selection strategies, energy balance, and nutrient education. Ultimately, the study serves as a foundational step to move away from traditional, passive educational models toward technology-driven, objective-oriented interventions like augmented reality, virtual reality, and digital games.

3.4 Phase 2: Solution Design

The second phase is the solution design as depicted in Figure 3.3 below. This phase is implemented to achieve the first and second objective of the research, which are to find the suitable components and elements in serious game framework promoting obesity awareness and to construct a serious game framework that promotes obesity awareness. A proposed framework is the artefact accomplished in this phase, whereby it serves as a guide for the design and development of the game. During this phase, several activities are being conducted to achieve these objectives. The activities involved are discussed in the next sections.

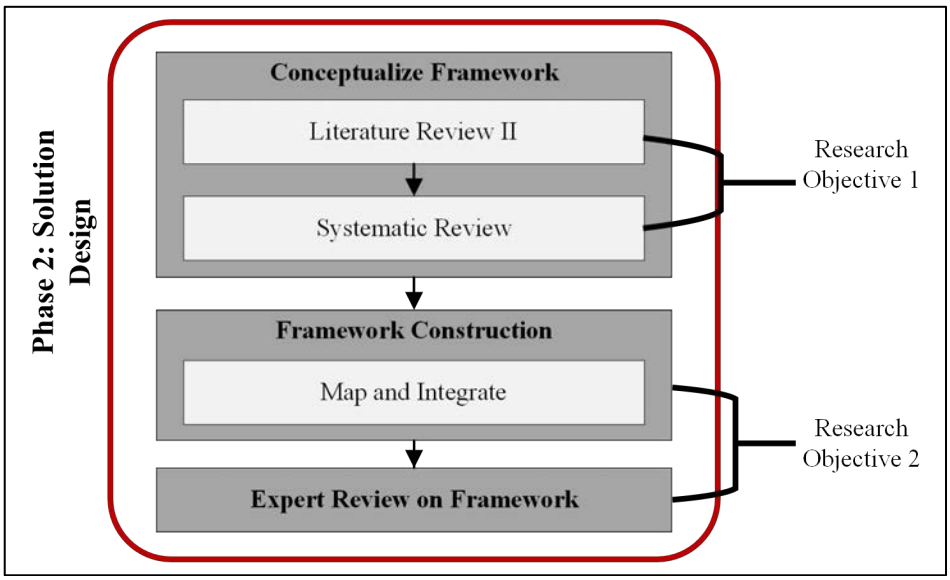


Figure 3.3 Phase 2: Solution Design

3.4.1 Conceptualize Framework

In this solution design phase, suitable components and elements for a serious game framework were the outcomes. It is based on two activities conducted that are (1) literature review II and (2) systematic review. First activity is the literature review II which involves an extensive review of relevant literature on existing game frameworks and models. Next activity is the systematic review. The aim is to find the suitable and common game elements in serious games for health and obesity awareness. During the systematic review activity, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used as a guideline in achieving the objective. In this section, first objective of the study was achieved:

a) To determine the suitable components and elements for a serious game framework that promotes obesity awareness.

The methodological approach in this phase is using the embedded mixed methods design whereby one method is the primary approach, while the other is the secondary. The secondary approach is embedded within the main design to complement or explain specific aspects. The use of the two methods are qualitative content analysis and quantitative statistical analysis, where both methods are then integrated to form an outcome of a proposed game framework. The qualitative method was conducted using

content analysis to determine the suitable game components for a serious game framework promoting obesity awareness, whilst the quantitative method was conducted using statistical analysis to determine the game elements of the proposed serious game framework. The latter is a method embedded within the larger qualitative design to provide quantitative insights on what specific components are effective. The quantitative statistical analysis is used to inform or supplement the qualitative content analysis which extract suitable themes and patterns related to game components which are linked to the statistical analysis of game elements. Chapter 4 further detailed on its process and results as part of the serious game framework construction.

3.4.1.2 Literature Review II

Literature review II is conducted to achieve the first objective. This review involves an extensive examination of existing game frameworks and models before conceptualizing the framework. Through literature review II, a comprehensive and content analysis had been done including mapping those frameworks and models. The mapping process involved comparing and analyse the different elements and components of existing game frameworks and models to identify commonalities and differences. The process involved the use of Information-Motivation-Behavioural Skills (IMB) model to serves as guideline, and as framework backbone of the proposed game framework. Besides that, this process also able to get insights from previous work on game frameworks and models. Additionally, the process of literature review II also able to determine the components involved in game framework. In this framework, components represent the domain and construct of the IMB model, serving as its guidelines. These components will serve as a foundation for the conceptualization of the serious game framework that promotes obesity awareness. In this activity, various sources have been scoured to retrieve the most recent and updated information on the framework. These include sources from journal publication and conference papers. These activities were further discussed in Chapter 4.

a) Sampling

The sampling methodology for this research design encompassed content analysis using the qualitative data method. Previous game frameworks or literature that

focus on serious games, educational games, or health-related games were searched to identify the themes and patterns related to game components suitable in the proposed game framework. A purposive sampling was performed whereby existing game frameworks were selected that are relevant to this research study which particularly addressing game design process, behaviour change, or educational goals. These existing frameworks were selected from academic papers, articles, and journals. The search strategy involved using keywords such as “serious game framework”, “game framework”, “serious game design”, and “game design process”. To ensure a comprehensive search, multiple databases such as Scopus, Science Direct and ACM Digital Library were utilized. The following criteria were used to select the frameworks for review. The criteria involved in this literature search are (1) framework that focuses on serious game design or game design process, (2) framework that includes components or elements relevant to the design of serious games, and (3) framework that has learning content or purposes or goals in the framework structure. Besides that, the criteria also include of papers that have been published or recognized in academic industry. The literature search found six existing frameworks that fulfilled the criteria for analysis.

b) Data Collection Methods and Analysis

The data collection methods employed in this research design encompass qualitative data, utilizing content analysis for data interpretation. The data collection was conducted by reviewing existing frameworks that studied game frameworks and game design process that consist of components related to game design. The data was first grouped into components from the existing frameworks using the intra- and inter-framework grouping (Khowaja, 2017). During the intra-framework grouping, the components are extracted from each of the selected frameworks and grouped into relevant categories. Then, the inter-framework grouping was conducted to identify the common component across the selected frameworks and compare their definitions or descriptions. To minimize researcher bias during the extraction phase, a dual-coding approach was employed. Game components and elements were independently coded against existing game design frameworks and models by the primary researcher and an independent coder. Discrepancies were resolved through a negotiated agreement process, in which coders discussed divergent codes and jointly agreed on a final

categorization, consistent with established directed content analysis and feature-level coding approaches in game-based design framework. The final grouping of game components was structured using the IMB model as overarching design guidelines for information, motivation, and behavioural skills, following prior IMB-based serious game frameworks. The content analysis done was to extract common game components and the goal is to identify recurring themes that represent effective game components across multiple frameworks.

3.4.1.3 Systematic Review

This phase was performed to achieve the first objective. Systematic review was performed using the PRISMA (Page et al., 2021) guidelines to identify and analyze most common and suitable and game elements in serious games for obesity awareness. This review identified and critically evaluated a range of scientific publication that explore the use of game elements in games aimed at promoting obesity or health awareness in general. These activities were further discussed in Chapter 4. Elements in this framework are the conceptual pieces that illustrate how components and other parts interconnect, as well as how they collectively form the entire framework. Figure 3.4 below shows the studies selection and identification flowchart using PRISMA guidelines.

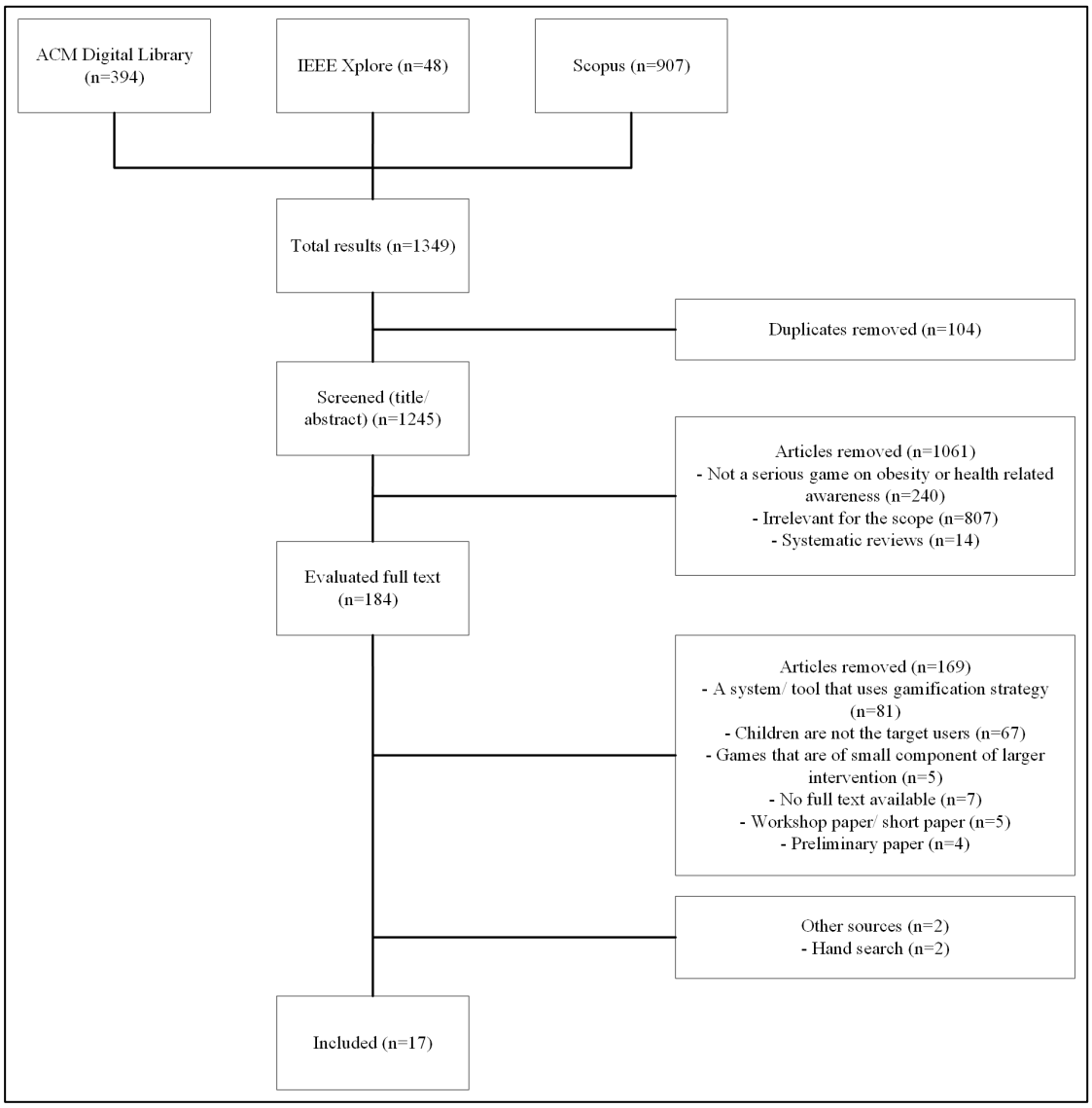


Figure 3.4 Studies Selection and Identification Flowchart Using PRISMA Guidelines

a) Sampling

The sampling methodology for this research design encompassed statistical analysis for the quantitative data. In this method, previous serious game interventions related to health or obesity awareness were searched using a systematic review sampling or secondary data sampling. This involved collecting data from databases which includes articles on serious games that report on the outcomes of game elements in serious game interventions. Literature search was performed through ACM Digital Library, IEEE Xplore, and Scopus databases that designed and developed serious games for obesity or health awareness. The databases yielded 1349 results in total. A total of 104 duplicates were removed during the first phase, followed by the next phase,

whereby articles were screened based on title and reading abstract. 1061 articles in this screening were then excluded, mainly because the articles were irrelevant for the scope and considered not serious games on obesity or health-related awareness. Systematic reviews were excluded during this phase. Next, the full text of the remaining articles were evaluated. Hereafter, 169 articles were excluded mainly because, after reading the full text, the studies are considered a system/application/tool that uses gamification strategy instead of serious game intervention. In addition, other reasons include that children are not the target users, games that are of small component of larger intervention, no full text available, workshop/ short paper, and preliminary paper. Finally, two hand searches were performed, resulting in the inclusion of 17 studies (see Figure 3.4). The criteria for this review include articles that is within the scope of serious games on obesity or health-related awareness. The studies were conducted in English and were published between 2013 and 2023.

b) Data Collection Methods and Analysis

The data collection methods employed in this research design encompass quantitative data, utilizing statistical analysis for data interpretation. Serious game interventions promoting health and obesity awareness from previous studies are the data sources of this analysis. Systematic review process is being done to collect relevant studies on serious game interventions to find the most suitable game elements to be embedded in the game element component of the proposed framework. The selected articles were screened, and data was extracted on common game elements. The statistical methods used descriptive statistics to evaluate the total amount of game elements extracted for each intervention with the purpose of finding the most suitable game elements that promotes health and obesity awareness.

3.4.2 Framework Construction

During the framework construction phase, the findings from the literature reviews and systematic review were used to develop a comprehensive and effective serious game framework for promoting obesity awareness. Based on the prior activities, Information-Motivation-Behavioural Skills (IMB) model (W. A. Fisher et al., 2003) was adapted to guide the construction of the framework. The components and elements in the model were examined and modified to fit the specific context of serious game framework for obesity awareness. Game elements were also selected and integrated into the framework based on the prior systematic review. The resulting framework provides a comprehensive guide for the design and development of serious games that effectively promote obesity awareness and motivate behaviour change. These activities were further discussed in Chapter 4.

3.4.2.1 Map and Integrate

In this section, the process of mapping the components and various game elements, as derived from the Literature Review II and Systematic Review, was undertaken. These elements are then integrated into a cohesive framework. This mapping and integration are based on the results of content analysis of existing frameworks and a systematic review of game elements in serious game interventions. During the mapping and integration process, three steps were carried out as follows:

a) Identification of components
b) Identification of structure (IMB model as framework guide)
c) Logical placement of components in structure

The proposed framework was subsequently developed through the mapping and integration process, with its components and elements identified within the serious game framework.

3.4.3 Expert Review on Framework

In this activity, expert review was conducted to gather reviews, suggestions and initial validation on the proposed framework developed. Expert review is a critical step in ensuring the quality and effectiveness of a developed framework, model or system. During the expert review phase, a panel of experts in the field of serious games and obesity awareness were invited to provide feedback on the developed framework. Results and analysis of the expert review process are further explained in Chapter 4 of the study. During this phase, mixed methods was used to evaluate the feedback given by the experts.

3.4.3.1 Sampling for Expert Review on Framework

A total of six experts were involved in this phase (see Table 3.4). The expert review process used non-random or non-probability sampling (purposive sampling method). Teddlie & Yu (2007) mentioned that purposive sampling method is the intentional selection of individuals who possess the necessary expertise and knowledge in a particular field. Therefore, based on this method, a total of six experts have been recruited. The experts are selected based on the expert selection criteria which is those with expertise in the fields of game design and Human Computer Interaction (HCI) and in health science (nutrition and dietetics). All experts had more than seven years of experience in their respective fields and had previously conducted research or published work related to their relevant area of expertise. The number of experts involved in this phase is in line with Rubio et al., (2003), who suggested that at least three experts can be used in the expert review process with a range up to 10.

Table 3.4
Expert Profiles for Expert Review

Expert	Profession	Academic qualification	Expertise	Years of experience
A	Lecturer	PhD	Game-Based Learning/ Gamification, Multimedia in Education, Game Design and Development, and Instructional Design	7 years
B	Lecturer	PhD	Game Design, Human Computer Interaction, E-Learning, Interface Design, Animation, Usability, and Interaction	13 years
C	Lecturer	PhD	Game Design, Gamification, User Experience, Eye-Tracking, AR/VR,	18 years

			Human Computer Interaction, Serious Game, Game Technology, Usability	
D	Lecturer	PhD	Food Hygiene and Safety, Food Science, Nutritional Sciences, and Nutrition Education	13 years
E	Nutritionist	Degree	Clinical Dietetic	21 years
F	Nutritionist	Degree	Nutrition	20 years

3.4.3.2 Data Collection Procedure

The procedure of performing the expert reviewing is illustrated in Figure 3.5 below. The data collection procedure of this study involved three phases. The first phase starts with identifying expert reviewers and approach them through email (see Appendix 2). Initial engagement occurred and agreement have been made to participate as expert reviewers. The second phase involves distribution of the framework document to the expert reviewers, along with a set of guiding questions for their review. Experts were given a week time to complete the questionnaire given. The third phase is the analysis and synthesis of the feedback received from the expert reviewers. During this phase, iterative process is followed to review the feedback and revise the framework based on expert suggestions. Finally, the revised framework is validated and finalized based on the consensus of the experts.

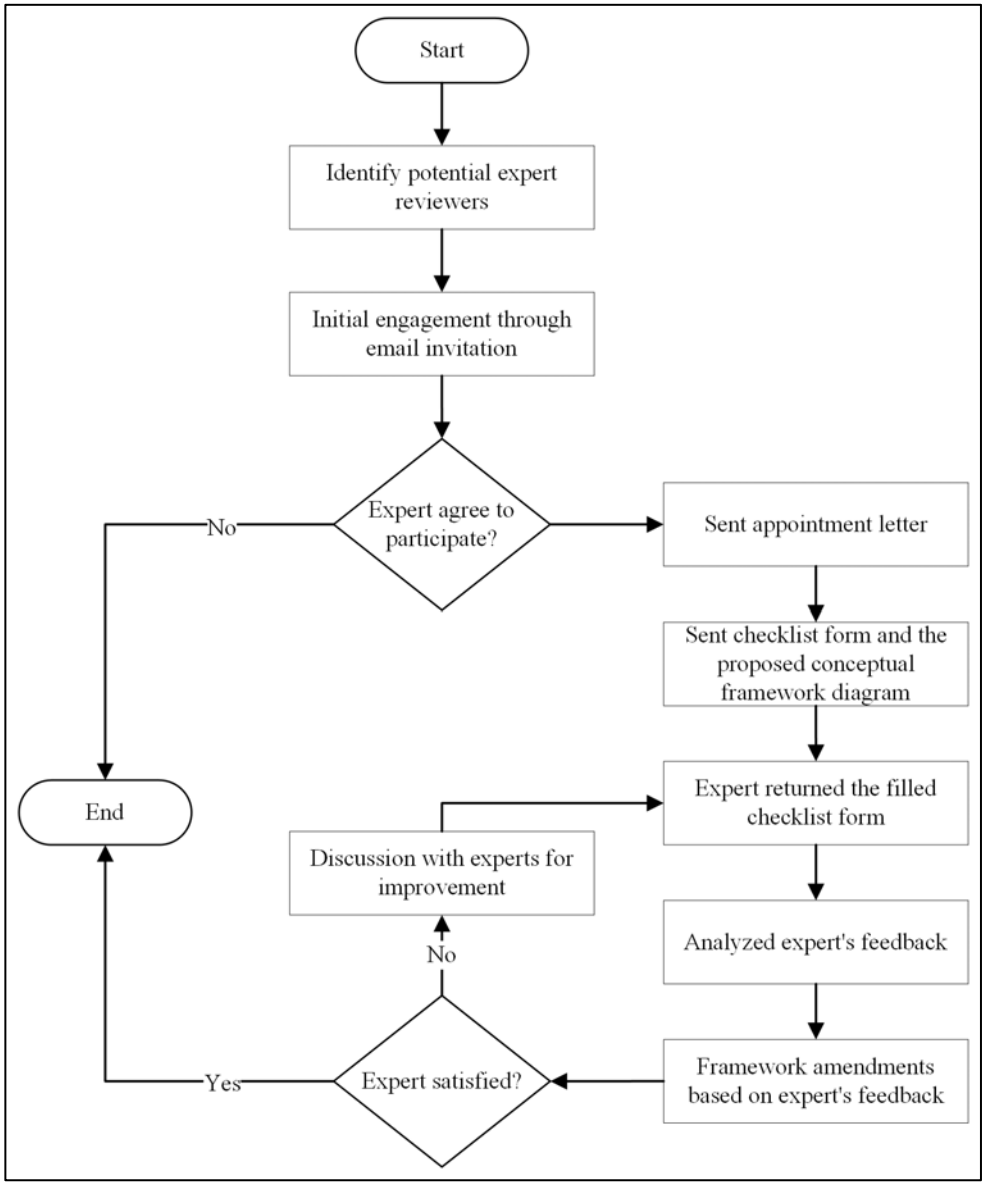


Figure 3.5 Phase 2: Flowchart of Expert Review Procedure

3.4.3.3 Ethical Consideration

This study had an approval from the University Research Ethics Committee to conduct the expert review process. Ethical considerations were considered throughout the process. The methods and procedure during the expert review process were conducted in accordance with ethical guidelines to ensure the validity and reliability of the study. The experts involved in the review process were provided with clear instructions regarding confidentiality and their feedback was anonymized to protect their identity in the letter of informed consent. This study involved experts from the field of game design and health nutrition using purposive sampling. There are six expert

reviewers in total, three from the field of game design and three from the field of health nutrition. Appointment letter and questionnaire were distributed to the expert reviewers after obtaining their informed consent to participate in the study (see Appendix 3 and 4). The instrument used for data collection was a proposed game framework document along with a set of guiding questions. The ethics approval from the University is shown in Appendix 5.

3.4.3.4 Research Instrument (Checklist)

This section describes the design of the instrument used in the expert review process. There are three documents for the expert review process: the overview information, the set of guiding questions, and the proposed framework document. The first document is the overview information document where information such as demographics and research work explanation was provided to the expert reviewers. The second document is the set of guiding checklists which were designed to prompt the experts in providing feedback on specific aspects of the framework. The third document is the proposed framework document, which outlines the structure and components of the framework.

The checklist instrument includes two sections. The first section consists of questions related to the structure and components of the framework with description of each component and the possible applicability in the game design (see Table 3.5). For all the questions, reviewers were requested to tick the appropriate box based on their level of agreement or relevance and fill up the comment section if they had any additional comments or suggestions. The next section is an open-ended question where reviewers were asked about learning content based on the proposed framework document and its potential impact on game design and health nutrition. The detail of the checklist research instrument is shown in Appendix 6.

Table 3.5
Description on the Components in Checklist for Expert Review

INFORMATION	
GAME CONTEXT	
Components	**Description**
Purpose	-To foster obesity awareness among children. -To underscore the significance of healthy dietary habits and engaging in physical activities as pivotal elements for sustaining a healthful lifestyle.
Aim	-To educate players regarding the criticality and repercussions of maintaining a balanced diet and participating in physical exercises.
Impact	-Facilitation of player comprehension and assimilation of game content aimed at

	cultivating obesity awareness. -Encouragement of behavioural modification among players.
Contents	-Dissemination of information, factual data, and insights concerning healthy and unhealthy dietary patterns. -Examination of sedentary versus active lifestyles. -Comprehensive coverage of topics pertinent to maintaining health, encompassing dietary choices and physical activity. -Integration of information focused on the core components of weight management and wellness: food consumption and physical exertion.
Game elements	-Incorporation of game elements within the game context, such as goals, challenges, and progression
Components	-Points, Quests (Goals), Avatar/ Character, Achievement
Mechanics	-Challenges, Feedback, Win states, Rewards
Dynamics	-Constraints, Progression
Narrative	-Game environment characterized by both indoor and outdoor settings, featuring scenarios delineating healthy and unhealthy dietary habits alongside physical activity engagement. -Player choice extends to the selection of a male or female child character.
Aesthetics	-Integration of upbeat, cheerful background music to enhance gameplay ambiance. -Utilization of sound effects to reinforce reward mechanisms and provide feedback cues. -Visual representation characterized by cartoon-style graphics, encompassing backgrounds, objects, and characters, designed to captivate player engagement.
MOTIVATION	
	Description
	-Presentation of information pertaining to obesity awareness serves as a catalyst for fostering motivation toward the initiation and sustained adherence to intended behavioural changes. -Exemplary behavioural changes may include the adoption of practices such as increased consumption of fruits and vegetables, reduction in sugar intake, or engagement in outdoor walking.
SELF-EFFICACY	
	Description
	-Individuals who are adequately informed and motivated, as facilitated by game participation, demonstrate enhanced efficacy in implementing behavioural modifications effectively.
OUTCOMES	
	Description
	-Integration of obesity awareness information within the game framework facilitates cognitive and behavioural transformations. -By imparting knowledge and instilling motivation, the game empowers players to embark upon and sustain a health-oriented lifestyle characterized by prudent dietary choices and regular physical activity.

3.4.3.5 Data Collection Methods and Analysis

A mixed methods approach was employed during the expert review phase. Quantitative data were gathered using a 16-item validation instrument and analyzed with Microsoft Excel to ensure the statistical significance of each framework component. This was complemented by qualitative feedback obtained through the evaluation of comments and recommendations, which underwent an iterative process and analysis to refine the framework's structural logic in alignment with the IMB model.

3.5 Phase 3: Evaluation

This final phase is the evaluation phase as depicted in Figure 3.6. This phase focused on evaluating the results from the proposed framework and expert review process. To evaluate the effectiveness and validity of the framework, a few activities were conducted. The activities were (1) game prototype development, (2) instrument construction, (3) experimental study and (4) data analysis. During the game prototype development, ADDIE model is implemented to design and develop game prototype based on the developed proposed framework. This phase is implemented to achieve the third objective of the research, which are to evaluate the effectiveness of game prototype that is based on the serious game framework promoting obesity awareness. The outcomes of this phase are game prototype, empirical results, publication and a thesis. The following sections further detailed activities during the evaluation phase. These activities were also further discussed in Chapter 5.

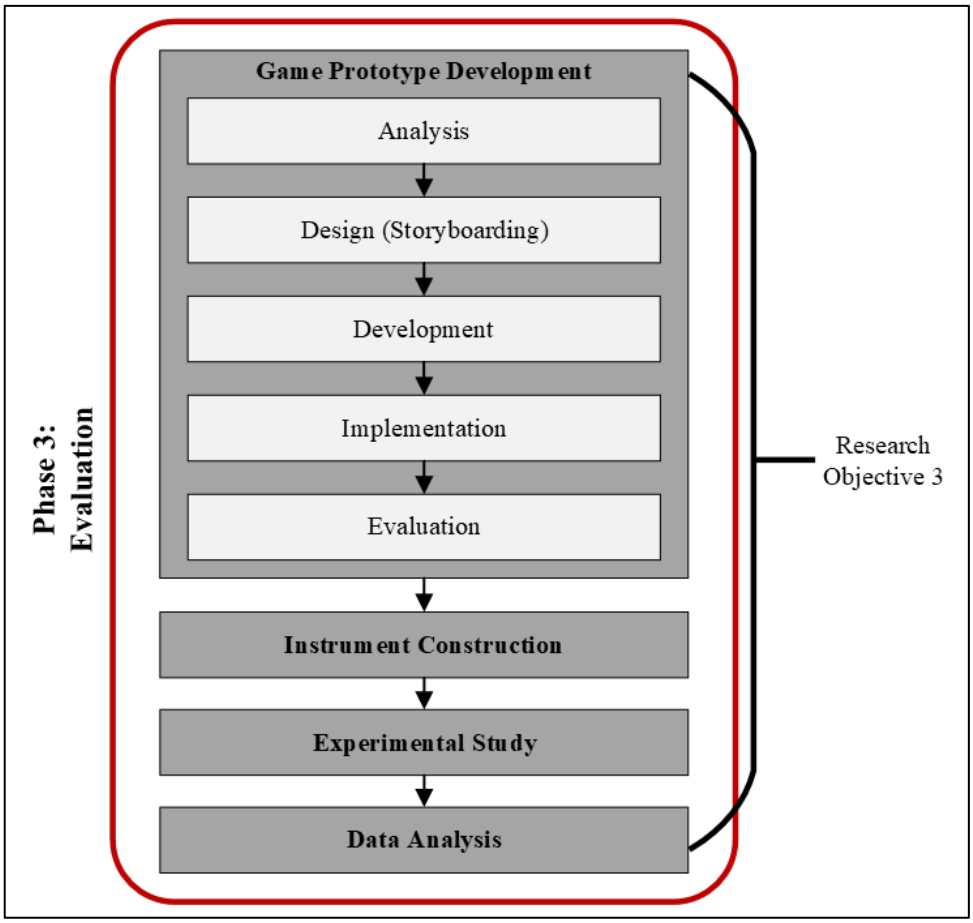


Figure 3.6 Phase 3: Evaluation

The effectiveness of the game prototype developed based on the serious game framework needed to be validated through game prototype development and experimental study. To promotes health and obesity awareness among young users, an experimental design approach was conducted to validate the serious game framework and evaluate the effectiveness of game prototype developed based on the serious game framework promoting obesity awareness. During this phase, mixed method was used to evaluate the findings based on the experimental task.

In this phase, game prototype development and an experimental study were conducted to answer the third research question of this research study. Below is the research question:

a) To what extent does the game prototype developed based on serious game framework meet the multi-dimensional quality factors of usability, player experience, and perceived learning for obesity awareness?

3.5.1 Game Prototype Development

The game prototype development phase involved implementing the ADDIE model to design and develop a game prototype. The game prototype was developed following the ADDIE model, a framework created by Florida State University for the military in the 1970s and later adapted by other fields to create effective training and instructional materials. This prototype was based on the serious game framework, which was developed in the earlier phases of the research. The purpose of developing the game prototype is to test the functionality and effectiveness of the framework in practice. The process of the game development includes five stages from the ADDIE model (see Figure 3.7). The first stage is analysis, followed by design, development, implementation, and evaluation. During the analysis stage, the researchers gathered information about the target audience, their needs and preferences, and identified the goals of the game prototype. The design stage involved creating the overall structure and mechanics of the game prototype, including the gameplay, levels, and narrative flow through storyboarding. The development stage focused on building the game prototype, including programming, visual and sound design, as well as testing for bugs and glitches. The implementation stage involved releasing the game prototype into the

target platform or device. The evaluation stage aimed to assess the effectiveness and validity of the game prototype based on the serious game framework.

Figure 3.7 ADDIE Model Phases

3.5.1.1 Analysis

During the analysis phase, the researchers collected information about the detailed components, elements, interface and gameplay of the game prototype that is based on the serious game framework. This also includes basic literature search to gather further information on the game design components, elements and content learning.

3.5.1.2 Design (Storyboarding)

Based on the initial validated serious game framework and the information gathered during the analysis phase, a storyboard was created to outline the overall structure, narrative and mechanics of the game. In this stage, the process of storyboarding serves the purpose as a guideline in the development process. Glebas, (2009) defines storyboard as a visual representation of the game's sequence of events that helps in planning and visualizing the gameplay. The storyboard created in this study provides a visual presentation of the overall overview of the game interface, gameplay, game information, and game content. It is crucial to ensure that the storyboard accurately represents the intended flow and interaction of the game prototype, and the storyboard designed are clear and concise to the reference of the developed serious game framework. During the storyboarding stage, four steps were conducted: idea generation through thumbnail sketches, story creation through rough sketches, visual representation through storyboard design, and storyboard review through expert review. A well-designed and visually appealing storyboard serves as a roadmap for the development of the game prototype, ensuring that it aligns with the serious game

framework that can promotes obesity awareness. Figure 3.8 below shows the storyboarding process taken during the design phase.

Figure 3.8 Storyboard Phases

During the thumbnail sketch stage of the storyboarding process, rough and quick sketches were created to capture initial ideas and concepts for the game prototype interface and gameplay (see Figure 3.9). Thumbnail sketches served as the initial point for visualizing and exploring different possibilities for the game's design and structure. Appiah & Cronje (2012) indicated that thumbnail sketches are crucial step to assist designers brainstorm and generate various design ideas. According to Mohd Daud et al., (2017), the process of thumbnail sketching starts with fundamental concepts, progresses to layout development, and concludes with the refinement of detailed sketches.

Rough sketches are the next step of storyboarding process, where more detailed and refined sketches are created based on the initial thumbnail sketches (see Figure 3.10). This rough sketches further develop and refine the visual elements, characters, scenes, and interactions of the game designed. The initial phase of storytelling involves creating a rough sketch (see Appendix 7). Additionally, the process of drawing allows artists greater flexibility to make corrections during the creation process (Parakkat et al., 2018). Once the rough sketches are complete, the storyboard design phase begins (see Figure 3.11). During this phase, the sketches are translated into a sequential narrative format, with each scene or frame representing a specific moment in the gameplay. The storyboard design phase involves arranging the sketches in a logical order to tell a cohesive and engaging story. Swearingen & Swearingen (2018) mentioned that a storyboard shows a sequence of drawings that visually represent the game flow and more detailed information.

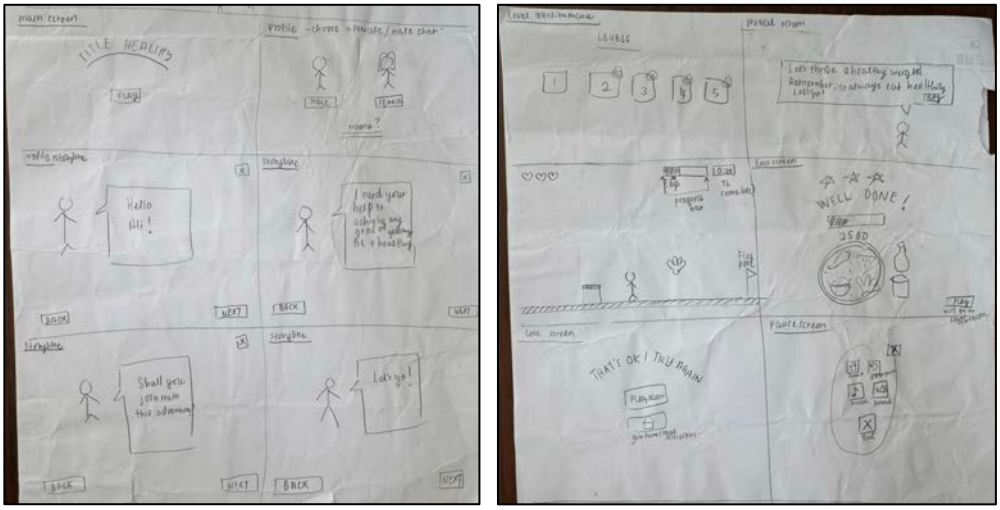


Figure 3.9 Thumbnail Sketches

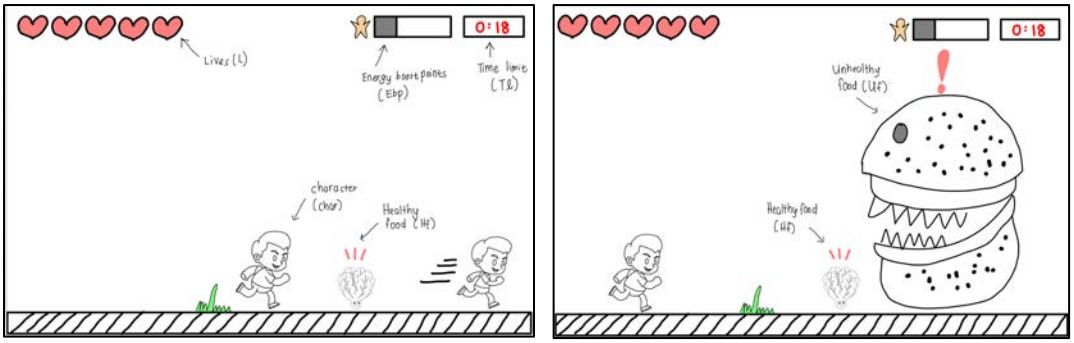


Figure 3.10 Rough Sketches

Figure 3.11 Storyboard Design

a) Storyboard Review

After the completion of the storyboard design, storyboard review was conducted to ensure the accuracy and effectiveness of the storyboard in conveying the intended flow of the game prototype. Storyboard review was conducted to get insights and feedback from the experts on the storyboard designed based on the proposed framework

developed earlier. The purpose of the storyboard design and validation are to outline the narrative flow, user interactions, and game components integrated into the game.

a. Sampling for Storyboard Review

The expert selection criteria include experts in the field of game design and health science that were consulted to provide feedback and recommendations for improvement for the storyboard design. Three experts in total were involved in the review process whereby two of the experts were experienced in game design, gamification, and user experience. Another expert had expertise in nutrition in community. The experts selected have between eight to eighteen years of experience. Table 3.6 shows the expert profiles for storyboard review.

Table 3.6
Expert Profiles for Storyboard Review

Expert	Profession	Academic qualification	Expertise	Years of experience
A	Lecturer	PhD	Game Design, Gamification, User Experience, Eye-Tracking, AR/VR, Human Computer Interaction, Serious Game, Game Technology, Usability	18 years
B	Lecturer	PhD	User Experience/ User Interface, Human Computer Interaction, Future Interaction Design, Software Engineering and Development, Information Visualization and Analytics, Information and Communication Technology/Information Technology/Multimedia/Information System	20 years
C	Nutritionist	Degree	Nutrition in Community	8 years

b. Data Collection Procedure

The storyboard review was conducted to validate the storyboard design and identify any potential issues or areas for improvement. Based on the procedure flowchart shown in Figure 3.12 below, potential experts were identified during the early phase. After careful consideration, experts in the field were chosen based on their relevant expertise and years of experience, thus initial engagement with them was initiated (see Appendix 8). Once the experts agree to participate, an appointment letter with informed consent form were distributed (see Appendix 9). The experts are then being sent the storyboard design including the checklist for review and evaluation through email. The instruments are consisted of (1) checklist of the storyboard, (2) storyboard design, (3) description of the items in storyboard design, and (4)

demographic information. The checklist included questions that evaluated the clarity and coherence of the storyboard that particularly focused on the game components and elements based on the developed proposed serious game framework. The experts were asked to agree or disagree with the provided statements and provide any additional comments or suggestions for improvement. Result and analysis of the expert review process of storyboard are further discussed in Chapter 5.

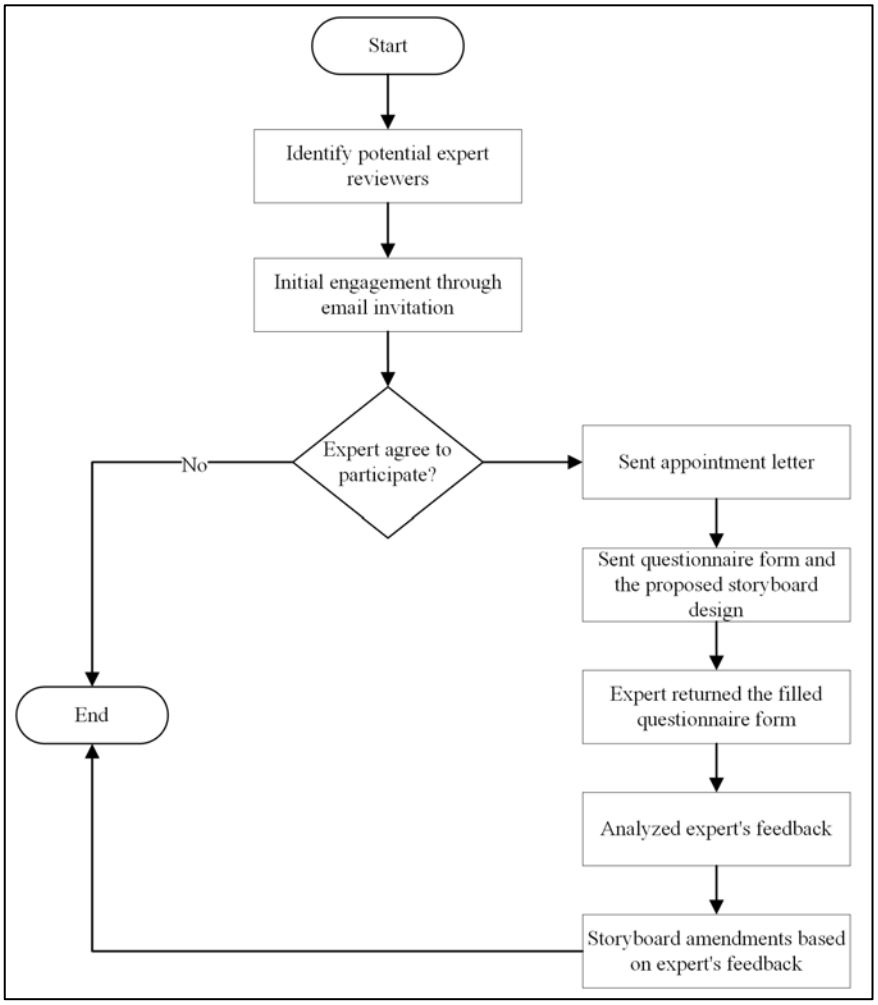


Figure 3.12 Flowchart of the Storyboard Review Procedure

c. Research Instrument (Checklist)

This section describes the design of the instrument used in the expert review process. There are four documents for the storyboard process: the checklist, the storyboard, the description and final evaluation form. The first document is a checklist containing guiding questions about the storyboard design, including the game

components and elements that might be suitable for implementation. These questions are intended to prompt experts to provide feedback on the storyboard design. The second document is the storyboard design with label buttons mentioned in each drawing which act as a storyboard walkthrough. The third document is the description document, which outlines the descriptions of game components and elements involved in the design of the storyboard. The final evaluation form includes the demographic information of the expert reviewers, along with their overall comments on the storyboard design, which are requested after the evaluation.

The storyboarding checklist instrument includes 24 items with 10 number of interfaces drawn to be reviewed namely storyline screen, level selection screen, initial screen, interface 1 screen, interface 2 screen, interface 3 screen, interface 4 screen, interface 5 screen, final screen, and end screen. For each of the interfaces featured, there is a guided questions with label, game elements/ components, description of the label and agree or disagree box to choose if the said label and the storyboard is agreeable. Besides that, comment section was also included to allow the expert reviewers to give feedback and recommendation on the interface of the storyboard design. For all the questions, reviewers were requested to tick the appropriate box based on their level of agreement or relevance and fill up the comment section if they had any additional comments or suggestions. The detail of the storyboarding checklist research instrument is shown in Appendix 10.

d. Data Collection Methods and Analysis

The data collection for the storyboard review employed a qualitative method approach. Experts were given a digital walkthrough of the 10-scene storyboard, accompanied by a heuristic evaluation checklist form comprising 24 items for assessment. Qualitative insights were derived through thematic analysis, pinpointing critical areas for improvement based on the components and elements of the game framework and the segments of the gameplay. This process ensured that the transition from the framework to the digital prototype was empirically grounded and aligned with the developed framework.

3.5.1.3 Development

Development phase in the game development process focuses on creating the actual game prototype based on the agreed-upon storyboard design. During the development phase, the game prototype is created following the storyboard design that was validated through storyboard review. This phase involves the inclusion and development of game mechanics, visual graphic design, and sound elements. Game prototype development was conducted using a software tool named Buildbox Classic Plus. The tool used drag and drop features to create and edit the gameplay and structure of the game developed. The overall view of the game structure is being portrayed as nodes connected by different pathways (see Figure 3.13). These pathways represent the different levels or stages of the game. Further discussion on the game prototype development will be discussed on Chapter 5.

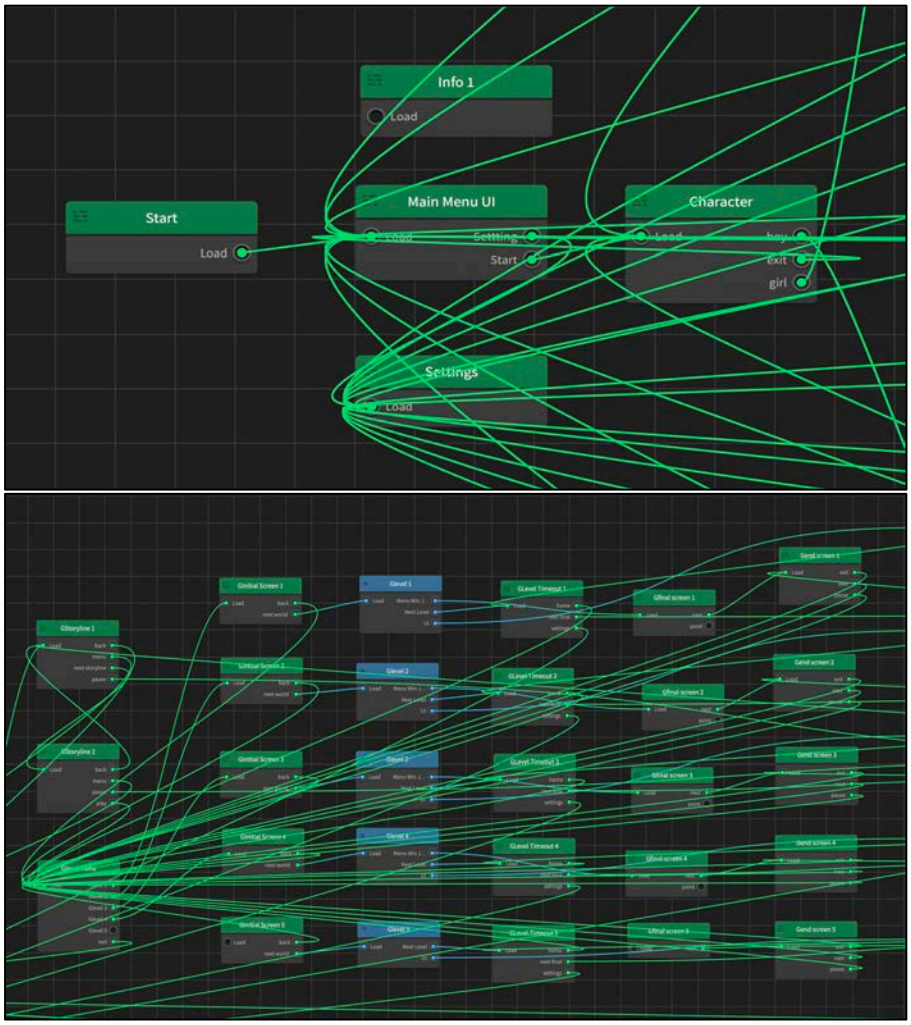


Figure 3.13 The Overall View of the Game Structure Potrayed as Nodes in Buildbox Classic Software Tool

3.5.1.4 Implementation

The implementation phase of the game development process involves integrating the developed game prototype into the target platform or device. This includes ensuring compatibility and functionality on the intended platform, such as mobile devices or desktop computers. The implementation phase includes testing the game prototype to identify and address any bugs or technical issues before its release. The game prototype is tested and published on Buildbox World, a platform under the Buildbox Company that allows developers to showcase and distribute their games. This game prototype was made available for playtesting purposes which is easily accessible for the target participants during the actual experimental study.

3.5.1.5 Evaluation

The evaluation phase of the game development process focuses on gathering feedback and assessing the effectiveness of the game prototype that is designed based on serious game framework. This phase involves conducting an alpha testing of the game developed to identify any areas of improvement, potential issues or bugs. The feedback gathered during the evaluation phase will be used to make necessary adjustments and improvements to the game prototype.

3.5.2 Instrument Construction (MEEGA+ Adapted Questionnaire)

The research instrument used in this study was a questionnaire adapted from MEEGA+ (Petri et al., 2018), which is a validated measure for evaluating the effectiveness of game developed. The questionnaire contained items that assess the participants' experience, motivation, and learning intentions, providing insights into the participants' attitude towards the game and its impacts on their learning outcomes. Based on Petri et al. (2018), the objective of MEEGA+ model is to assess the quality of games based on the usability, player experience, and perceived learning and its effectiveness from the perspective of computing education, and the focus is on determining how well the games meet the needs and expectations of the target audience.

3.5.2.1 Improvement in the MEEGA+ Research Instrument

We adapted and refined the MEEGA+ model by considering the significance of perceived learning as one of the crucial aspects related to the proposed game framework, the objective that encompasses this research study, and defined dimensions that could impact this research evaluation and study. First step is employing the Smileyometer scale (Sim & Horton, 2012). Second step, in the original MEEGA+ model (Petri et al., 2016), perceived learning was included as one of the domains of the MEEGA+ model. However, in the recent MEEGA+ model (Petri et al., 2018), perceived learning was categorized under the player experience domain. Consequently, the improved version of this research instrument treated perceived learning as a separate domain, alongside usability and player experience, due to its significance in this research evaluation. Third step, the social interaction dimension has been removed due to its lack of relevance to the game's design and objective. The game does not incorporate social interaction among players. Fourth step, the MEEGA+ (2018) (Petri et al., 2018) instrument comprised more than 35 questions categorized under two primary domains: (1) usability and (2) player experience. However, the improved version of this research instrument encompassed three main domains to evaluate the effectiveness of the game prototype: (1) usability, (2) player experience, and (3) perceived learning. The item descriptions were reduced due to the finding that responding to 35 or more questions can be frustrating for children (Moosa et al., 2020). Consequently, the questionnaire was minimized to align with the children's comprehension abilities. Thus, this improved instrument consisted of 18 questions that were consolidated and refined to enhance comprehension among children and young users, who constituted the target participant group.

3.5.2.2 Scale

A response format used by MEEGA+ instrument is scale of 5-point Likert scale with response alternatives ranging from strongly disagree to strongly disagree. A 5-point Likert scale from 1 to 5 was used, where 1 equal to "strongly disagree", 2 equals to "disagree", 3 equals to "indifferent", 4 equals to "agree" and 5 equals to "strongly agree". The data collected were then analysed using Microsoft Excel and statistical package IBM social sciences (SPSS) software tools. The use of Likert scale gives

participants the ability to independently express their opinion comfortably especially with the availability of neutral point in the scale that can lead to a quality of answer in research study (Dawes, 2008). Besides that, the responses were also converted to Smileyometer (Sim & Horton, 2012) that consists of images of Smiley icons based on the feelings or reactions from the 5-point Likert scale. The Smileyometer is utilized in this instrument to tailor it to the target participant demographic, which comprises children. This is attributable to children's tendency to identify more readily with the smiley emoticon than with numerical scales. Furthermore, it facilitates children's completion of the questionnaire and eliminates the need for writing on their behalf (Sim & Horton, 2012).

3.5.2.3 Organization of the Research Instrument

There are three main parts of the research instrument. Section A is on demographic information. Next, section B is questionnaire on the quality evaluation of serious game for obesity awareness. Finally, section C is an open-ended question on opinions and suggestions.

In section A, respondents require to fill up their demographic information that includes age, gender, and the frequency of playing digital games. Section B requires the respondents to answer 18 items of questions by ticking in the appropriate Smiley response that suits their preferences. Each question was categorised based on its factor and dimension. The quality factor contributed to the questionnaire involved usability, player experience, and perceived learning. Dimension involved in the questionnaire are aesthetics, learnability, operability, accessibility, user error protection, confidence, challenge, satisfaction, fun, focused attention, relevance, and learning goals. Section C is an open-ended question that follow-up on suggestion to improve to game and additional comments on the game to further improve the game based on the feedback by the respondents. The adapted and improved MEEGA+ questionnaire is shown in Appendix 14.

3.5.2.4 Pilot Study

A pilot study was conducted prior to the experimental study. Validity testing was performed using the expert pre-testing method (Jeldres et al., 2023) whereby the

experts evaluate the relevance and representativeness of items in a measurement instrument. Next, reliability testing was assessed based on the accuracy or precision of the questionnaire's measurements. (Kumar, 2011).

a) Validity Testing

Validity testing was conducted to ensure the quality and appropriateness of the questionnaire used to assess the effectiveness of the serious game prototype. Before the actual experimental study was conducted, content validity of the questionnaire was done via expert pre-testing. To ensure content validity of the questionnaire, a panel of experts was invited to review the instrument items. The experts were selected based on their experience in game design technology and public health education. Their feedback was used to assess the relevance, clarity, and appropriateness of the items.

The experts were provided with the questionnaire and asked to review each item in terms of (1) its alignment with the intended construct (usability, player experience, perceived learning), (2) clarity and age-appropriateness for the target population (students aged 7–18), and (3) completeness and coverage of the domains. While no formal rating scale was used, experts gave narrative feedback and suggestions for improvement. According to their comments, the experts noted that some items need rewording and simplification to ensure easy comprehension for children. Additionally, certain items should be discarded. Furthermore, the rating scale was adjusted from a 3-point to a 5-point rating scale to allow children to express their level of agreement or disagreement without being confined to a middle or extreme option that might not be suitable. The inclusion of Smiley icons (Smileyometer) also enhances the rating of the items. The experts' feedback contributed to refining the questionnaire before the actual experimental study was conducted. Table 3.7 below shows the improved version of the questionnaire.

Table 3.7
Description of the Components in Questionnaire Based on Improved MEEGA+

Quality factor	Dimension	Q	Item Description
Usability	Aesthetics	Q1	The game design is attractive (interface, graphics, sounds, character).
	Learnability	Q2	Learning to play this game was easy and straightforward.
	Operability	Q3	The game is easy to control and play.

	Accessibility	Q4	The fonts (size and style) and colours used in the game are understandable and meaningful.
Player experience	User error protection	Q5	When I make a mistake, it is easy to recover from it quickly.
	Confidence	Q6	When I first looked at the game, I am confident that it is easy to play, and I would learn with this game.
	Challenge	Q7	The game challenges are appropriate as it progresses without feeling frustrated and boring.
	Satisfaction	Q8	I feel satisfied with the things I learned from the game and after completing the game task.
		Q9	I would recommend this game to my friends.
	Fun	Q10	I had fun playing the game.
	Focused Attention	Q11	There was something interesting at the beginning of the game that captured my attention.
		Q12	I feel relaxed and immersed while playing the game.
	Relevance	Q13	The game contents are relevant to my interest.
		Q14	I prefer to learn through playing the game rather than traditional learning methods.
Perceived Learning	Learning goals	Q15	The game contributed to my learning on the importance of healthy food intake and physical movement.
		Q16	The game allowed me to understand the impact of not eating healthy food and performing physical activities.
		Q17	The game allowed me to understand the importance of healthy food intake and physical movement.
		Q18	The game encourages me to eat healthy food and perform physical activities.

b) Reliability testing

Reliability testing measures the degree of accuracy or precision in the questionnaire's measurement. 30 participants were involved in the testing to examine the internal consistency of instrument used based on the dimensions grouped in the adapted MEEGA+ model. The reliability testing results indicate that a lower degree of error in measurement corresponds to higher reliability of the measurement whereas higher degree errors in measurement reflect unreliability in the adapted instrument. The reliability testing employed Cronbach's coefficient alpha. Table 3.8 below shows the values computed in the SPSS software for the Cronbach's Alpha for the dimensions used in the instrument that is usability, player experience and perceived learning. Cronbach's Alpha value for usability dimension is 0.807, player experience dimension is 0.898, whereas perceived learning dimension is at value 0.759. Based on the Cronbach's Alpha values for all three dimensions, it can be shown that all values are above 0.70. Nunnally (1978) mentioned that Cronbach's Alpha coefficient of 0.70 or

greater are considered an acceptable value for internal consistency. Thus, suggesting that the instrument measured is reliable.

Table 3.8
Reliability Statistic for Usability, Player Experience, and Perceived Learning Dimensions

Dimensions	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Usability	.807	.797	5
Player experience	.898	.905	9
Perceived learning	.759	.782	4

3.5.3 Experimental Study

The experimental study was conducted to evaluate the game prototype developed based on the initial validated serious game framework. The experimental study was conducted to a group of children as target participants. Quantitative and qualitative data analysis were conducted to answer the third research question. The data were collected and analysed based on the domains in the research instrument namely; usability, player experience and perceived learning. The adaption of the research instrument was modified and amended to suit the objective of this research study. Besides that, various statistical analyses were performed during this experimental study such as, descriptive statistics on the game prototype effectiveness based on the domains (quality factors) and correlation analysis to find the correlation between the domains (quality factors). Below sections further discussed about the experimental study performed.

3.5.3.1 Sampling for Experimental Study

Children are considered those under the age of 18 years old based on (Convention on the Rights of the Child, 1989). Thus, the target sample for this study are students and children between the ages of 7 and 18 years old. A purposive sampling method is used to select sample of potential participants. Purposive sampling is a non-probability sampling technique in which the researcher selects participants based on certain criteria, such as age or gender, to ensure that the sample is representative of the population under study. The sampling relies on the judgement of the researchers on the

number of participants selected to be studied. It is an intentional selection of these individuals in order to retrieve vital information (Rai & Thapa, 2015). To decide the sample size, Roscoe (1975) suggested that the majority of studies should employ a sample size of at least 30 and 500. Therefore, this study was able to gather 47 participants who agreed to participate in the experimental study. However, only 45 participants were included in the data collection because of listwise deletion due to incomplete responses whereby after the screening, it is found that two participants were considered as excluded cases with missing data. The inclusion criteria for the study participants are that they must have given consent for the study from their legal guardian or parent, be between 7 to 18 years, be digital literate, and be able to understand English language. The exclusion criteria are that the participants must not have declined consent for the study from their legal guardian or parent, be older than 18 years old and younger than 7 years old, be digital illiterate, and be unable to understand the English language.

3.5.3.2 Data Collection Procedure

The data collection procedure for this study involved three phases. In phase one, a consent form is submitted to the legal guardian or parent of the participants (see Appendix 11). Once the consent form is received, phase two is taken place at a designated place which is a tuition centre where the participants are being briefed on the study's procedure. Before participants start playing the game, they are allowed to practice playing the game for a while in two-minute time duration to allow them to understand the game control. Then, after the trial gameplay completed, they start to play the game to complete the whole quests of the game which means to complete all four levels to be able to reach the goals of the game. The participants play the game application installed on a smartphone or tablet that have been set up priorly. The estimation time to complete the whole experimental study were about two hours and 30 minutes. However, per individual only requires an estimation of 10 to 15 minutes per gameplay session including answering the questionnaire after the gameplay.

The questionnaire was distributed through different mobile devices that have specifically been prepared for answering questionnaire using the MEEGA+ measurement tool that evaluates the game's quality and effectiveness in terms of usability, player experience, and perceived learning on mobile devices prepared readily prior to the playtesting. In phase three, the questionnaire is being analysed using both

quantitative and qualitative data analysis methods. Data collection is through questionnaire that had been administered to the participants after the game playtesting. The questionnaire is based on the MEEGA+ instrument (Petri et al., 2018), which is a validated tool for evaluating the quality and effectiveness of the game. The questionnaire contained items that assess the game's usability, player experience and perceived learning as well as providing insight into the participants' attitudes towards the game and its impact on their learning outcomes. Figure 3.14 shows the flowchart of experimental study procedure.

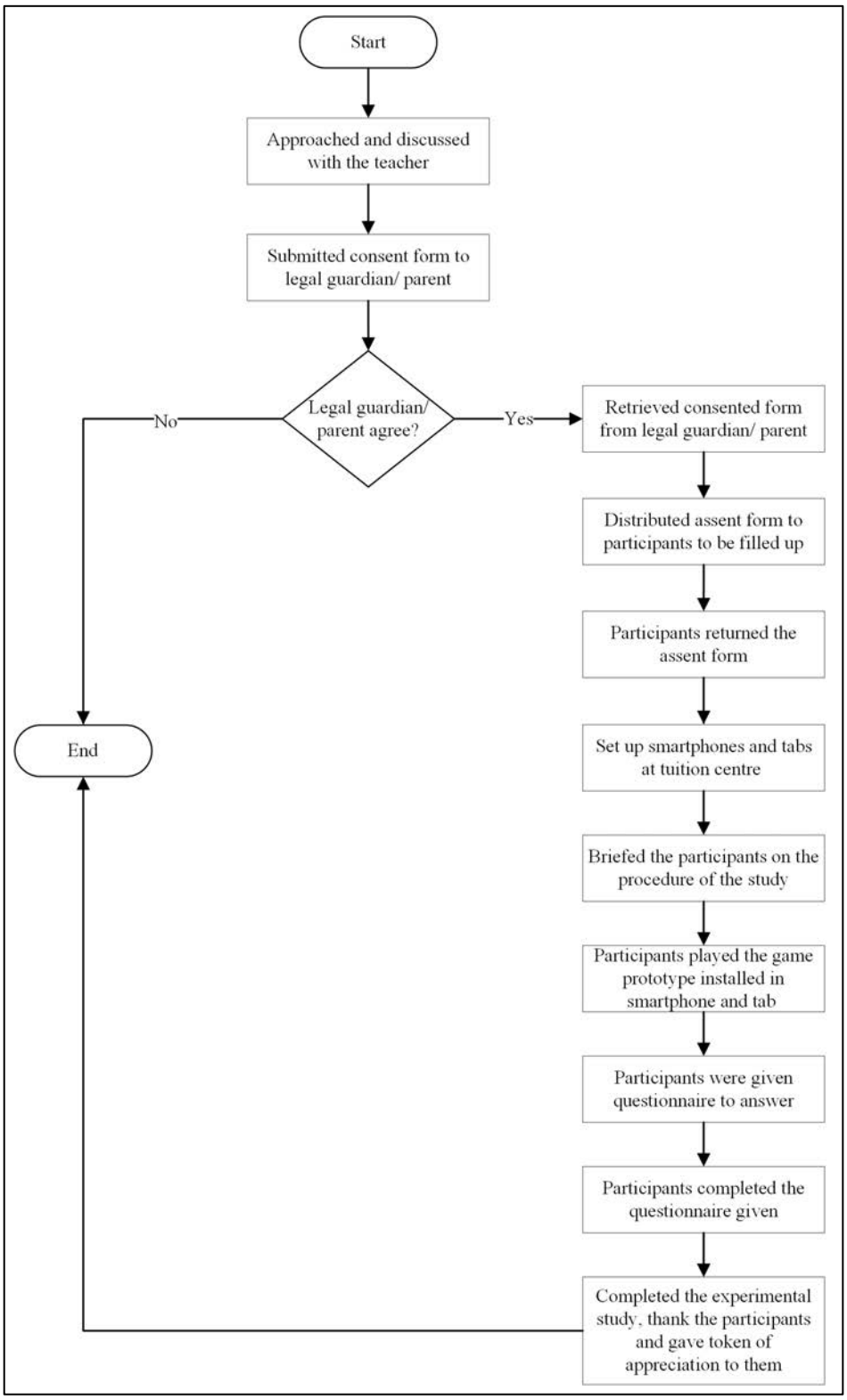


Figure 3.14 Flowchart of Experimental Study Procedure

3.5.3.3 Ethical Consideration

This study had an approval from the University Research Ethics Committee to conduct the experimental study with students and children as the participants to test out the game prototype developed. Ethical considerations were considered throughout the experimental study. The methods and procedure during the experimental study were conducted in accordance with ethical guidelines to ensure the validity and reliability of the study. The informed consent form and assent form were read to all participants prior to the experimental study to understand about the participation in the playtesting, the benefits, research risk and confidentiality. The letter of informed consent follows the University Research Ethics Committee guidelines. The risks to human subjects associated with this study is minimal. All participants were under 18 years old, with consented given from their legal guardians. The participants are also digital or computer literate and able to understand English language. These criteria qualified them as participants in this study. Additionally, this study had an approval from the Ministry of Education to conduct experimental study with the children as participants. The ethics approval from the University Research Ethics Committee and Ministry of Education are shown in Appendix 12 and 13.

3.5.4 Data Analyses

Throughout the evaluation phase, empirical evidence was gathered and then validated through rigorous data analysis. The methodologies employed were specifically tailored to the data and findings, strategically designed to address the research questions. The subsequent analyses in the experimental study are outlined as follows:

a) Reliability analysis using Cronbach's Alpha: to check the internal consistency of the adapted questionnaire items for each domain.
b) Descriptive statistics analyses: to summarize the central tendency and dispersion of scores for each domain.
c) Content analysis: to gather and analyse feedback from participants regarding the game play and experience.
d) Correlation analysis: to determine if there are significant relationships

between the scores in different domains.

The data analyses were conducted using statistical package IBM social sciences (SPSS) version 29.0.2.0 (20) and Microsoft Excel version 16.88 to analyse and visualize the findings from the study. Further explanation on the analyses is in Chapter 4 and Chapter 5. Firstly, reliability analysis was conducted using Cronbach's Alpha to check the internal consistency of the adapted MEEGA+ questionnaire items for each domain. The next analysis is the descriptive statistics involve the representation and numerical analysis of a set of data. It calculates the frequency of responses, means and standard deviations for each measurement item to summarise data and identify patterns. The results are presented in accordance with the quality factors and dimensions of the MEEGA+ model. Data analysis involved the use of mixed method analysis. Quantitative data are analyzed using a data spreadsheet, such as Microsoft Excel, along with the SPSS software tool to analyze and visualize the results, which are then translated into charts and graphs for enhanced visualization and understanding. Meanwhile, qualitative data are analyzed through content analysis to gather feedback and further insights based on participants' comments.

Subsequently, correlation analysis was conducted using Spearman's Rank Correlation Coefficient (ρ). Additionally, the p-value was obtained to determine the statistical significance. The measured data is by a correlation coefficient ranging from -1 to +1 whereby +1 indicates a perfect positive relationship, -1 indicates a perfect negative relationship and 0 has no relationship. Besides that, the significance (p-value) indicates $p<0.05$ as the correlation is statistically significant and $p>0.05$ indicates that the correlation is not statistically significant. This study utilised data spreadsheet in Microsoft Excel and SPSS software tools to analyse and provide the visualization outputs from the findings. Table 3.9 below shows the statistical procedures used in the experimental study. Further explanations for the analysis are in Chapter 5.

Table 3.9
Statistical Procedures Used in the Experimental Study

Statistical procedures	**Type of procedures**
Descriptive analysis	Frequency, mean and standard deviation
Reliability analysis	Cronbach's Alpha
Correlation analysis	Spearman's correlation

3.5.4.2 Unit of Analysis

Data analysis stage is closely related to unit of analysis. Unit of analysis refers to the major entity studies at the subsequent data analysis stage (Sekaran & Bougie, 2010; Trochim & Donnelly, 2001). The unit of analysis, therefore, could be in the form of individuals, groups, or even artefacts. The following are the units of analysis identified in this whole study:

a) Experts interview in preliminary study

The interviews were conducted with experts during the early phase to gather insights, perspectives, and expert opinions on the problem of obesity awareness and potential solutions through serious games. Five experts were selected which came from field of public health. They came from various background such as (1) nutrition and dietetics, (2) physiotherapy, and (3) nursing.

b) Experts review for the proposed serious game framework

A total of six experts were involved in the expert reviewing. Three experts are from game design field and another three experts specialize in health nutrition field. The experts are selected based on their expertise in the fields of game design such as Human Computer Interaction (HCI) and in health science (nutrition and dietetics). All experts had more than three years of experience in their respective fields and had previously conducted research or published work related to their relevant area of expertise.

c) Expert review in storyboard review

Experts in the field of game design and health science were consulted to provide feedback and recommendations for improvement in the storyboard. Three experts in total were involved in the review process whereby two of the experts were experienced in game design, gamification, and user experience. Another expert had expertise in nutrition in community. The experts selected have between seven to seventeen years of experience.

d) Participants of pilot study

A pilot study was conducted to examine the reliability test of the questionnaire provided for the actual experiment study. Validity testing was performed using the expert pre-testing method. Subsequently, thirty participants were involved in the pilot study to assess the internal consistency of the instrument used using the reliability test before the actual experimental study. The number of participants involved is considered relevant and reliable as suggested by (Sekaran & Bougie, 2010).

e) Participants in experimental study

47 participants agreed to participate in the experimental study. However, 45 participants' result were being evaluated because of the outliers/ missing data. The respondents participated to assess the evaluation of the effectiveness of game prototype developed based on proposed serious game framework.

3.6 Summary

The aim of this chapter was to elucidate the research methodology employed for addressing the research questions. A comprehensive discussion on the sampling design, data procedures, data collection, research instruments, and data analyses outlined the specifics of the study execution. This study employed a mixed method approach and aimed to address the research questions posed herein. The development of a serious game framework was enhanced through the collaborative efforts of experts who shared their expertise in game design and health nutrition, resulting in a more comprehensive and effective outcome. Subsequently, a game prototype was developed to validate the game framework in an experimental study. Chapter 4 and 5 are dedicated to presenting the findings and confirming adherence to the methodology delineated in Chapter 3.

CHAPTER 4
THE PROPOSED SERIOUS GAME FRAMEWORK FOR OBESITY AWARENESS AND EXPERT REVIEW FINDINGS

4.1 Introduction

This chapter focuses on the serious game framework construction process and the initial validation of the framework through expert review. The methods used in developing the framework include literature research, systematic review, and expert reviews. The main objective of constructing the serious game framework is to provide a structured and comprehensive approach to designing serious game that promotes obesity awareness. These processes were conducted to answer the first and second research questions within this research domain:

a) What are the suitable components and elements for a serious game framework promoting obesity awareness?
b) To what extent does the game prototype developed based on serious game framework meet the multi-dimensional quality factors of usability, player experience, and perceived learning for obesity awareness?

4.2 Conceptualize Framework

In the field of serious game design, the development of a comprehensive framework is essential for creating effective serious games. This chapter aims to discuss the construction process of a serious game framework, as well as presenting the results of expert review initial validation on the framework. The proposed framework is based on the established Information-Motivational-Behavioural Skills (IMB) model, which serves as a guiding framework and foundation for the development of the new proposed framework. The IMB Model is a well-established framework from the field of health behaviour research that has been adapted for use in serious game design. Besides that, Social Cognitive Learning, Self-Determination Theory, and Theory of Planned Behaviour were also incorporated into the framework as supplementary theoretical lenses, specifically because these theories serve to operationalize the ‘Motivation’ and

'Behavioural Skills' components of the IMB model, providing a more granular understanding of the psychological mechanisms at play which is to enhance understanding of health behaviour change, motivation and cognitive gains in the context of serious games for obesity awareness. The construction of the serious game framework involved several steps as mentioned in Figure 4.1 below.

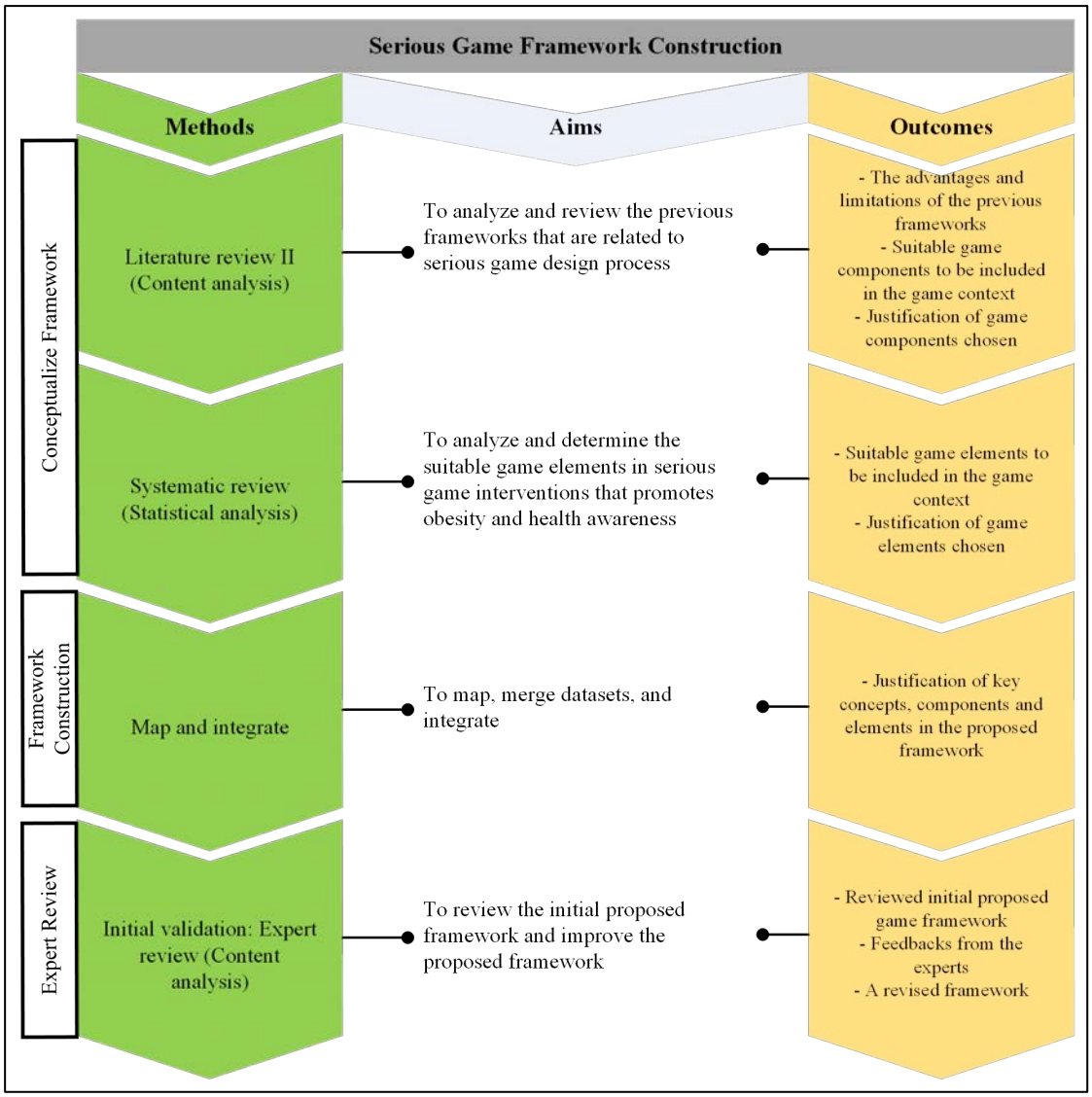


Figure 4.1 Summary of Activities for Serious Game Framework Construction

Figure 4.1 above shows the summary activities involved in the construction of the serious game framework. The process involved four phases, beginning with a literature search (literature review II) to analyse and review existing frameworks and models relevant to the game design process to identify suitable components for the proposed framework. This was followed by a systematic review of literature to analyse

and determine the relevant suitable game elements in serious game interventions that promotes health and obesity awareness. These first two methods were conducted using content analysis, followed by statistical analysis. Both methods aimed to answer the first research question. In this framework, components represent the domain and construct of the IMB model, serving as its guidelines. Meanwhile, elements are the conceptual pieces that illustrate how components and other parts interconnect, as well as how they collectively form the entire framework.

Next, the process of mapping and integration were conducted to synthesize the findings from the literature reviews and systematic reviews to develop the initial proposed framework. The objective is to map and integrate the components and elements selected after the findings. The final phase is the initial validation through expert review, where the proposed framework components were reviewed and validated by experts in the field of game design and health nutrition. Quantitative and content analysis method were used to analyse the feedback provided by the experts and identify any areas of improvement or refinement for the framework.

4.2.1 Findings on Existing Game Frameworks and Models (Literature Review II)

The results of the literature review revealed several existing serious game design frameworks that met the selection criteria. These frameworks were further analysed and compared to identify common components and elements that are suitable to be included in serious game design frameworks. The literature search revealed six existing frameworks that fulfilled the criteria as mentioned in Chapter 3. The six existing frameworks are by Thompson et al. (2010), Starks (2014), Mitgutsch & Alvarado (2012), Yusoff et al. (2009), Ibrahim & Jaafar (2009), and Garris et al. (2002). Since the focus is on game design process and serious game, most frameworks cater to educational purposes and incorporate learning content within their structure. Besides that, there are also frameworks that focus on game design principles and game evaluation.

4.2.1.1 Grouping of Components from Existing Game Frameworks and Models

Grouping components from existing frameworks is a viable way to identify related or similar-meaning components. The method used to group the components were based on Khowaja (2017), whereby the first step is grouping the components within the intra-frameworks. The components were determined through the descriptions mentioned, provided insight into the various terms used to express similar meanings across the frameworks. The second step is grouping the components within the inter-frameworks. Based on the analysis performed, the term used were of similar meaning between one another. Hence, the next step is to take these generic components and either create new descriptive names for them or maintain the existing names as intended. The new names for the components were based on the existing components in the selected frameworks.

a) Grouping within intra-frameworks

The grouping of components is based on their functionalities and their relationship to the overall game design process. Within the intra-frameworks, the components are extracted from each of the selected frameworks and grouped into relevant categories. The description of the components in the framework was influenced by the IMB model, which emphasizes the role of information, motivation, and behaviour skills in driving health behaviour change.

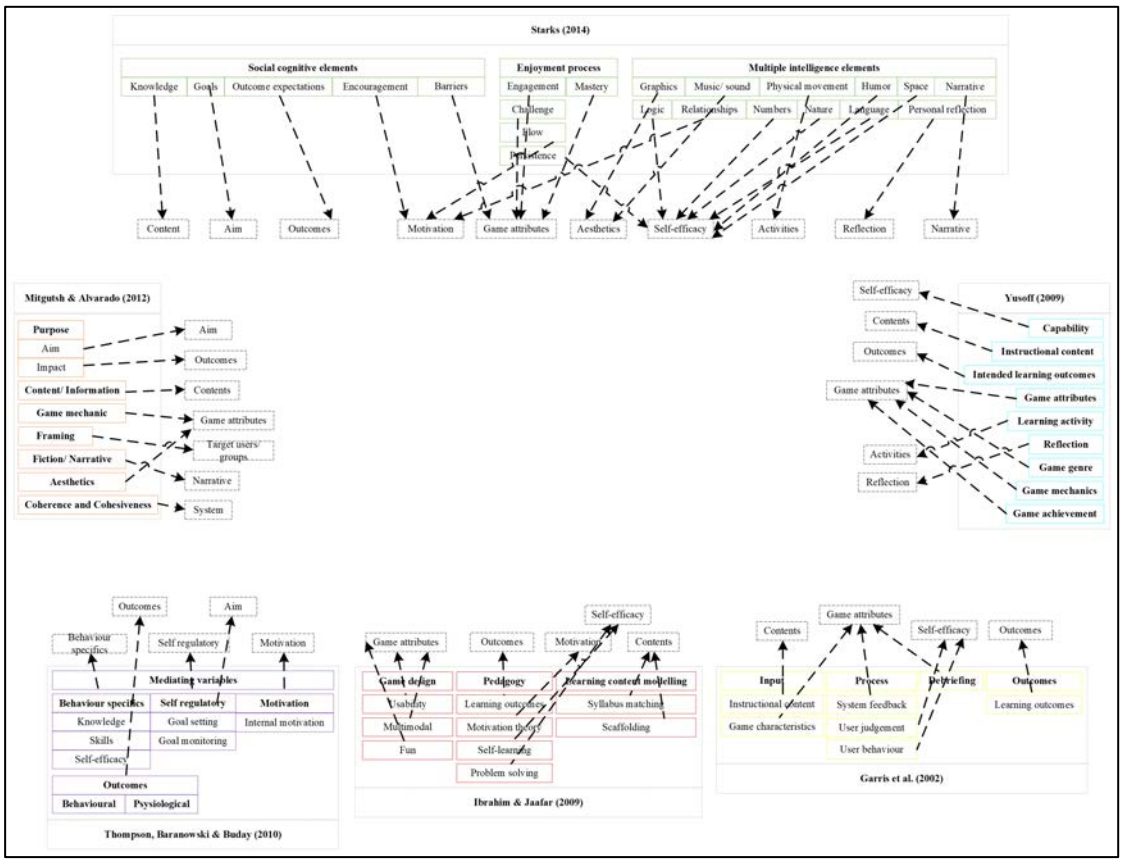


Figure 4.2 Components Grouping Within Intra-Frameworks

A total of 14 components were extracted from the components in the selected frameworks out of the original 51 components. The 14 components were ‘Contents’, ‘Aims’, ‘Outcomes’, ‘Motivation’, ‘Game attributes’, ‘Aesthetics’, ‘Self-efficacy’, ‘Activities’, ‘Reflection’, ‘Narrative’, ‘Self-regulatory’, ‘Behaviour specifics’, ‘System’, and ‘Target users’. Almost all components mentioned are identified in all frameworks with slight variations in terminology or level of detail. In some cases, different frameworks may use different terminology to refer to similar components. For example, ‘Outcomes’ were extracted as a common component from all the selected frameworks, but may be referred to as ‘Learning goals’, ‘Impact’, ‘Outcome expectations’ in other frameworks. Additionally, the term ‘Game attributes’ in the selected frameworks may be referred to as ‘Game mechanics’, ‘Game elements’, or ‘Game features’ in other frameworks. Some may use a much-detailed term such as ‘Engagement’ or ‘Multimodal’ which refers to a broader term of game attributes. Figure 4.2 above shows the components grouping within intra-frameworks.

b) Grouping within inter-frameworks

Within the inter-frameworks grouping, a more detailed analysis was conducted to identify the common component across the selected frameworks and to compare their definitions or descriptions. The method used for the inter-framework grouping involved analysing the definitions and descriptions of the already extracted components during the intra-framework grouping. This means that the 14 components extracted in the intra-framework grouping were used as a basis for comparison and further analysis within the inter-frameworks grouping. The purpose of this analysis was to identify any similarities or overlapping concepts between the frameworks, as well as any variations or differences in terminology or level of detail used to describe the components. Figure 4.3 below shows the components grouping within inter-frameworks.

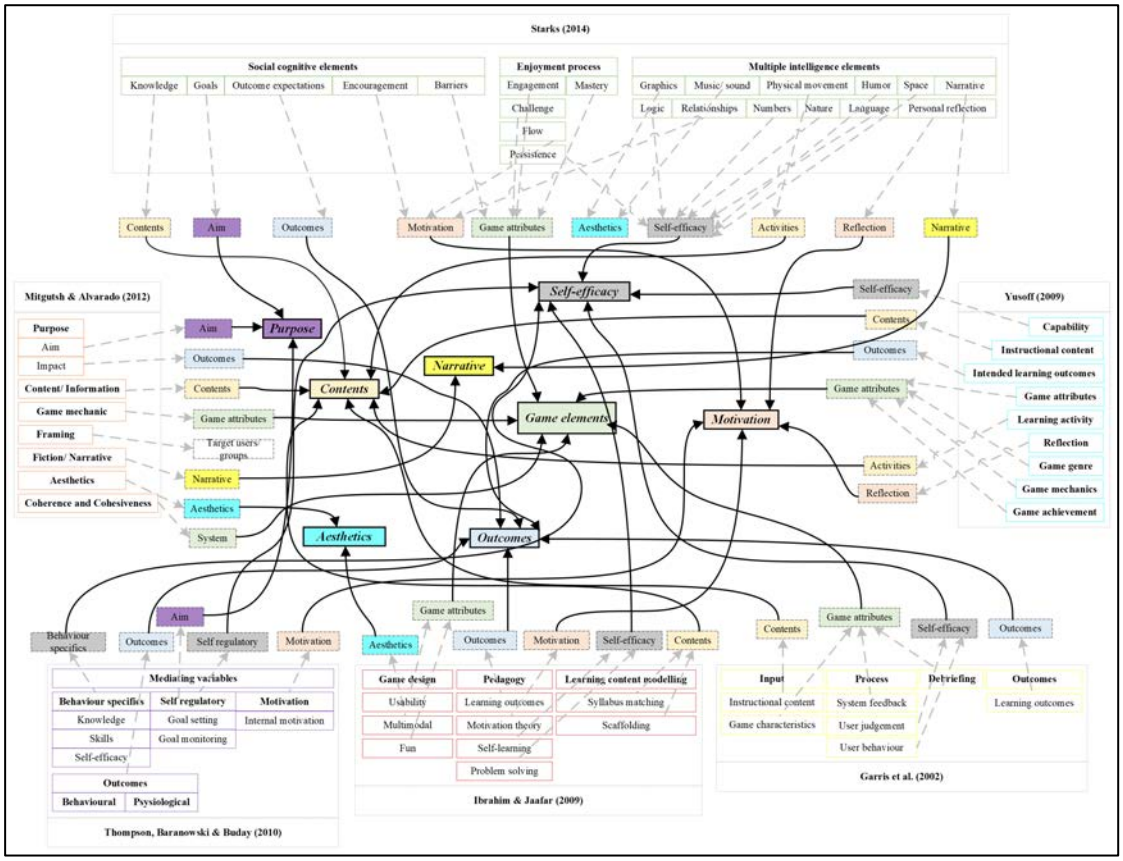


Figure 4.3 Components Grouping Within Inter-Frameworks

After the inter-frameworks grouping, a total of eight components were identified. These components were grouped based on their similarity in terms of their definitions and descriptions of the extracted components earlier. The identified

components were: ‘Purpose’, ‘Contents’, ‘Narrative’, ‘Aesthetics’, ‘Game elements’, ‘Self-efficacy’, ‘Motivation’, and ‘Outcomes’. Besides that, similar to the intra-frameworks grouping, the description of the components in the framework was influenced by the IMB model, which emphasizes the role of information, motivation, and behaviour skills in driving health behaviour change. Therefore, while analysing the frameworks, the components in IMB model were keep in mind to tally with the components extracted from the selected game frameworks. For example, ‘Motivation’ in IMB model was referred to the similar components such as ‘Encouragement’, ’Reflection’, ’Flow’, ‘Internal motivation’, and ‘Motivation theory’. Whereas ‘Behaviour skills’ in the IMB model were represented by ’Self-efficacy’, ’Self-regulatory’, and ‘User behaviour’ and ’Judgement’. Additionally, ‘Health outcomes’ were included to align with components named ‘Outcome expectations’, ‘Intended learning outcomes’, ‘Learning outcomes’, or ‘Physiological and ‘Behavioural outcomes’.

As a result of the analysis, several new generic components were identified and group in the framework shown in Figure 4.3. These components include ‘Purpose’ (represented by the colour purple), ‘Contents’ (beige), ‘Narrative’ (yellow), ‘Aesthetics’ (turquoise), ‘Game elements’ (green), ‘Motivation’ (orange), ‘Self-efficacy’ (grey), and ‘Outcomes’ (blue).

Consequently, the choice of using generic component names was made based on the need for uniformity and clarity across the frameworks being analysed, as well as their alignment with the components in IMB model. The generic component names were selected based on existing component names or newly created names to represent the common meanings and descriptions that emerged from the analysis of the frameworks. For example, the component ‘Contents’ was chosen from the existing component name by Mitgutsch & Alvarado (2012) to represent the content or information included in the game framework. Other frameworks also represent the similar meaning of contents with different terms such as instructional contents (Garris et al., 2002; Yusoff et al., 2009), ‘Learning content modelling’ (Ibrahim & Jaafar, 2009) or ‘Knowledge’ (Starks, 2014) which all brings forth the idea of including relevant information or content in the game framework. The choice to remove the framing/target users component in the framework was based on the finding that only one of the analysed frameworks explicitly included this component. This suggests that including target users as a separate component may not be a common practice in the existing game

design frameworks. Instead, the focus of the framework is on the components that are consistently identified across multiple frameworks and are essential for designing serious games.

The common term extracted during the intra-frameworks such as 'Aims' gives similar meaning like 'Purpose' that is one of the components proposed by Mitgutsch & Alvarado (2012). In this framework, the author used the term 'Purpose' to bring the meaning for both aim and impact. However, in other frameworks such as by Starks (2014) and Thompson et al. (2010), the term that refers to 'Purpose' or 'Aim' are 'Goals' and 'Goal setting', which brings similar meaning to the generic term used which is 'Purpose'. The change to generic terms was made to ensure uniformity and clarity across the frameworks being analysed.

Table 4.1
Grouping of Common Components in Game Frameworks

Related components in the selected frameworks and the references	**Components within intra frameworks**	**Grouping components within inter frameworks with the same/ similar/ new name created**	**IMB related components**
Narrative (Starks, 2014; Mitgutsh & Alvarado, 2012)	Narrative	Narrative	Game context (Information)
Aesthetics (Mitgutsh & Alvarado, 2012); Multimodal (Ibrahim & Jaafar, 2010)	Aesthetics	Aesthetics	Game context (Information)
Goals (Starks, 2014); Goal setting (Thompson, Baranowski & Buday, 2010); Aim (Mitgutsh & Alvarado, 2012)	Aim	Purpose	Game context (Information)
Encouragement, Flow, Relationships, Personal reflection (Starks, 2014); Internal motivation (Thompson, Baranowski & Buday, 2010); Motivation theory ((Ibrahim & Jaafar, 2010); Reflection (Yusoff, 2009)	Motivation, Reflection	Motivation	Motivation
Barriers, Engagement, Challenge, Mastery (Starks, 2014); Game mechanic, Coherence and cohesiveness (Mitgutsh & Alvarado, 2012); Fun, Usability (Ibrahim & Jaafar, 2009); Game characteristics, System feedback, Debriefing (Garris et al., 2002), Game attributes, Game genre, Game mechanics, Game achievement (Yusoff, 2009)	Game attributes, System	Game elements	Game context (Information)
Outcome expectations (Starks, 2014); Impact (Mitgutsh & Alvarado, 2012); Behavioural and physiological outcomes (Thompson, Baranowski & Buday, 2010); Learning outcomes (Ibrahim & Jaafar, 2010; Garris et al., 2002); Intended learning outcomes (Yusoff, 2009)	Outcomes	Outcomes	Outcomes
Persistence, Logic, Numbers, Nature, Language, Humour, Space (Starks, 2014); Knowledge, Skills, Self-efficacy, Goal monitoring (Thompson, Baranowski & Buday, 2010); Self-learning, Problem solving (Ibrahim & Jaafar, 2010); User judgement, User behaviour (Garris et al., 2002);	Self-efficacy, Self-regulatory, Behaviour specifics	Self-efficacy	Behaviour skills

Capability (Yusoff, 2009)			
Knowledge, Physical movement (Starks, 2014); Content/ Information (Mitgutsh & Alvarado, 2012); Syllabus matching, Scaffolding (Ibrahim & Jaafar, 2010); Instructional content (Garris et al., 2002); Instructional content, Learning activity (Yusoff, 2009)	Contents, Activities	Contents	Game context (Information)

Table 4.1 above shows the summary of the overall components and sub-components identified from the existing selected game frameworks. Based on the content analysis; 'Learning contents', 'Self-efficacy', and 'Learning outcomes' are the common components present in most frameworks. Other components include 'Game attributes', 'Motivation', 'Purpose', 'Aesthetics', and 'Narrative'. In conclusion, through the analysis, it is found that 51 components have been identified and extracted from the selected frameworks that is related to game design process. After the extraction and grouping components process through intra- and inter framework, eight components have been identified.

4.2.2 Findings based on Game Elements in Serious Game Interventions (Systematic Review)

A systematic review of game elements in serious game interventions was conducted to identify the most common and suitable game elements utilized in such interventions. The PRISMA guideline was employed for this review. 17 studies were selected based on the inclusion and exclusion criteria provided. The list of selected studies is shown in Table 4.2 below.

Table 4.2
The List of Selected Studies

References	Year	Game title	Focus of awareness
(Robles et al., 2020)	2020	Run Boy Go!	Nutrition and physical activity
(S. Michael et al., 2018)	2018	NutritionBuddy	Nutrition
(Gonçalves et al., 2020)	2020	Barty	Nutrition
(Saad et al., 2018)	2018	GrowHealthy	Nutrition and physical activity
(S. L. Kim et al., 2014)	2014	Calory Battle AR	Physical activity
(Lindberg et al., 2016)	2016	Running Othello 2 (RO2)	Physical activity

(Fadhil & Villafiorita, 2017)	2017	CiboPoli	Nutrition
(Saksono et al., 2015)	2015	Spaceship Launch	Physical activity
(Ma et al., 2020)	2020	FitBirds	Physical activity
(Alnaqbi et al., 2021)	2021	ObeseGo	Nutrition and physical activity
(Espinosa-Curiel et al., 2020)	2020	FoodRateMaster	Nutrition and physical activity
(Y. Wang et al., 2020)	2020	Exer-Learning Playground Game	Physical activity
(Dias et al., 2016)	2016	DigesTower	Nutrition and physical activity
(Garde et al., 2015)	2015	MobileKids Monster Manor	Physical activity
(AL-Qurishi et al., 2014)	2014	StarsRace	Physical activity
(Mayr et al., 2016)	2016	Aquamorra	Nutrition and physical activity
(Majumdar et al., 2013)	2013	Creature-101	Nutrition and physical activity

All 17 studies considered serious game interventions to promote a healthy lifestyle for children. Furthermore, these studies varied in terms of the focus of awareness in obesity health promotion. In this review, 18% of the studies focused on nutrition awareness, while 41% targeted encouragement of physical activity alone and awareness of both nutrition and physical activity in serious game intervention (see Figure 4.4). In this study, children are the target users. According to the Convention on the Rights of the Child (CRC), a child means any individual under eighteen years of age, except in cases where applicable laws recognize an earlier age of majority for the child (Convention on the Rights of the Child, 1989). In addition, World Health Organization (2020) set out recommended interventions to promote health and wellbeing of children and adolescents which they considered as those aged below 19 years old. In conclusion, the target end users of the intervention in most of these studies were aged between 3 and 14 years, with one study mentioning that their intervention could be used in all age ranges.

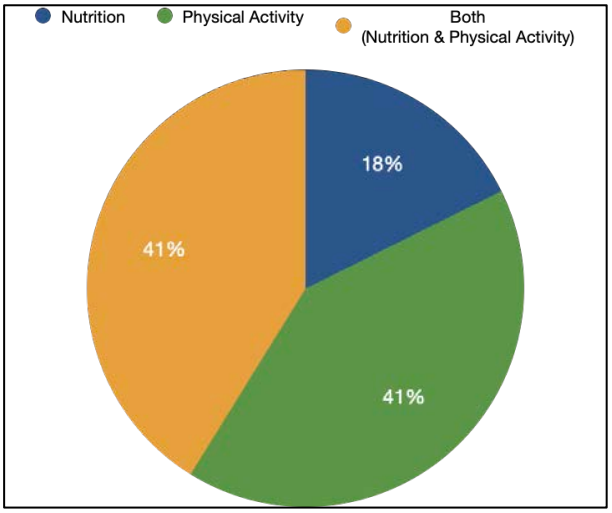


Figure 4.4 Focus of Awareness in Serious Game Interventions

Besides that, all games in the selected studies were digital games that involved several platforms such as Augmented Reality (AR), Virtual Reality (VR), and mobile applications. Most serious games are either 2D or 3D games, including platform game, board game and persuasive games. Most of these studies targeted children as sole end users, and some serious games allow children to collaborate with their parents, guardians, tutor and experts. Even though, the targeted group is children, there are also

serious games that target all age groups for intervention. Furthermore, some of the interventions included single and multiplayer modes and collaborative game involvement.

Table 4.3
Game Elements Categorization Taxonomy Based on Werbach & Hunter (2012)

Studies	Categories	Components													Mechanics									Dynamics					
	Game elements	Achievement	Avatar	Boss fights	Collections	Content unlocking	Gifting	Leaderboards	Levels	Points	Quests	Social graph	Teams	Virtual goods	Challenges	Chance	Competition	Cooperation	Feedback	Resource acquisition	Rewards	Transactions	Win states	Emotions	Constraints	Narrative	Progression	Relationship	Total
(Robles et al., 2020)		√	√					√	√	√	√			√	√		√		√	√	√		√		√		√		15
(Michael et al., 2018)		√	√			√			√	√	√						√	√	√	√	√		√	√	√		√		15
(Gonçalves et al., 2020)		√	√							√	√				√				√					√	√		√		9
(Saad et al., 2018)		√	√						√	√	√				√				√	√	√		√	√	√	√	√	√	15
(Kim et al., 2014)		√	√		√					√	√				√					√			√		√	√			10
(Lindberg et al., 2016)		√			√					√	√				√		√	√	√				√	√	√				11
(Fadhil & Villafiorita, 2017)		√	√				√	√	√	√	√	√			√	√	√	√	√	√	√	√			√		√		18
(Saksono et al., 2015)		√				√					√		√		√			√	√		√		√	√		√	√	√	13
(Ma et al., 2020)			√					√	√	√	√		√		√		√	√	√		√				√	√	√		14
(Mohamed Alnaqbi et al., 2020)			√							√	√		√		√	√		√	√	√			√	√	√		√		13
(Espinosa-Curiel et al., 2020)		√	√	√		√		√	√	√	√								√	√	√		√	√	√	√	√		16
(Wang et al., 2020)								√	√	√	√		√		√		√	√	√		√		√		√		√		13
(Dias et al., 2016)		√	√						√	√	√				√				√	√	√		√		√	√	√		13
(Garde et al., 2015)		√	√		√			√	√	√		√	√		√			√	√	√	√		√	√	√	√	√		18
(Al-Qurishi et al., 2014)										√	√				√		√			√			√		√		√		8
(Mayr et al., 2016)			√						√	√	√			√	√			√	√	√	√	√		√		√	√		14
(Majumdar et al., 2013)		√	√			√			√	√	√	√			√				√		√		√	√	√	√	√		15
Total per game element		12	13	1	3	4	1	6	11	16	16	3	5	2	15	2	7	9	15	11	12	2	13	10	15	9	15	2	
Total per category		93									86								51										

In this review, we found 27 game elements distributed across the selected 17 studies. These game elements are classified under the taxonomy of Werbach & Hunter (2012) which consist of three categories: 'Components', 'Mechanics', and 'Dynamics'. The components category represents the basic elements, the mechanics category defines the rules and interactions, and the dynamic category focuses on the emotional and social aspects of the game experience (Werbach & Hunter, 2012). Table 4.3 above shows the frequency of game elements from each of the selected studies, including the total number of game elements for each study, total number per game element, and total number of game elements per category included in this review.

Under the components category, the most frequently included game elements were 'Points' (n=16), 'Quests' (n=16), 'Avatar' (n=13), and 'Achievement' (n=12) (see Figure 4.5). The least common game elements in this category are 'Boss fights' (n=1) and 'Virtual goods' (n=2). Total amount of game elements mentioned in this category is 93 elements.

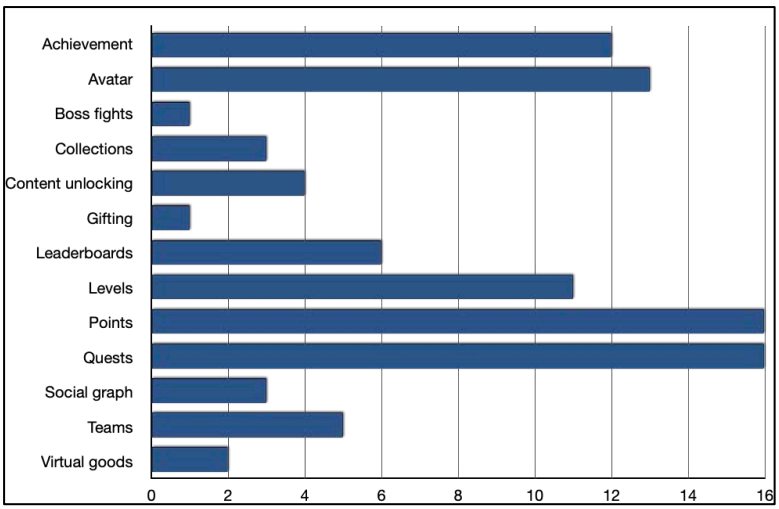


Figure 4.5 Game Element Components Category

Figure 4.6 below shows the frequency of game elements in the mechanics category extracted from Werbach & Hunter (2012) taxonomy. It is shown that the most common game elements in this category are 'Challenges', 'Feedbacks' (n=15), followed by 'Win states' (n=13), 'Rewards' (n=12), 'Resource acquisition' (n=11), 'Cooperation' (n=9), 'Competition' (n=7), and the least common game elements extracted were 'Chance' and 'Transactions' (n=2). The total amount of game elements listed in this category is 86 elements.

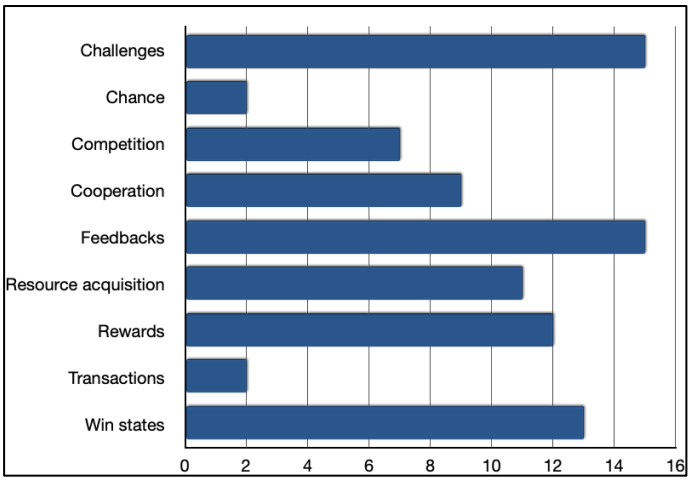


Figure 4.6 Game Element Mechanics Category

The dynamics category of this game taxonomy consists of five game elements that had been extracted from the selected studies. The most common game elements found were 'Constraints' and 'Progression' (n=15), then 'Emotions' (n=10), followed by 'Narrative' (n=9) and the least one is 'Relationship' (n=2) (see Figure 4.7). The number of game elements listed in this category is 51.

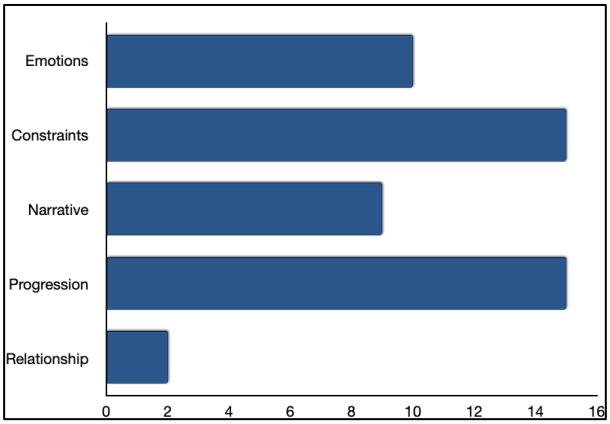


Figure 4.7 Game Element Dynamics Category

Overall, out of the 17 studies selected for this review, two studies had the highest number of game elements extracted in a paper, with a total of 18 game elements extracted. On average, each study extracted 13 game elements. Additionally, the extraction of more than 12 game elements per category (n>=12) suggests that these elements are considered the most common and suitable game elements for serious game

interventions. This study identified ‘Points’, ‘Quests’, ‘Challenges’, ‘Feedback’, ‘Constraints’, ‘Progression’, ‘Avatar’, ‘Win states’, ‘Achievement’, and ‘Rewards’ as the prevalent and most appropriate game elements in serious game interventions.

4.3 Framework Construction

The proposed game framework is based on key components identified through the analysis of existing frameworks and systematic approach to identifying game elements suitable in serious game interventions. The components included were identified through a content analysis and systematic review of existing game design frameworks and game elements in serious game interventions. The findings from previous activities are now mapped and integrated to develop a proposed game framework. In this section, the process of constructing the framework is underway. The Information-Motivation-Behavioural Skills (IMB) model serves as both a guiding framework and a foundational backbone for the proposed game framework.

4.3.1 Map and Integrate

In this activity, the process of mapping and integration is undertaken to develop a comprehensive proposed game framework. The components and elements identified in game design process are then mapped to the appropriate components and structure of the framework. Furthermore, they are integrated to ensure all components and elements are seamlessly blended.

4.3.1.1 Information-Motivation-Behavioural Skills (IMB) Model as Framework Guide

The IMB Model, which stands for Information-Motivation-Behavioural Skills Model, serves as a guiding framework for the proposed game framework. According to the model, if an individual possesses the adequate information, motivation to engage in the target actions, and the necessary behavioural skills, they will likely commence and maintain health-promoting behaviours, leading to a favourable health outcome (W. A. Fisher et al., 2003). The components involved in this model is ‘Information’, ‘Motivation’, ‘Behavioural Skills’, and ‘Health Outcome’. These four components

serve as the foundation for the proposed game framework, ensuring that the game is designed to effectively deliver information, motivate players, and develop necessary skills for targeted behaviour change. The model indicates that for a serious game to effectively facilitate behavioural change, the game must incorporate the necessary components and elements that align with the existing components of this model.

The 'Information' construct in IMB model is the major component, as the game context is encompassed within this component. It provides the necessary information to educate players about health and obesity awareness through the design of serious game. In the proposed game framework, the 'Information' construct is where all components found based on the content analysis of existing game frameworks are incorporated, including systematic review on finding the game elements suitable in promoting health and obesity awareness. Besides that, the 'Motivation' construct in the IMB model is integrated into the proposed game framework by considering motivational elements and strategies that can engage and encourage players to actively involve in the game play. Furthermore, the 'Behavioural skills' construct in the IMB model is translated into behaviour specifics, such as self-efficacy, self-regulatory, capability or user behaviour in the proposed game framework. The 'Health Outcome' in the IMB model is the desired health outcome that is targeted through the game play of serious game. These components together create a comprehensive framework that encompasses the necessary elements for achieving targeted behavioural change and cognitive gain through serious games.

4.3.1.2 Mapping and Integration Process

In this section, the process of mapping and integrating components and various game elements into a cohesive framework will be discussed. Mapping and integration stem from the results of content analysis of existing frameworks and systematic review of game elements in serious game interventions.

a) Identification of components

The first step in the process of mapping and integrating components is the identification of components. The components were identified through a thorough content analysis of existing frameworks and a systematic review of game elements in

serious game interventions. The identified components include ‘Purpose’, ‘Contents’, ‘Narrative’, ‘Aesthetics’, ‘Game elements’, ‘Self-efficacy’, ‘Motivation’, and ‘Outcomes’. These components were found to be common across various frameworks and interventions, indicating their importance in the design of serious games (see Table 4.4). The game elements that were most suitable within serious game interventions were included under the ‘Game elements’ component. The identified elements are ‘Points’, ‘Quests’, ‘Challenges’, ‘Feedback’, ‘Constraints’, ‘Progression’, ‘Avatar’, ‘Win states’, ‘Achievement’, and ‘Rewards’. The identification of these components and elements provide a foundation for the mapping and integration process, ensuring that all relevant aspects are considered in the framework construction.

Table 4.4
Components, Description in Framework, and the Sources Used to Gather Details

Components	Purposes/ Description	Sources
Purpose	Act as a driving force that shapes dynamic and coherence game system through the game’s aim and impact to the players	(Starks, 2014; Mitgutsh & Alvarado, 2012; Thompson, Baranowski & Buday, 2010)
Narrative	The setting, theme, story, scenario, characters, back story and problem in the gameplay	(Starks, 2014; Mitgutsh & Alvarado, 2012)
Aesthetics	The audio and visual representation for the display of the elements in the game	(Mitgutsh & Alvarado, 2012); Ibrahim & Jaafar, 2010)
Contents	Information, learning contents, facts, and data offered that are used in the game context	(Starks, 2014; Mitgutsh & Alvarado, 2012; Ibrahim & Jaafar, 2010; Yusoff, 2009; Garris et al., 2002)
Game elements	Components or parts that are embedded in a game	(Starks, 2014; Mitgutsh & Alvarado, 2012; Ibrahim & Jaafar, 2009; Yusoff, 2009; Garris et al., 2002)
Motivation	The ability and influences toward the inclination of health behaviour action when well-informed	(Starks, 2014; Thompson, Baranowski & Buday, 2010; Ibrahim & Jaafar, 2010; Yusoff, 2009)
Self-efficacy	The capability to impose behaviour change when well-informed and well-motivated	(Starks, 2014; Thompson, Baranowski & Buday, 2010; Ibrahim & Jaafar, 2010; Garris et al., 2002; Yusoff, 2009)
Outcomes	Well-informed and well-motivated individuals can engage in health promotion activities by leveraging behavioural skills to influence perceived behaviour change	(Starks, 2014; Mitgutsh & Alvarado, 2012; Thompson, Baranowski & Buday, 2010; Ibrahim & Jaafar, 2010; Yusoff, 2009; Garris et al., 2002)

b) Identification of structure (IMB model as framework guide)

The next step in the process of mapping and integrating components is the identification of structure, which will be guided by the IMB model. The structure involved the components in IMB model which are information, motivation, behaviour skills, and health outcomes (see Table 4.5). This original structure gave the foundation of the proposed framework and works as framework guide in designing framework supporting obesity awareness in serious game. The primary goal of this research study is to develop a serious game framework that can foster perceived changes in behaviour and increased knowledge regarding health and obesity awareness. To achieve this comprehensive proposed game framework, a robust and innovative framework is essential as the foundation and guiding principles.

Table 4.5
IMB-Based Serious Game Framework

IMB-construct	Proposed framework in this research	IMB Model
Information	Game context: Components in game context -Purpose (Aim and Impact) -Narrative -Aesthetics -Contents -Game elements	Health behaviour information
Motivation	Motivation – Well-motivated during game play and gain knowledge on obesity awareness	Health behaviour motivation
Behaviour skills	Self-efficacy – Capability to retrieve information obesity awareness while playing the game	Health behaviour skills
Health outcomes	Outcomes – Knowledge gaining in obesity awareness and perceived behaviour change (cognitive and behavioural change)	Health behaviour

c) Logical placement of components in structure

The logical placement of components in the structure is a crucial step in the mapping and integration process. The goal is to arrange the identified components in a logical manner within the structure of the framework. This ensures that the different components are interconnected and contribute to the overall design and effectiveness of the serious game framework. As the base of the framework structure, components and phases in IMB model are implemented as the backbone of the framework whereby 'Information' construct is considered the game context in this proposed framework. The 'Information' construct also comes with components in it and inclusion of game elements. Besides that, 'Motivation' is maintained in the proposed framework which

meant the purpose of being motivated during game play and ability to gain knowledge on obesity awareness.

Next, ‘Behaviour skills’ is replaced to ‘Self-efficacy’ because of the similarity of the meaning it brings in the original IMB model and this proposed framework. It brings the meaning of capability to retrieve information on obesity awareness while playing the game. The final phase is the ‘health outcomes’ or ‘health behaviour’ in IMB phase, and the proposed framework was changes to ‘Outcomes’. ‘Outcomes’ brings the intended outcomes through knowledge gaining in obesity awareness after playing the game and intended behaviour change.

4.4 Discussion on the proposed serious game framework

The serious game framework will be a comprehensive model that incorporates the identified components, their purposes, and their logical placement within the structure. The information discussed above are used as basis for the development of this game framework. It shows the phases and components inclusion in the proposed framework. The related components selected in the game framework includes the IMB-related constructs that served as the framework backbone. Figure 4.8 below shows the mapping and integration of the suitable components extracted to construct a proposed framework. Next, the following sub-sections describe all the phases of the proposed framework and the components associated with it. The discussion is based on the chosen game components of a game framework, which include ‘Purpose’, ‘Narrative’, ‘Content and Information’, ‘Aesthetics’, and ‘Game elements’. Additionally, components embedded from the IMB model, such as ‘Information’; which acts as the game context, ‘Motivation’, ‘Self-Efficacy’, and ‘Health Outcomes’, are also considered.

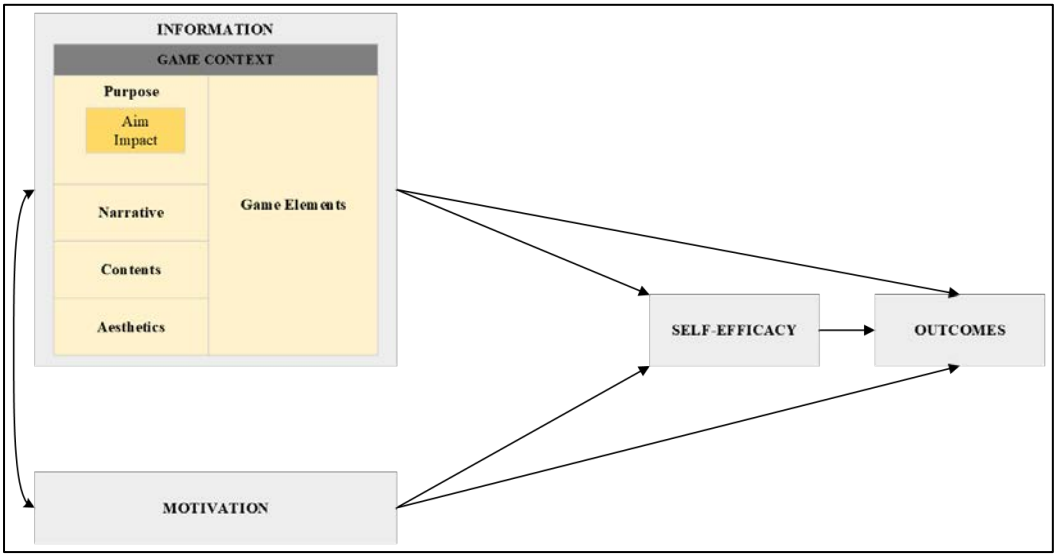


Figure 4.8 Mapping and Integration of Game Components in Proposed Framework

4.4.1 Information – Game Context

Information refers to specific information about health promotion of health and obesity behaviour in this research study context. The Information component, based on the IMB model, represents accurate and pertinent knowledge that forms the basis for informed behaviour change, Based on Fisher et al. (2003), individuals who are knowledgeable and well-informed are likely to be motivated to act and feel capable of doing so effectively. As a result, they are more inclined to begin and sustain behaviours that promote good health information, ultimately leading to positive health outcomes. Therefore, in this research study, information phase is where game context is included as it serves as a medium of information transfer. The game context involves components that are related to game design components. Each component and elements included in this game context provides different purposes in the development of serious game that promotes health and obesity awareness. The game elements included within the Information component act as guiding features, embedded in a game crafted with factual content to be delivered to the players. The elements incorporated in the Information component are Purpose, Narrative, Contents, Aesthetics, and Game elements.

4.4.1.1 Purpose

Social awareness requires purpose to achieve future change. Purpose acts as a driving force that shapes dynamic and coherence game system through the game's aim and impact to players (Mitgutsch & Alvarado, 2012). Besides, purpose is also critical whereby it can achieve a given set of learning goals by playing the game (Braad et al., 2016). Hence, the 'Aim' and 'Impact' in serious game should be clearly defined so players recognize the serious purpose of the game. In the context of serious games, it is imperative that the game possesses a well-defined objective, accompanied by structured educational content and context. The content must consist of accurate and well-scaffolded educational information that is closely aligned with the game's purpose (Asadzadeh et al., 2024).

4.4.1.2 Narrative

Narrative is a key component to provide meaningful context and storyline for players to engage with the game. It can be used to enhance the emotional connection between the player and the game, which can increase the player's motivation and immersion. Narrative can also be leveraged to convey messages or lessons in a more compelling manner. Narrative is the setting, theme, story, scenario, characters, back story, and problem in the gameplay. These enables players to create their own stories in the game (Mitgutsch & Alvarado, 2012). In the gameplay, narrative context assists player in identifying or constructing patterns of cause and effect (Ahmad, 2019). Thus, enabling the player to immerse in the gameplay and allow them to connect with the real and abstract details in the game plot.

4.4.1.3 Contents

Contents is another key component that underpins the knowledge and data required for the learning objectives. The contents in a serious game aimed at raising obesity awareness must be accurate, as this is critical for facilitating knowledge acquisition and perceived behaviour change among players. Based on Mitgutsch & Alvarado (2012), information, facts, and data offered that are used in the game context

are visible and are made approachable to the player. Easy retrievable information makes ease to the player in getting specific information, facts, and data about health promotion and relevant heuristics information (Mitgutsch & Alvarado, 2012). The contents embedded within this proposed framework align with the guidelines provided by the Ministry of Health regarding healthy habits, which encompass healthy eating and engaging in physical activity.

4.4.1.4 Aesthetics

Game aesthetics is another crucial component that can influence player's learning experience and engagement. Aesthetics encompasses the visual and auditory representation for visualization and the display of the elements in the game (Mitgutsch & Alvarado, 2012). It is also said to be the look and feel of the game interface. Aesthetics are closely linked to how the game's overall environment appears. The players' experience has a direct beneficial correlation. Hence, the aesthetic features through visual and auditory elements must be designed with care as it can influence the player's overall experience and perceived learning. Additionally, interactive elements are also included in the game aesthetics to establish the game's ambiance, visual style, and overall atmosphere.

4.4.1.5 Game elements

Game elements are a set of components and mechanics that underpin the game design and experience. Based on Ferro (2021), game elements are referred to as components or parts. These integrated game elements can be leveraged to create an engaging and motivating gameplay experience. Game elements can significantly alter people's perceptions of cognitive activities, influencing their affective experience, motivation, and perceived effort. Thus, incorporating game elements can motivate players to stay engaged in cognitive tasks, ultimately helping them achieve greater rewards in the future (Bernecker & Ninaus, 2021). Some common game elements include goals, interactivity, challenge, rewards, feedback, and rules, among others.

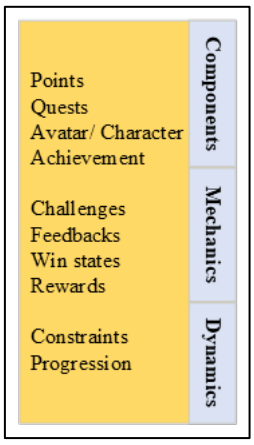


Figure 4.9 Mapping and Integration of Game Elements in the Proposed Framework

Based on Tori et al. (2022), game elements are the playful components embedded in a game that keep players motivated to play. In addition, integrating game elements can promote healthy competition among individuals, whether they are competing against each other, or their own past performances. The extracted game elements are based on a pyramid with three categories: Components, Mechanics, and Dynamics (Werbach & Hunter, 2012). Each category consisted of various game elements. Based on the above findings, it is revealed that 'Points', 'Quests', 'Challenges', 'Feedback', 'Constraints', 'Progression', 'Avatar', 'Win states', 'Achievement', and 'Rewards' were the most frequently included game elements. Below sections discussed further on the game elements extracted based on its category. Figure 4.9 above shows the inclusion of the mentioned game elements into the 'Game elements' component during mapping and integration phase of this proposed framework construction.

a) Components

Under the Components category, it is found that 'Points', 'Quests', 'Avatar', and 'Achievement' were the commonly used elements in serious game interventions. 'Points' serve as a scoring system in the game, motivating players, enhancing engagement, and helping to achieve desired outcomes or goals (Hammady & Arnab, 2022). 'Quests' are a fundamental aspect of gameplay that allow players to feel a sense of progression as they work towards achieving the game's objectives (Lewis-Evans, 2013). While both 'Quests' and 'Goals' serve the purpose of achieving tasks, objectives, or milestones in a game, they are similar in that they both aim to achieve the desired

outcome. In addition, ‘Avatars’ represent the players in the game and convey the message or idea of the game concept (Zufri et al., 2016). In serious game interventions, the aforementioned represents the player’s identification and the characteristics they wish to portray, although in reality, the player may not necessarily align with the avatar they have created. Furthermore, the player ‘Achievement’ system motivates players and drives them to accomplish their goals in the game. According to Grant & Betts (2013), achievement is attained through the repeated completion of challenging tasks or goals, which eventually leads to game success. Thus, the implementation of specific game elements in serious game interventions is considered crucial, especially for promoting health and raising awareness about obesity among children.

b) Mechanics

The most included game elements in the Mechanics category were ‘Challenges’, ‘Feedback’, ‘Win states’, and ‘Rewards’. ‘Challenges’ present players with obstacles or tasks of varying difficulty to overcome and are commonly integrated into the game through level selection. However, incorporating the element of challenges into the game should be carefully balanced. The tasks given should not be too easy or too difficult to avoid demotivating players. Hence, achieving a balance in creating task difficulty is crucial to enabling players to fully immerse themselves in the game, develop the skill to think outside the box, and enhance knowledge acquisition (Landers et al., 2017). In addition, integrating feedback into serious games enhances player engagement, encouraging them to continue playing. In particular, positive feedback can boost players’ confidence and encourage them to persist in challenging tasks (Burgers et al., 2015). However, negative feedback, such as penalization in serious games, should be minimized to prevent players from becoming frustrated and demotivated (Larsen, 2009).

Moreover, ‘Winning states’ are considered in-game rewards, which include virtual badges, achievements, power-ups, and desirable objects (Caserman et al., 2020). The ability to win the game at the end of a level or the entire game provides rewards and positive reinforcement to the players. Additionally, incorporating ‘Rewards’ into a game promotes engagement and improves desired behaviour change (Sekhavat, 2019). In a study conducted by Mulcahy et al. (2021), a short-term game design that utilized game rewards encouraged players to continue playing the game. This ultimately

resulted in repeated gameplay, reinforcement of learned information, and a strong desire to change behaviour. It is essential to incorporate game elements that present challenges, offer feedback to enhance players' gaming experience, and provide incentives and win conditions to boost their motivation to continue playing.

c) Dynamics

In the Dynamics category, 'Constraints' and 'Progression' are two game elements commonly utilized in serious game interventions for health and obesity awareness. 'Constraints' provide the structure, rules, and focus of gameplay. It provides boundaries and limitations within the game that guide players in achieving specific goals or tasks. Garris et al. (2002) mentioned that the rules and constraints of a game constitute the goal structure of a game. Clear and well-defined rules are essential to facilitate learning. However, unclear and boring rules can hinder motivation to continue playing. Furthermore, progress in a game can be displayed in various ways, such as during gameplay, at the end of the game, or at specific levels. This information is beneficial not only to players but also to those involved in the game progression, such as therapists, parents, or educators (Caserman et al., 2020). Therefore, it is important to display a player's progress and performance while simultaneously increasing the complexity or difficulty of the game as they improve (Caserman et al., 2020). This highlights the importance of both limitations and progress being integrated with each other in game design and development.

4.4.1.6 Motivation

Motivation is one of the key components in serious game design as it fuels the players' willingness to engage and persist in the gameplay. Based on Fisher et al. (2003) motivation is the ability and influences towards the inclination of health behaviour when well-informed. To sustain motivation, serious games need to integrate motivational affordances such as autonomy, competence, and relatedness which are based on the Self-Determination Theory (SDT). The integration of this motivational theory substantiates the notion that players exhibit increased motivation and engagement when they possess autonomy and control over their learning experiences (Maxim & Arnedo-Moreno, 2025). Consequently, players who engage with the gameplay not only

participate actively but also acquire knowledge. Therefore, this further suggests that the motivation component is a vital element in individuals' perceived behavioural change.

4.4.1.7 Self-Efficacy

Self-efficacy is the players' belief that they can successfully perform game tasks. As a component, it is justified because higher self-efficacy reliably predicts better engagement, persistence, and performance in games and learning contexts. Besides that, self-efficacy shapes what activities people choose, how much effort they invest, and how long they persist under difficulty (Chen et al., 2020) which in games, it is built through mastery experiences, feedback or physiological states (Chen et al., 2020; Samadi et al., 2024). Game-specific frameworks explicitly use Bandura's principles to structure mechanics and feedback loops (Chen et al., 2020; Samadi et al., 2024). This component is designed to offer players opportunities to practice these skills within the game environment, thereby systematically enhancing their confidence, which subsequently fosters engagement, persistence, and performance. Additionally, it may lead to improved competence and perceived behavioural change.

4.4.1.8 Outcomes

Outcomes are the final component that focuses on the expected health-related outcomes that players can perceive and attain through their engagement with the serious game. It represents the intended impact of the game on player's knowledge, attitudes, and behaviours related to the targeted health issue (W. A. Fisher et al., 2003), which in this case, obesity awareness. Furthermore, health outcomes are the ultimate results derived from enhanced knowledge, motivation, and behavioural skills. These outcomes include improved nutrition knowledge, increased engagement in physical activity, weight loss, reduced risk behaviours, and a heightened awareness of general healthy lifestyle knowledge.

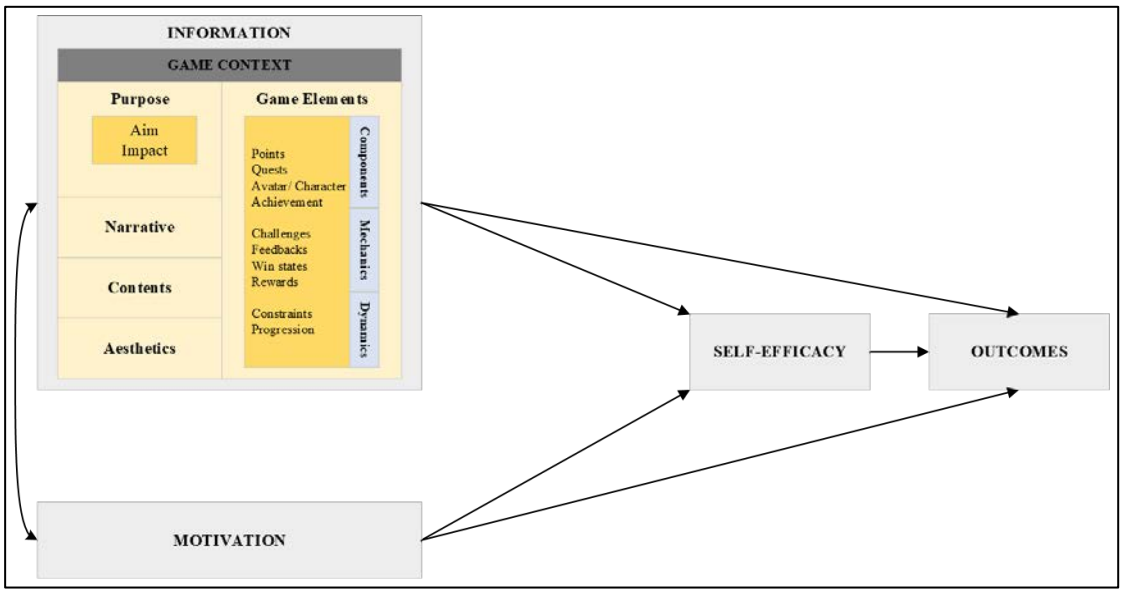


Figure 4.10 The Proposed Serious Game Framework

Therefore, the process of mapping and integration of the suitable components and elements were constructed to form a proposed serious game framework as shown in above Figure 4.10 based on IMB model. The components and elements are all interconnected and contribute to the overall design and effectiveness of the serious game framework based on the analysis conducted in the above sections.

4.5 Expert Review on Framework

To further validate and refine the proposed serious game framework, it is crucial to obtain feedback from domain experts. This is an initial validation of the proposed framework. Expert review process aims to ensure the comprehensiveness, coherence, and relevancy of the framework. This section elaborates the process of validating the proposed framework, which resulted from the construction of the game framework. The main activities performed during expert reviewing were primarily to thoroughly review the components and elements in the framework, provide feedback on its comprehensiveness and coherence, and validate the applicability of the framework in the context of obesity awareness serious games.

As mentioned in the Chapter 3, six experts were involved with expertise in fields such as game design and health nutrition related. The data obtained in expert reviewing is through the frequency of responses (“disagree”, “uncertain”, and “agree”) in relation to the questions in the expert review instrument. Plus, the responses are based on the

relevancy of the construct 'Information: Game Context' with its sub-construct, 'Motivation', 'Self-efficacy', and 'Outcomes'.

4.5.1 Findings and Discussion from Expert Review on Framework

Based on the findings, it is found that in 'Information: Game Context' construct, almost all experts indicated that 'Purpose', 'Contents', 'Game elements', 'Narrative', and 'Aesthetics' are relevant in serious game design for obesity awareness. However, there is a single expert who disagree with the component 'Narrative' as relevant, because of the opinion that narrative context should drive the players toward the mission or challenges related to obesity awareness, rather than the story per se. Nevertheless, the consensus among experts is that the components covered in 'Information: Game Context' are relevant and comprehensive.

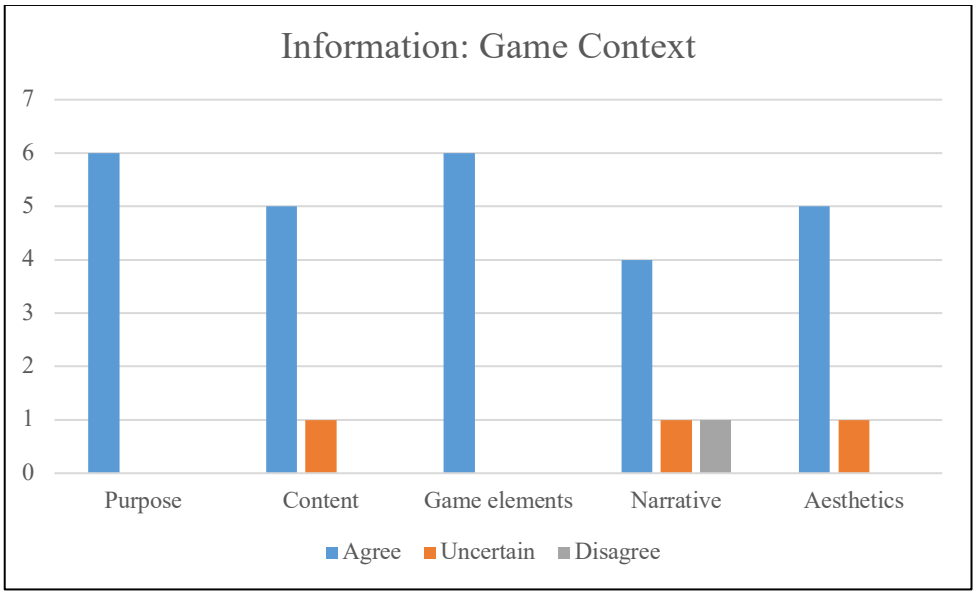


Figure 4.11 Frequency of Responses for 'Information: Game Context' Construct

For the 'Motivation' construct, four experts agreed that it is a relevant component in serious game design, as it is critical to sustain players' engagement and persistence throughout the gameplay. However, one expert provided neutral responses, as she commented that 'Motivation' is considered a sub-element of behaviour skills. However, this framework was being guided by the Information-Motivation-Behavioural Skills (IMB) model by Fisher et al. (2003) that posits motivation as a distinct component, which the experts also acknowledged as relevant. Another expert

expressed disagreement with the view that motivation may not be necessary, arguing that players should be able to perform the desired behaviour change through direct action, without the need for intrinsic motivation from the game.

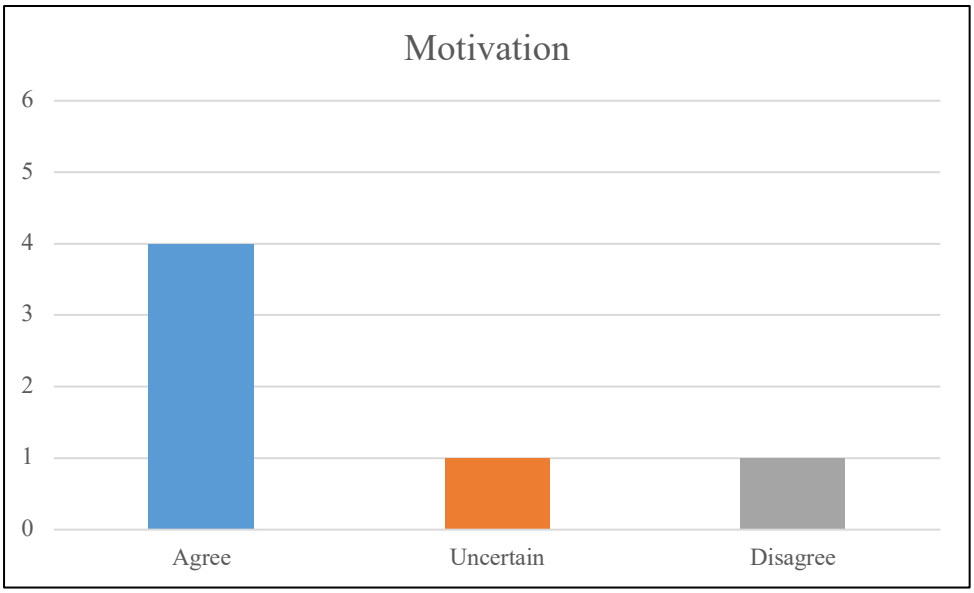


Figure 4.12 Frequency of Responses for 'Motivation' Construct

Regarding the 'Self-efficacy' construct, all experts but one agreed that the inclusion of this construct is relevant and important in serious game design for obesity awareness. The dissenting expert argued that 'Self-efficacy' should be considered a sub-component of 'Outcomes', as the latter also encompasses health behaviour change.

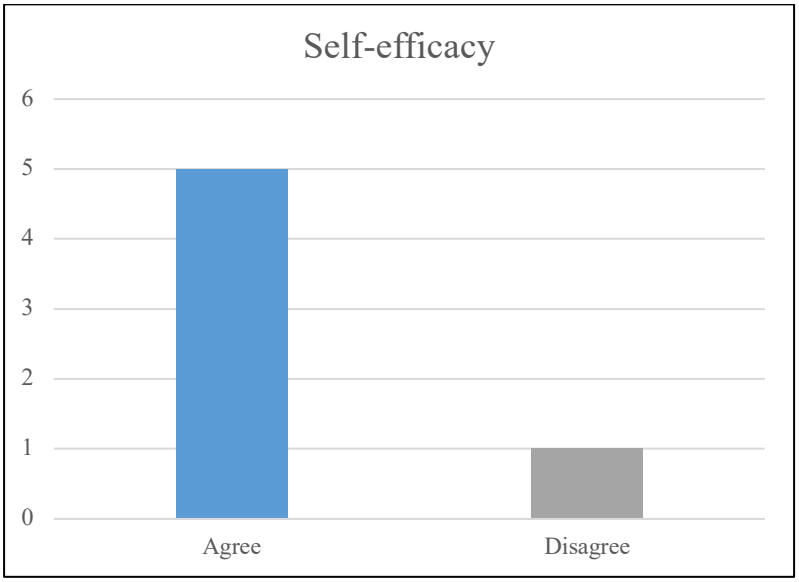


Figure 4.13 Frequency of Responses for 'Self-efficacy' Construct

Lastly, for the ‘Outcomes’ construct, all experts but one agreed that it is a relevant construct to be included in the framework, as it represents the intended impacts of the game on players’ knowledge, attitudes, and behaviours related to obesity. An expert gave an uncertain response on this component suggesting ‘Outcomes’ could be separated into two themes: one for knowledge/attitudes and one for behaviour change.

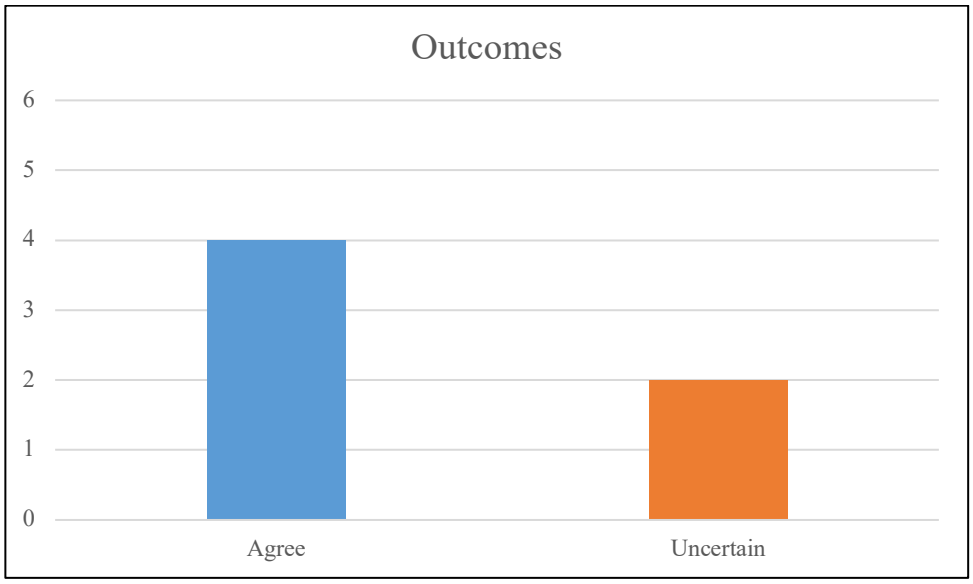


Figure 4.14 Frequency of Responses for ‘Outcomes’ Construct

In general, the experts provided positive feedback on the overall comprehensiveness and coherence of the proposed framework, acknowledging that the key components are relevant and important in the context of serious game design for obesity awareness. Even though there were some disagreements and suggestions for refinement, the consensus among the experts was that the proposed framework is a useful starting point for developing effective serious games for obesity awareness.

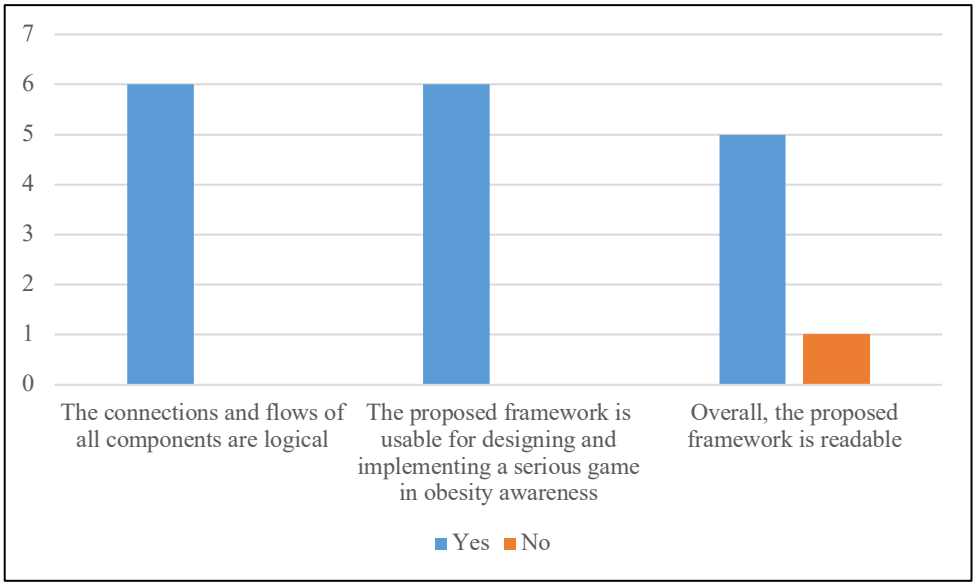


Figure 4.15 Frequency of Responses for Overall Proposed Framework

Further comments and responses provided by the experts were discussed. Certain comments from the original version were rephrased to convey a clearer meaning, and more comprehensive perspective of the experts' comments and facilitates easy understanding and interpretation, as well as recommendations for enhancing the proposed framework.

Based on the feedback provided by experts regarding the proposed serious game framework, several concerns, agreements, and disagreements have been identified. The experts commented that the framework is commendable and promising for its contribution to game-based learning. Furthermore, the experts concur that 'Aim' sub-component and 'Motivation' construct are essential to incorporate into the proposed game framework. The term 'Aesthetic' was also recommended for reconsideration, potentially incorporating audio and video or storytelling elements. However, some experts preferred the use of the original term for its broader meaning. Regarding the logical flow of components, all elements were noted and agreed upon, though some aspects require redefinition. The experts concurred that the proposed framework is valuable for serious games on obesity awareness. Overall, the experts expressed agreement and affirmed the relevance of the proposed framework.

However, there exists disagreement among experts regarding the proposed framework. One expert suggested that the term 'Impact' should be replaced with 'Effect' to more accurately reflect the immediate changes observed after a player engages with the game. Nevertheless, the term 'Impact' is retained to indicate the

knowledge acquisition following gameplay and perceived behavioural change, wherein the knowledge gained could be acquired in the future, hence the use of the term 'Impact'. Besides that, an expert contended that consuming a nutritious diet and engaging in outdoor physical activity do not necessarily generate motivation, despite these two factors being considered primary components of health behaviour modification. However, during this research's preliminary study (further discussed in Chapter 3), interviews with public health experts unanimously indicated that the solution to reduced weight gain lies in consuming a nutritious diet and performing physical activity. Consequently, the 'Motivation' construct remained in the proposed framework, as it is deemed necessary to initiate healthy behaviours.

Besides that, several concerns have been raised among the experts. An expert requested an explanation regarding the presence of a narrative or story in the game to drive the player towards achieving the mission. Furthermore, the expert addressed the impact of obesity on both physical and mental health and suggested considering it from a religious perspective. However, this approach was deemed unfeasible and inappropriate, as the study primarily focused on health and obesity awareness and was not intended to incorporate religious perspectives. The expert also emphasized the importance of precisely defining constructs such as 'Motivation' and 'Self-efficacy', ensuring a connection between them in the framework. Additionally, clarification was sought on whether the 'Aims' focuses on informing in-game content or the game's objective, distinguishing long-term goals from short-term goals. The distinctions are incorporated in the proposed framework, wherein long-term goals are referred to as 'Aims' and short-term goals are referred to as 'Goals'.

Furthermore, the expert posited that the term 'Quests' element under the 'Game element' should be critically defined, as it frequently overlaps with the element 'Aims' under the 'Purpose' component. Moreover, experts identified the necessity to specify elements under the 'Narrative' component and re-examine if the operational definition pertains to User Preference. However, this concept does not pertain to User Preference, as 'Narrative' is considered a storytelling element of game design that conveys to players the story and purpose of the game, thereby initiating motivation to commence playing and maintain engagement throughout the gameplay (Naul & Liu, 2020). One of the experts noted that the construct of 'Self-efficacy' should align with the study's discussion on behaviour change. The 'Self-efficacy' construct is changed to the term 'Behaviour skills' since it is consistent with the literature on behaviour change. Skills

and self-efficacy are considered sub-construct to behaviour skills. Overall, the concerns emphasize the need for clear definitions in the proposed model as well as the need to change term of the construct or components to ensure the effectiveness of the resulting serious game.

Based on the feedback provided by the experts, several recommendations were proposed for improving the framework. One expert suggested ensuring that 'Contents' is derived from reliable sources. Furthermore, the expert proposed considering 'Motivation' as a sub-element of 'Behavioural skill' and incorporating cognitive elements into the framework. Nevertheless, this approach is not feasible, as the construct of 'Motivation' is predicated on the original IMB model and serves to complement the improved components. Moreover, it was advised to identify the target age group for users, as game elements, approach, and design must be tailored for different age groups. Additionally, it was suggested to specify elements under 'Content', considering terms such as engaging, enjoyable, fun, or gamified content. However, the construct is modified to the term 'Content and Information' to indicate the knowledge and information acquired that can contribute to promoting obesity awareness. Under the component 'Aesthetics', it was proposed to consider changing the term for 'Audio and Visual' or 'Storytelling' components. The construct is maintained due to the consensus among experts regarding the utilization of the term, as it encompasses a broader meaning. Overall, the experts concurred with the positive feedback, providing specific suggestions for improving content accuracy, user engagement, framework elements, and game design.

Table 4.6
Experts' Comments on Content and Information in Game Context of the Framework

Questions	Comments/ Opinions/ Recommendations
Does the integration of learning content and other elements important and necessary in designing and developing framework for obesity awareness game?	- Yes, and relevant - Consider adding interactions with other players to the game platform for sharing sessions and mutual motivation for a healthy lifestyle.
Does the implementation of learning content in mobile technology application environment important and necessary in designing and developing framework for obesity awareness game?	- Yes, and relevant - Emphasize the importance of targeting the young generation. - Highlight the critical role of learning content in the design of any serious game. - Note that teenagers today spend long hours on mobile apps with less real-life interaction.
Does all integral elements including the learning content suitable/ relevant in designing and developing framework for obesity awareness game?	- Yes, and relevant - Specify the content and elements based on the game's objective. - Motivation, game elements, learning content, and skills are equally important but must be clearly designed. - The elements/ components are relevant.
In your opinion, does all the integral elements in the	- Yes, and relevant

proposed framework able to initiate/ maintain player's perceived behaviour-change?	- Specify cognitive and behaviour skills based on the game's objective. - The mentioned elements are common for frameworks aimed at creating awareness in any serious game. - Emphasize the challenge of behaviour change in combating obesity, highlighting the important role of family (especially parents) in motivating children to adopt a healthy lifestyle. - Behavioural changes typically follow awareness and the stress to change.
In your opinion, does the learning content in game implementation could evoke player's obesity awareness?	- Yes, and relevant - The framework lacks clarity on content; if it refers to food intake and lifestyle, it is suitable. - Consider adding the effect of player actions on obesity awareness. - Scepticism about games improving obesity awareness but interested in seeing proof of their effectiveness. - Strong agreement on the importance of awareness. - Games can evoke awareness among players.
General comments/ recommendations	-

The following comments from experts pertain to the content and information within the game context of the framework, and it is shown in Table 4.6. Regarding the integration of learning content and other elements in designing and developing a framework for an obesity game, one expert affirmed its importance and necessity, suggesting the addition of player interactions on the game platform for sharing sessions and mutual motivation towards a healthy lifestyle. Concerning the implementation of learning content in a mobile technology application environment, experts emphasized the importance of targeting the younger generation, highlighted the critical role of learning content in serious game design, recommended revisiting and redefining certain framework components, and noted the prolonged mobile application usage among teenagers with reduced real-life interaction. Nonetheless, all experts concurred with the statement and deemed it relevant.

When queried about the suitability or relevance of all integral elements, including learning content, in designing and developing a framework for an obesity awareness game, experts provided diverse comments and opinions. One expert suggested specifying content and elements based on the game's objective. Another noted that motivation, game elements, learning content, and skills are equally important but require clear design. Other experts concurred on the relevance of the elements and components.

Regarding whether all integral elements in the proposed framework could initiate or maintain players' perceived behaviour change, experts offered varied perspectives. One expert recommended specifying cognitive and behavioural skills

based on the game's objective, while another noted that the mentioned elements are common in frameworks aimed at creating awareness in serious games. An expert emphasized the challenge of behaviour change in combating obesity, highlighting the crucial role of family, particularly parents, in motivating children to adopt a healthy lifestyle. The expert also stressed that behavioural changes typically follow awareness and the impetus to change.

Concerning whether the learning content in game implementation could evoke players' obesity awareness, one expert noted that the framework lacks clarity on content but suggested that if it refers to food intake and lifestyle, it might be suitable. Another expert emphasized the importance of considering the effect of player actions on obesity awareness. Additionally, there was scepticism about games improving obesity awareness, coupled with interest in evidence of their effectiveness. However, all experts strongly agreed on the importance of awareness and the potential for games to evoke awareness among players.

4.5.2 The Revised Framework

Based on the expert review, the framework was refined to incorporate the feedback and suggestions provided. The subsequent sections provide a detailed elaboration of the modifications and changes incorporated into the proposed framework following the process of initial validation: expert review.

4.5.2.1 Changes incorporated in the proposed framework

The proposed framework has undergone an expert review process for initial validation. This expert review process facilitates the collection of feedback and comments from experts to enhance the proposed framework. The retrieved feedback is acknowledged, and the corresponding modifications are subsequently incorporated into the proposed framework, resulting in an improved, revised version. The changes made to the proposed framework were guided by the experts' feedback and recommendations, with the aim of enhancing the comprehensive and holistic representation of the key elements in the serious game design framework.

Table 4.7
The Changes Incorporated in the Proposed Framework

Before refinement	After refinement
The connection flow is confusing	The connection flow is structured and modified
The term 'Contents' is not comprehensive	The term is refined to 'Content and Information'
Motivation construct is confusing	'Internal Motivation' is included as a sub-component under the Motivation construct
'Self-efficacy' construct is not defined clearly	'Self-efficacy' is changed to 'Behaviour skills' to clearly defined its purpose with the inclusion of 'Skills and Self-Efficacy' as sub-constructs
The term 'Outcomes' is too broad	The term is refined to 'Perceived Outcomes'
'Outcomes' construct should narrow down the type of outcomes required	The Outcomes construct includes a sub-construct which is 'Cognitive and Behaviour Change'
The term 'Narrative' is not clearly defined and confusing	The term 'Narrative' is clearly defined
Specify the 'Narrative' component	The 'Narrative' component is specified and defined
Clarify the term 'Aims'	The term 'Aims' is clarified
Clarify the term 'Impact'	The term 'Impact' is clarified
Emphasize clear definitions of the components in the proposed framework	Clear definitions of the components in the proposed framework
Ensure the content and information comes from reliable source	The content and information come from reliable source such as the Malaysia Ministry of Health (MoH)
Identify the target age group for users	The target age group is identified
Specify the type of content in the game	The type of content in the game is specified

Based on Table 4.7 above, the changes incorporated in the proposed framework were listed. Some experts highlighted the importance of motivation as motivation plays a critical role in sustaining player engagement and persistence in serious games (Watt & Smith, 2021). As such, the motivation construct was retained as a distinct element, with the addition of a sub-component named 'Internal Motivation' to capture the intrinsic drive of players. The experts also emphasized on the importance of behavioural skills, acknowledging its significance in enabling players to perform the desired behaviours. Hence, the change in term 'Self-efficacy' construct to 'Behaviour skills' construct. The experts believed that the behaviour skills construct requires additional two sub-components which defined more comprehensively to better capture the required behaviour skills of the players, that is 'Skills' and 'Self-Efficacy'. Furthermore, the experts pointed out the need to refine the 'Outcomes' construct by including and separating the cognitive/knowledge outcome and behaviour change as two distinct sub-components. This change was made to better capture the nuances between the cognitive/knowledge outcome and the actual behaviour change, which are both crucial outcomes for the serious game (Aleven et al., 2010).

The proposed framework incorporates several modifications, including a restructured and refined connection flow to align with the framework's overall purpose. Furthermore, the term 'Narrative' has been clearly defined in response to expert feedback regarding its ambiguity and potential for confusion. Additionally, the

'Narrative' component has been specified and defined to enhance comprehension of its meaning. The terms 'Aim' and 'Impact' have been clarified to address expert concerns about their distinction, as both convey different meanings within the concept and game design. Moreover, refinements have been made to provide clear definitions of the framework components, ensure the reliability of content and information sources (such as by the Malaysia Ministry of Health (MoH)), identify the target age group, and specify the type of content in the game. These modifications were implemented based on expert feedback to enhance the proposed framework as comprehensive guidelines for creating serious games to promote obesity awareness. Thus, the revised framework has been amended as shown in Figure 4.16.

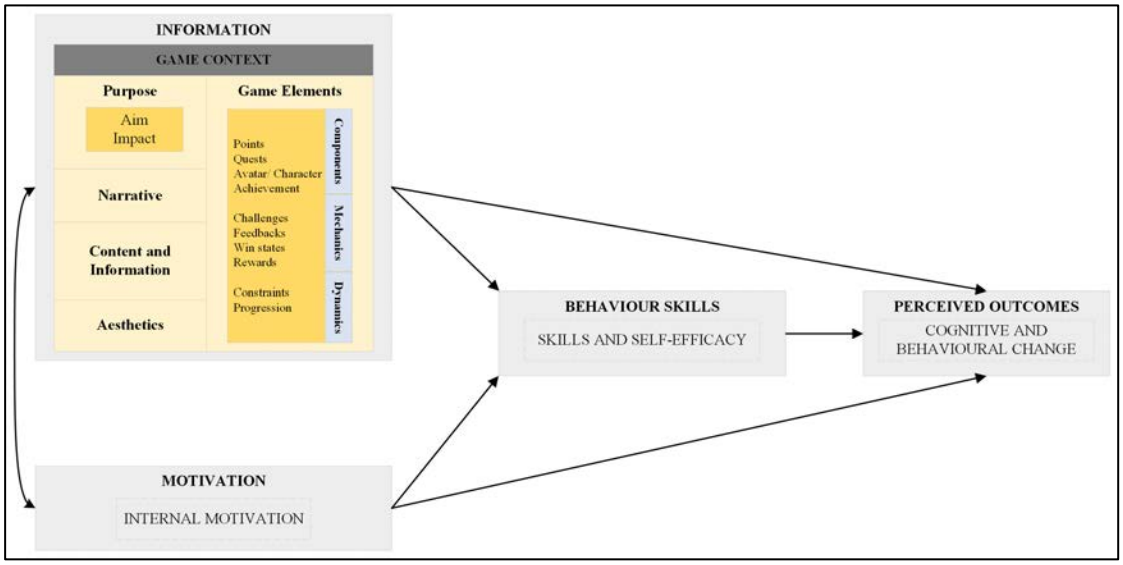


Figure 4.16 The Revised Serious Game Framework

4.5.3 Novel Contributions of the Game Framework

The proposed framework introduces several novel contributions to the field of serious game design for health awareness. Primarily, this study contributes a structured integration of multidisciplinary components by systematically combining game design components and behavioural change theory (IMB model) into a unified framework. While many serious game frameworks acknowledge the importance of integrating behavioural theory, game design, and user experience, they often treat these aspects as separate layers or checklists rather than explicitly modelling their interconnections

(Arnab et al., 2015; Sarasmita et al., 2024; Verschueren et al., 2019) . This approach facilitates a more unified design process and establishes a computationally and conceptually linked model that can guide concrete design decisions.

Furthermore, the framework introduces a method for reducing and consolidating components, where 51 initial components identified from the literature were refined into 14 essential components. This process also involved integrating game elements into the framework through a systematic filtering and expert validation process. Previous reviews highlight that developers often encounter overwhelming lists of elements, theories, and requirements, which can impede practical use in real projects (Aster et al., 2024; Hammady & Arnab, 2022; Verschueren et al., 2019). Thus, this approach and integration not only improve usability but also enhance the practical applicability of the framework for game developers, making it more usable and implementable. Moreover, this research introduces a model-driven design perspective instead of a static checklist. Behavioural constructs such as information, motivation, and behavioural skills are incorporated into the game mechanics and narrative structure, allowing the framework to serve not just as a guideline, but as a conceptual model that informs design decisions in a structured and replicable manner. This enables more consistent, theory-aligned design for health-awareness games.

Finally, the framework is validated through a multi-phase evaluation approach, including expert review, pilot testing, and user evaluation through a functional game prototype. This thorough validation strengthens the framework's reliability and demonstrates its applicability in real-world development settings. Besides that, it demonstrates both feasibility and perceived usefulness of the framework in a real development context, surpassing typical proof-of-concept validations (Anderson et al., 2024; Cheek et al., 2015; de Visser et al., 2025; Sarasmita et al., 2024). Consequently, this strengthens the practical credibility of the framework and demonstrates that the integrated, reduced component set is sufficient for real-world design. The novelty of this work lies not in the introduction of entirely new individual components, but in the systematic integration, refinement, and modelling of existing components into a cohesive and functional framework for serious game design.

4.6 Summary

This chapter presented the construction of game framework and the initial validation through expert review to assess the relevance and comprehensiveness of the proposed framework in the context of serious games for obesity awareness. The process involved gathering previous frameworks to identify common components suitable for inclusion in the proposed framework through content analysis. The proposed framework is guided by the IMB model by Fisher et al. (2003). This review identified eight components: 'Purpose', 'Narrative', 'Content and Information', 'Aesthetics', 'Game elements', 'Motivation', 'Behaviour skills', and 'Perceived outcomes'. Concurrently, within the 'Game elements' component, a systematic review was conducted to pinpoint game elements frequently used in serious game interventions. Ten game elements were found to be the most common and suitable for serious game interventions focused on health and obesity awareness: 'Points', 'Quests', 'Challenges', 'Feedback', 'Constraints', 'Progression', 'Avatar', 'Win states', 'Achievement', and 'Rewards'. Experts in the field of game design and health nutrition were recruited to review and provide feedback on the proposed framework as an initial validation. The findings from the expert review indicate that the key components of the proposed framework are relevant and comprehensive in the context of serious game design for obesity awareness.

CHAPTER 5
EVALUATION OF GAME PROTOTYPE

5.1 Introduction

This chapter delves into the development of the game prototype and its evaluation through an experimental study. It addresses the third research objective, which is to assess the effectiveness of the game prototype created based on the serious game framework aimed at promoting obesity awareness. The game prototype was developed using the serious game framework outlined in the previous chapter, and it was designed in accordance with the Analysis-Design-Development-Implementation-Evaluation (ADDIE) model. An experimental study was conducted with children as the target participants to evaluate the effectiveness of the serious game prototype in improving their knowledge and awareness of obesity. Figure 5.1 below illustrates the summary of activities for game prototype development and experimental study. It delineates the methodologies employed to address the aims of this study in this chapter, with the anticipated outcomes corresponding to the research objective.

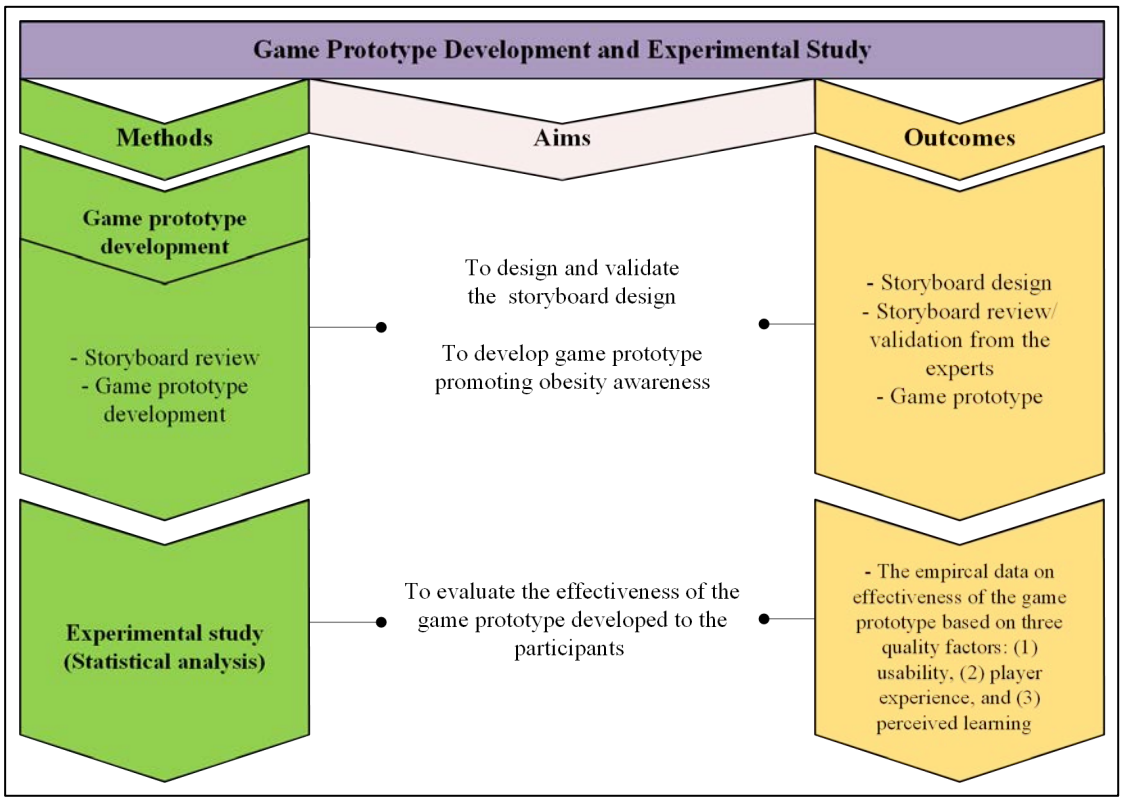


Figure 5.1 Summary of Activities for Game Prototype Development and Experimental Study

5.2 Game Prototype Development

The game prototype was designed and developed based on the ADDIE model. A game prototype was named *FitFuel Frenzy* to validate the serious game framework. The game prototype was designed and developed to promote obesity awareness among children. This game aims to educate children on healthy eating habits and physical activities to prevent obesity in future. Additionally, the game utilizes a fun and engaging platform game format to facilitate learning.

Figure 5.2 *FitFuel Frenzy* Game

During the design phase of the ADDIE model, storyboarding was carried out prior to developing the game prototype. The storyboarding process went through phases such as thumbnail sketches, rough sketches, and storyboard design. Finally, a storyboard review was conducted whereby the storyboard, and the checklist were distributed to experts for reviewing. The storyboard design and the checklist were incline towards the integration of game context and all components in serious game framework of this study. The experts provided feedback for amendments, which was then used to enhance the storyboard design.

In this game prototype, it was developed following the ADDIE model. This model consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The analysis stage involves understanding the target audience, learning objectives, and constraints. The design stage focuses on the game components and elements, with a storyboard design. The development stage involves creating the game prototype based on the design specifications based on the proposed framework. In implementation stage, the game prototype is tested and refined. Finally, the evaluation stage assesses the effectiveness of the game prototype developed. The game prototype designed and developed were based on the serious game framework as discussed in the previous chapter. The framework integrates game context with Information-Motivation-Behavioural Skills (IMB) model as the framework guideline. IMB model is known for its effectiveness in addressing health behaviour change. Thus, integrating game context with IMB components offers a comprehensive framework for developing serious games. The following section and its sub-sections will discuss the storyboard

review, game prototype description and gameplay, and the game context within the developed game prototype. Additionally, experimental study was also elaborated in the sections, including the findings and discussions of the effectiveness of the game prototype based on the quality factors measured.

5.2.1 Storyboard Review

Storyboard review was conducted after the storyboarding process to get insights and feedback from the experts. Storyboarding and storyboard review were done during the design phase of game prototype development (see Figure 5.3). A total of three experts were selected for the storyboard review, including experts in game design and public health. Their diverse expertise ensured comprehensive feedback on both game-related and health content aspects of the storyboard. The storyboard was sent to experts via email, whereby softcopy documents with the storyboard design and checklist were attached. The checklist was created based on a predefined set of criteria including health-related content, narrative flow, and game components feasibility. Additionally, experts were asked to evaluate the storyboard based on the following criteria: (1) content, (2) narrative coherence and progression, (3) alignment with the goals of obesity awareness, (4) user engagement and interactivity (5) appropriateness of visual and technical design elements. In Chapter 3, the process of reviewing storyboards is explored in more depth.

Figure 5.3 Storyboard Design for Storyboard Review

5.2.1.1 Findings from Storyboard Review

This section presents the findings from expert reviews of the storyboard design created for the obesity awareness game prototype. The purpose of the storyboard was to outline the narrative flow, user interactions, and game components integrated into the game. The expert feedback was instrumental in validating and refining the design. The objective of the expert reviews was to assess the game flow effectiveness, narrative clarity of the storyboard, and game components integrated to ensure that it aligns with the intended goals of promoting obesity among children. Below shows Table 5.1 that summarize the experts' comments and suggestions. Based on the feedback given by the experts, the feedback can be categorized into five categories which are (1) aesthetics and visual design, (2) usability and interface design, (3) gameplay mechanics and feedback, (4) educational and content feedback, and (5) game objective and progress clarity.

Table 5.1
Summary of Experts' Comments and Suggestions

Category	Key Expert Recommendations	Intended Impact on Players
Aesthetics & visual design	- Use consistent colour schemes and typography - Include appealing icons and motivational imagery - Change backgrounds to relatable environments like forests or fields	Creates a harmonious and professional interface that connects emotionally with children.
Usability & interface design	- Implement dialogue boxes/speech bubbles - Provide prominent goal displays - Include a character selector (male/female) and name slot - Use numerical/percentage indicators for progress	Enhances storytelling and clarity, giving players a sense of direction, personalization, and precise tracking.
Gameplay mechanics & feedback	- Add subtle time-limit reminders - Provide visual/auditory warnings for obstacles - Include interaction animations for collisions - Expand exercise types to include running or brisk walking	Improves immersion and responsiveness, ensuring players understand the consequences of their actions and stay engaged.
Educational & content accuracy	- Align food items strictly with MHP (1/2 fruits/veg, 1/4 protein, 1/4 carbs) - Replace bread with whole grains or rice - Use single serving sizes (e.g., drumsticks) - Include milk for calcium - Cast sweets/burgers as "enemies"	Ensures nutritional literacy is accurate and culturally relevant, helping children understand healthy versus unhealthy choices.
Objective & progress clarity	- Clarify final energy boost points using MHP criteria - Provide a simple summary focusing on the goal of "becoming healthy"	Makes the educational outcomes more understandable and attainable for a younger demographic.
Overall game evaluation	- Maintain focus on interactivity and engagement - Consider adding specific user experience and accessibility metrics	Validates the game as a satisfying and motivational tool for obesity awareness while suggesting technical refinements.

In terms of aesthetics and visual design, the experts suggested that it is essential to maintain consistency in colour schemes, typography, and graphical elements to create a cohesive and harmonious interface. Attention to small aesthetic details, such as appealing icons, visually pleasing fonts, and well-designed visual effects, enhances the overall experience. Key aesthetic factors, including balance, colour, and visual weight, should work in harmony to complement the aesthetic aspect and functionability. To add,

it is suggested to change the background interface of the main screen to a land-based or nature-related environments, such as field or forest, to align and engage children emotionally. Besides that, to further enhance the interface, experts also suggested adding icons or images with motivational words, along with a progress bar that uses green and red indicator to signify good and bad progress.

Furthermore, regarding usability and interface design, one of the experts emphasizes the enhancement of dialogue presentation and text-based content, whereby improvements can be implemented using visually appealing fonts, readable text sizes, and appropriate formatting. The expert suggests incorporating dialogue boxes and bubbles to enhance storytelling. Besides that, one of the experts also mentioned that goals and objectives should be prominently displayed to guide players, with clear visual elements. Clear icons or buttons should also be displayed representing the level selection menu and visual indicators such as checkmarks and progress bars tracking progress and completion. A numerical or percentage display alongside the progress bar is recommended for precise tracking. Moreover, one expert also suggested the initial screen interface should be noticeable by removing transparency and using a hide-unhide toggle instead of next and back buttons. The experts noted on the visual progress indicators like progress bar should show proximity to objectives, and the game should conclude with a resolution to the narrative or gameplay. One expert suggested that, instead of single-male character the main character, players should have the option to choose between male and female characters and the ability to type their character's name.

The experts also commented and gave suggestions in terms of gameplay mechanics and feedback. The experts recommend incorporating subtle reminders as the time limit nears critical stages, using notifications, pop-ups, or visual effects. They also suggest adding visual and auditory warnings to alert players to obstacles or enemies. To enhance immersion, the design should include animations that visually communicate the impact of obstacles, such as collisions or damage. Audio feedback should be provided when players collect or activate energy boost points. Additionally, while cycling is a good exercise option in the game design, it is advised to include running or brisk walking, allowing players to gain power by interacting with healthy objects marked by a flash sign.

Under the educational and content feedback category, experts recommend replacing bread with more representative complex carbohydrates like brown rice, whole

wheat, oats, and quinoa to better reflect the whole grain category. They suggest modifying the Malaysian Healthy Plate (MHP) components by adding point values where fruits and vegetables like lettuce and watermelon give higher energy boosts, while chicken and bread give lower points. A glass of milk should be included as an energy boost object, highlighting its importance for children's calcium intake. Additionally, replacing the whole chicken with a single serving size (e.g., drumstick) or fish is advised for better alignment with the MHP. Bread should be substituted with wholegrain rice, a Malaysian staple, and shown as a single serving size. Lastly, introducing small sweets, candy, or ice cream as enemy soldiers before the final boss (burger and coke) would enhance the gameplay's challenge.

Furthermore, in game objective and progress clarity, experts suggest clarifying the final energy boost points, especially for children, by summarizing them using the MHP criteria or categories. The summary should be simplified and focused on the overall goal of promoting a healthy lifestyle, making it easier for children to understand.

In conclusion, the game effectively aligns with its objective by incorporating strong elements of engagement and motivation while delivering educational content on health and obesity awareness. Its interactivity and gameplay are solid, though there are opportunities to enhance the visual and aesthetics aspects. Additionally, user experience and accessibility features could be considered for further improvement if necessary. Overall, all experts agreed that the game is both entertaining and educational in promoting obesity awareness.

5.2.1.2 The Revised Storyboard Design

In response to expert suggestions, the background of the main screen interface has been updated to a greenish tone to evoke a nature look and characters riding bicycles have been incorporated enhancing the aesthetic look of the game. Additional amendment was made by adding a female character, allowing players to choose between two characters, thereby allows choice preferences for the players. Besides that, dialogue box in the narrative interface has been redesigned as bubble dialogue box to enhance the storytelling experience. Adding to that, the character is now animated, replacing the previously static image. Based on the feedback, level selection buttons also have been replaced with images of healthy points icons such as lettuce and watermelon image at level 1 button, chicken image at level 2 button, a bowl of rice image at level 3 button,

and a bottle of milk and a glass of milk image at level 4 button. Additionally, lock icons also included to indicate levels that have not yet been unlocked. In the gameplay interface, a progress bar has been added to visually display the player's advancement. A clear numerical display of the time limit also has been included to allow precise tracking.

Additional interactive elements were incorporated into the storyboard, such as auditory warnings to alert players to the presence of obstacles or enemies. In addition, audio feedback also has been implemented to provide auditory cues when players collect points or activate energy boosts. Besides that, an extra healthy object point from the Malaysian Food Pyramid group category has included a glass of milk as a healthy object point in the game, apart from a glass of water. Based on the feedback from the expert who has the expertise in health nutrition, it is viable to include milk as a healthy object point because of the importance of calcium for children. Other visual elements that have been improved is the bread from the carbohydrate/ grains group has been substituted with a bowl of rice. This modification was implemented to align with Malaysian culture, in which rice serves as a staple food in Malaysian households. Next, the visual representation of a whole chicken as a healthy object point under the protein group category, was modified to depict a single chicken component, specifically a chicken thigh, to accurately convey the recommended nutritional quantity for an individual serving. Finally, an additional unhealthy food item, functioning as an antagonistic element in the game, was incorporated in the form of candy, in addition to the original items depicted in the storyboard, namely coke and burger.

The expert reviews for the storyboard design were instrumental in refining the storyboard's narrative structure and enhancing the learning goals of promoting obesity awareness. By addressing concerns related to content-related to game visual elements and functionability, the final design is better positioned to meets its goals and appeal to the players. While the expert feedback provided valuable insights, it was limited by the small sample size of experts providing the feedback and the absence of direct user testing. Future iterations of the game prototype will benefit from testing with real users to further assess the game's engagement and learning outcomes. In conclusion, the expert reviews of the storyboard design were critical in identifying areas for improvement and ensuring that the game aligns with its objectives of health and obesity awareness. The revisions made based on the experts' input have strengthened the narrative, usability, and learning impact of the storyboard design and game prototype.

5.2.2 Game Prototype Description and Gameplay

Game prototype development was conducted during the development phase of ADDIE phases. The game was developed utilizing the Buildbox Classic Plus software tool (see Figure 5.4). This phase encompassed the development of game mechanics, visual graphic design, and auditory elements. The game development process adhered to the storyboard design that was validated through a storyboard review.

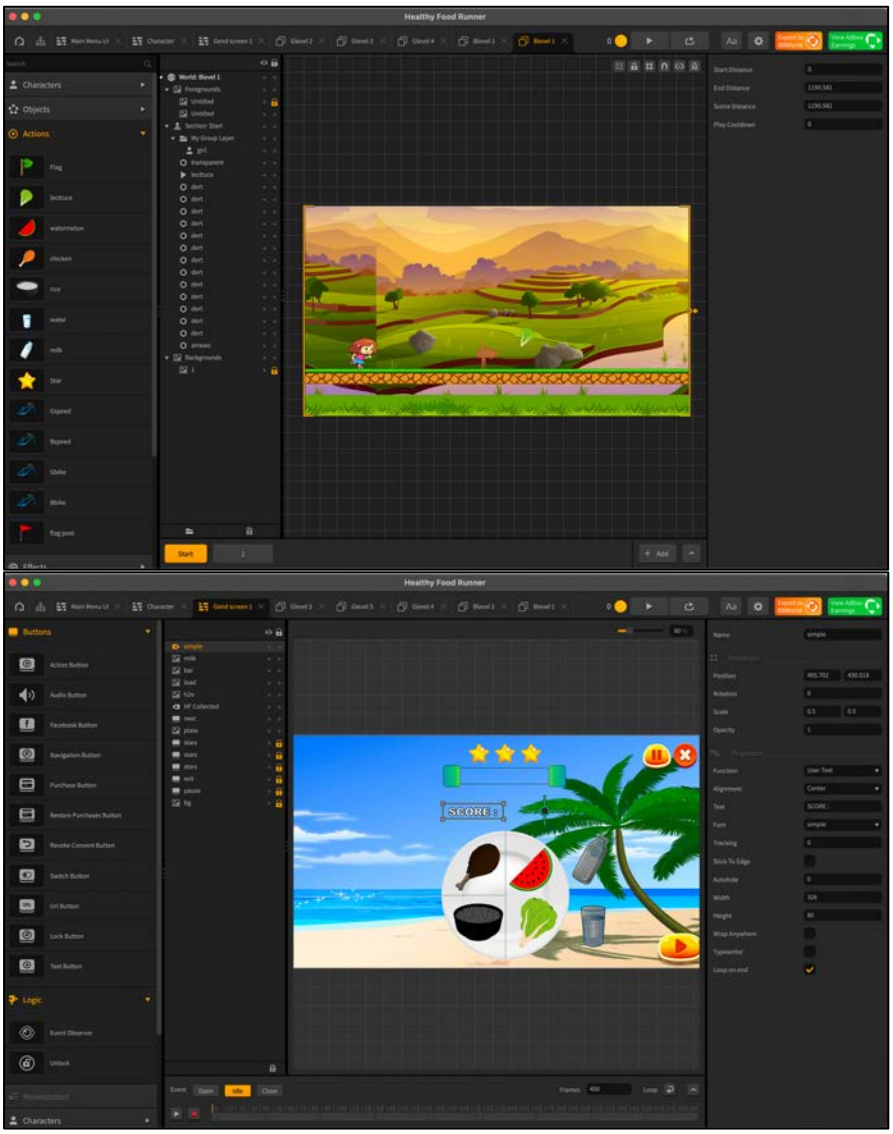


Figure 5.4 The Game Prototype Development Process Using Buildbox Classic Plus Software Tool

FitFuel Frenzy is a platform game that serves a dual purpose: it is both a source of informative knowledge and an enjoyable game to play. Players interact with the game using mobile touch screen devices such as smartphone and tablet, by tapping the screen with fingers. *FitFuel Frenzy* was designed to portray the impact of healthy and unhealthy eating habits, and the importance of performing physical activities. Healthy foods were represented by fruits, vegetables, protein, whole grain, water, and milk while unhealthy foods represented by junk foods (e.g. candy, burger, and coke drink). Players adopt the role of individuals who journey to various locations while searching for healthy foods and avoiding unhealthy options. As part of this role, players engage in physical activity, which underscores the significance of exercise. In this context, riding a bicycle enables players to move more quickly. This approach demonstrates the context of healthy eating and healthy lifestyle are not always easy in real life, however it is beneficial. Individuals who are trying to be healthy, usually encounter challenges and difficulties to live a consistent and long-term impact of healthy lifestyle.

In general, *FitFuel Frenzy* starts with a welcome screen with the instructions on how to play the game. The player then is prompted to choose between two-character roles that are ‘male’ or ‘female’ character. The chosen character will be the role character of the player throughout the game. Then, the player will be navigated to a storyline screen where a storyline about the adventure that the player is about to encounter. Upon clicking the ‘Next’ button, the player will be directed to the level selection menu screen, where only Level 1 remains unlocked among all levels. The reasoning behind this is that the player is obligated to finish each level before progressing to the following one, which only becomes accessible once the current level is successfully completed. However, the game concludes when the player fails to finish a level, thereby requiring them to restart from the beginning.

The levels consist of four levels, each dedicated to specific food groups. Level 1 focuses on fruits and vegetables (e.g., lettuce and watermelon), Level 2 on protein (e.g., chicken), Level 3 on whole grains (e.g., rice), and Level 4 on milk and water. Additionally, a physical activity component (e.g., riding a bicycle) is incorporated throughout each level to emphasize its importance, alongside the significance of understanding healthy food groups. Furthermore, each level increases in difficulty as the player progresses through the gameplay.

Next, an initial screen displays fun facts and motivational quotes before starting each level. This feature has been incorporated to enhance the player's motivation and

encourage their engagement in the game. As the game progresses, the player will need to collect as many healthy points as possible and avoid the unhealthy foods and barriers such as box, bricks and saw blades. If the player accidentally encounters unhealthy foods or collides with barriers, they will be penalized by losing points and risking the loss of lives. The player has a limited number of lives, which is represented by three heart-shaped symbols. If all the lives are lost, the game will come to an end, and the player will need to start over. Besides that, the game also progresses through the time limit and progress bar at the top of the screen interface, thus allowing the player to challenge themselves during the gameplay. After each level completion, an end screen with score points and a highlighted healthy plate are shown. The healthy plate is a concept suggested by the Ministry of Health Malaysia called Malaysian Healthy Plate (MHP) (Nutrition Society of Malaysia, 2016) and it highlighted the importance of group foods which include fruits, vegetables, protein, whole grain, water drinking, and milk.

5.2.3 Game Context

The proposed serious game framework is based on the IMB model, which includes the constructs of 'Information: Game Context', 'Motivation', 'Behaviour Skills', and 'Perceived Outcomes'. All these constructs are retained in the framework, with a Game Context phase embedded within the 'Information' construct. The Game Context is the highlight of this section, and it encompasses various game components and elements suitable for serious game interventions. These game components include 'Purpose', 'Narrative', 'Content and Information', 'Aesthetics', and 'Game Elements'. The game elements are categorized into three categories based on Werbach and Hunter's game taxonomy: Components, Mechanics, and Dynamics. The specific game elements listed are 'Points', 'Quests', 'Avatar/Character', 'Achievement', 'Challenges', 'Feedback', 'Win states', 'Rewards', 'Constraints', and 'Progression'.

5.2.3.1 Purpose

In this game prototype, the purpose is achieved based on the aim and impact of the game's purpose. The game's aim is to promote obesity awareness among children. While maintaining the fun aspect of gameplay, the game still serves its intended purpose for the target users. Even though the game utilizes a platformer type of game, the target

users can still achieve engagement and an enriching gaming experience, which will further impact their cognitive gains after the gameplay. The framework's perceived outcomes refer to the impact, which could manifest in the short or long term. Additionally, the impact may indicate health outcomes behaviour change after the gameplay or perceived outcomes that could take longer to materialize but deeply affect the players.

Table 5.2
Purpose Component in Game Development

Purpose	Description
Aims	Aims are the objectives or goals to achieve in the gameplay
Impact	Impact is the perceived outcomes after the gameplay which could impact player in short terms or long terms.

5.2.3.2 Narrative

The narrative of the game prototype outlines the storyline of the game (see Figure 5.5). The game follows the adventure and journey of a character, who aims to get fit and healthy. Throughout the journey, the character must eat healthy food and engage in physical activity, such as riding a bicycle, to achieve their goals. To succeed, the player must earn as many points as possible by collecting healthy food and performing physical activities like bicycling, while avoiding fast-food enemies. The healthy food to be collected includes lettuce, watermelon, a piece of chicken, a bowl of rice, a glass of water, and a bottle of milk as shown in Table 5.3. Meanwhile, the fast-food enemies are candy, a burger, and a can of soda as shown in Table 5.4.

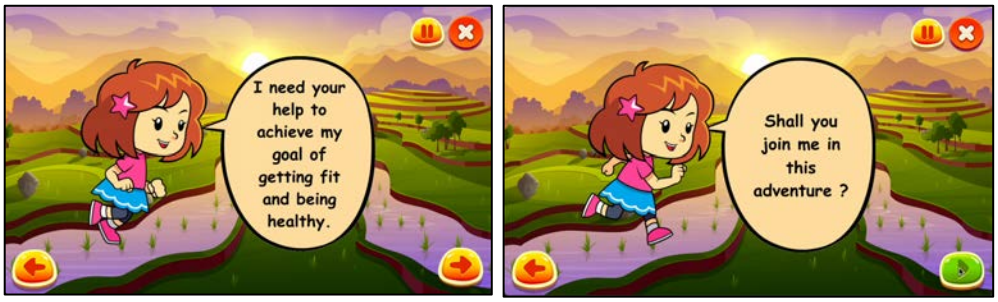


Figure 5.5 Storyline Screens

Table 5.3
Healthy and Unhealthy Food Items as Points in the Game

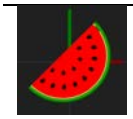
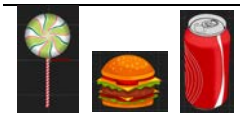
Healthy food items	Description
 Lettuce	Lettuce refers to vegetable category in Malaysian Healthy Plate (MHP)
 Watermelon	Watermelon refers to fruit category in Malaysian Healthy Plate (MHP)
 A piece of chicken	Chicken refers to protein category in Malaysian Healthy Plate (MHP)
 A bowl of rice	Rice refers to carbohydrate category in Malaysian Healthy Plate (MHP)
 Water and milk	Water and milk refer to recommended drinks by the Malaysia Health Ministry and also in Malaysian Healthy Plate (MHP) drink category

Table 5.4
Fast-Food Enemies and Obstacles in the Game

Fast-food enemies and obstacles items	Description
 Candy, burger, coke	Fast-food enemies such as candy, burger and coke to indicate unhealthy foods that the player needs to prevent taking
 Box, brick, and saw blades	The obstacles such as box, brick and saw blades to prevent player's progression in game

5.2.3.3 Content and Information

The content and information provided in the game prototype are based on official guidelines from the Ministry of Health Malaysia. For example, the Malaysian Healthy Plate (MHP) recommends a 'Quarter-Quarter-Half' approach, with a quarter plate of grains, a quarter plate of proteins, and half a plate of fruits and vegetables (see Figure 5.6). Additionally, the game promotes the replacement of sugary drinks with

plain water. Thus, as shown in Figure 5.7, a depicted Malaysian Healthy Plate (MHP) is displayed at the end screen after player completed each level. Furthermore, the game prototype emphasizes the importance of two key components for improving health outcomes, as advised by the World Health Organization (WHO): proper food nutrition intake and engaging in physical activity.

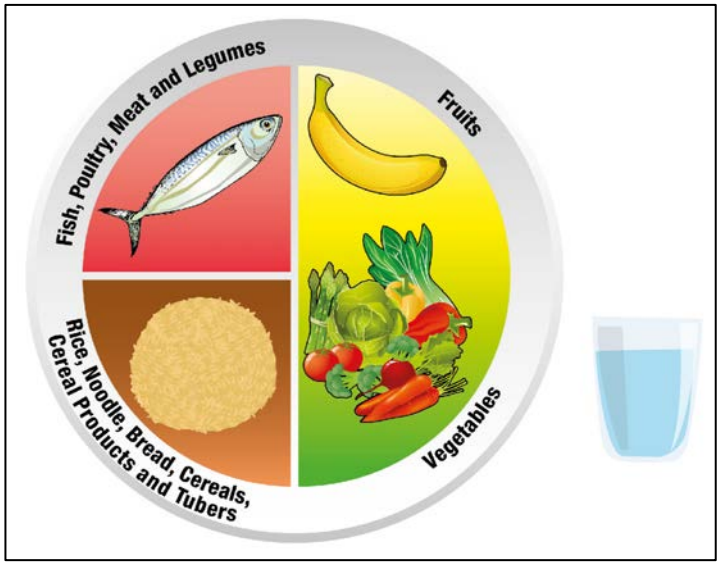


Figure 5.6 Malaysian Healthy Plate (MHP)

Figure 5.7 Malaysian Healthy Plate (MHP) Displayed at the End Screen After Player Completed Each Levels

5.2.3.4 Aesthetics

Game aesthetics in this prototype involved visual and auditory representation to display the elements in the game. Under the visual representation, it is important to include the 'healthy food' as the main collectable items and the 'unhealthy food' as the

main obstacles or enemies to be avoided by the player. Besides that, the character display should be visually appealing and relatable to the target audience, which in this case, young people or children. Background images are also crucial to set the mood and atmosphere of the game. Each level in the game consists of different background images as shown in Figure 5.8 below. Multimedia elements for visual displays may include hand-drawn illustrations, photos, or even animated graphics. For the auditory representation, background music and sound effects can be implemented to further enhance the gaming experience. Additionally, interactive elements are also included in the game aesthetics to establish the game's ambiance, visual style, and overall atmosphere.

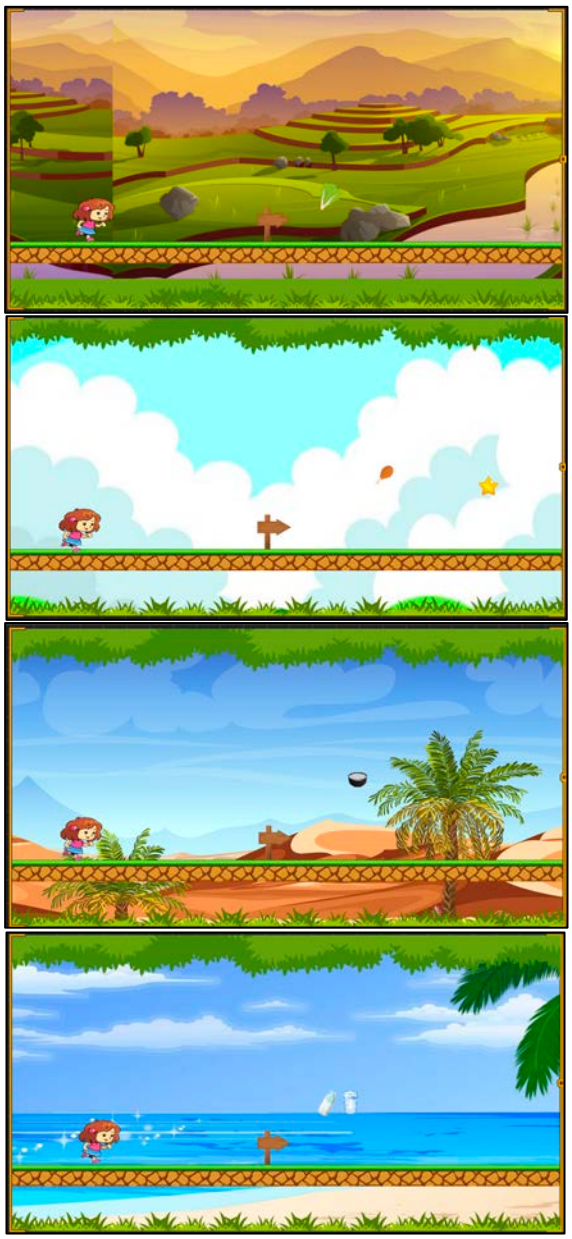


Figure 5.8 Background Screens for Level 1, Level 2, Level 3, and Level 4

Table 5.5
Visual and Auditory Representation

Visual representation	Auditory representation
Character displays, background images, multimedia elements for visual displays	Sound and audio elements, music background

5.2.3.5 Game Elements

The game prototype incorporated various game elements from the three main categories identified by Werbach & Hunter (2012): Components, Mechanics, and Dynamics. The game elements were selected based on a systematic review of the

literature discussed in the previous chapter, which identified the most suitable and commonly used game elements in serious game interventions. The implemented game elements include Points, Quests, Avatar, Achievements, Challenges, Feedback, Win States, Rewards, Constraints, and Progression (see Table 5.6). These game elements collectively determined the overall flow and progression of the game prototype.

Table 5.6
Game Elements Based on Component, Mechanics, and Dynamics Category

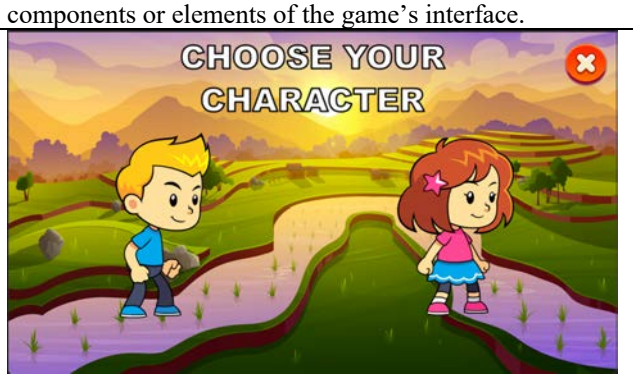
Game elements		
Components	**Mechanics**	**Dynamics**
Points	Challenges	Constraints
Quests	Feedback	Progression
Avatar	Win states	-
Achievement	Rewards	-

a) Components

The game prototype incorporates various game elements from the Component category, including Points, Quests, Avatar, and Achievement. Points are represented by the 'healthy food' collected during gameplay, with points deducted for unintentionally collecting 'unhealthy food' (enemies). Quests, or game missions and goals, involve collecting as many 'healthy foods' as possible to reach the flag post at the end of each level and progress to the next. Next, the game prototype features an avatar or character that players can choose between a male or female, designed to be relatable to the young target audience. This also further enhances their engagement during gameplay. Achievements are depicted through reaching the flag post at the end of each level, triggering a motivational quote and displaying the final score and unlocked healthy food items. The flag post at the end of each level provides a sense of success and achievement, and a motivational message such as "Well done! I'm feeling much better now" reinforces the player's accomplishment. The final screen displays the total points collected, along with the Malaysian Healthy Plate (MHP) showing the healthy food categories. This allows the player to unlock the next level once they have reached the goals. Table 5.7 below shows the screenshots and description of the game elements under Component category.

Table 5.7
Game Elements Under Component Category

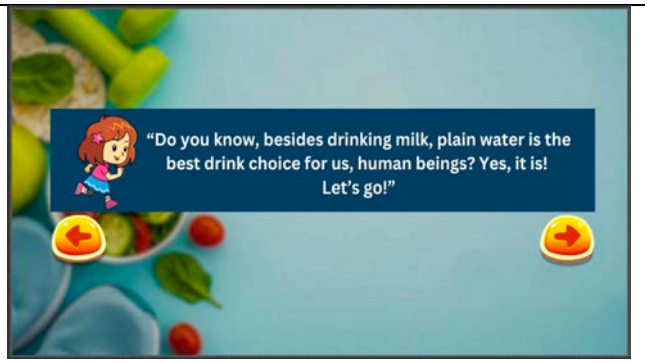
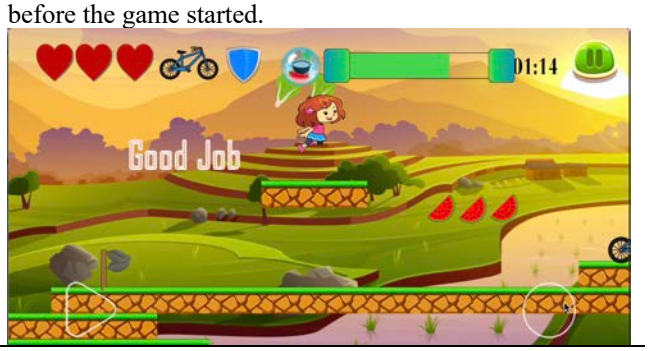
Game elements	**Screenshots and description**

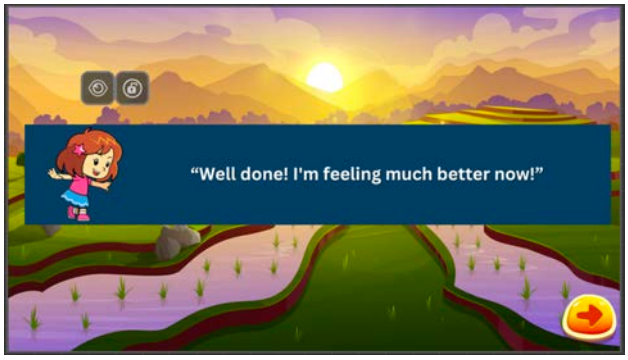
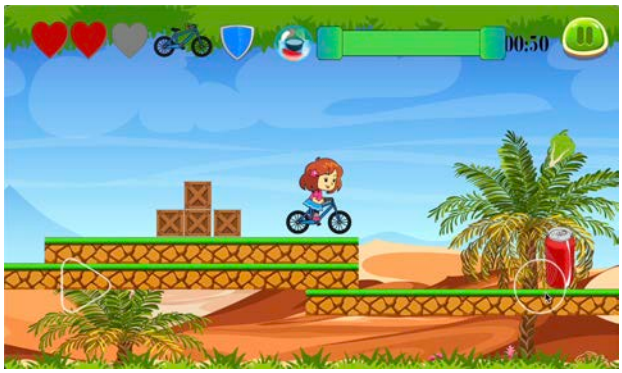
Points	 Points were collected based on the 'healthy food' items such as lettuce and watermelon which represent vegetables and fruits in food pyramid and MHP.
Quests	 Screen that explained the quests of the game and components or elements of the game's interface.
Avatar/ Character	 The character screen shown the availability to choose between two character: male or female.
Achievement	 Player reached the goal by reaching the end flag post, and within the stipulated time to complete the level.

b) Mechanics

The Mechanics of game elements in this category include Challenges, Feedback, Win States, and Rewards. Challenges in the game prototype involve obstacles such as boxes, bricks, and saw blades. Additionally, the player must avoid 'unhealthy foods' like candy, burgers, and soda, which serve as enemies in the game. The game prototype provides various forms of feedback to engage and motivate the player. Before each level, the player is presented with fun facts about healthy lifestyles, such as the importance of proper nutrition and physical activity. Additionally, during gameplay, the player receives short words of affirmation and encouragement, such as "Stay healthy!" or "Good job" to further motivate their progress. Furthermore, upon successfully reaching the flag post at the end of each level, a congratulatory pop-up screen appears. Conversely, if the player fails to reach the flag post within the time limit or falls into a hole, a positive feedback message will still appear to discourage the player from giving up and encourage them to try again. In this game, win states are represented by in-game rewards like the star collectible item, which provides the player with a power-up that allows them to further progress in the game and increase their chances of winning. The power-up ability grants the player a shield to protect the character from enemies and obstacles, preventing the deduction of lives. Additionally, rewards in this game are provided during the points collection through the 'healthy food' collectible items. Furthermore, rewards are given after the player completes each level, including the level unlock achievement and the accumulated points throughout the gameplay. The Malaysian Healthy Plate (MHP) in the end screen also will be unlocked for each category based on each level. For instance, level 1 unlocks the vegetables and fruits category (lettuce and watermelon), level 2 unlocks the protein category (a piece of chicken), level 3 unlocks the carbohydrate category (a bowl of rice), and level 4 unlock the water and milk category. Each level and MHP category indicate the importance of healthy food intake based on the recommended proportion. Table 5.8 below shows the screenshots and description of the game elements under Mechanics category.

Table 5.8
Game Elements Under Mechanics Category

Game elements	Screenshots and description
Challenges	 Obstacles such as boxes, bricks, and saw blades that the player had to hinder so the player lives (heart-shaped lives) would not be deducted.  'Unhealthy foods' like candy, burger, and coke are considered enemies in the game, hence player should avoid them.
Feedback	 The initial screen whereby fun fact about healthy food intake and importance of physical activity is prompted before the game started. 

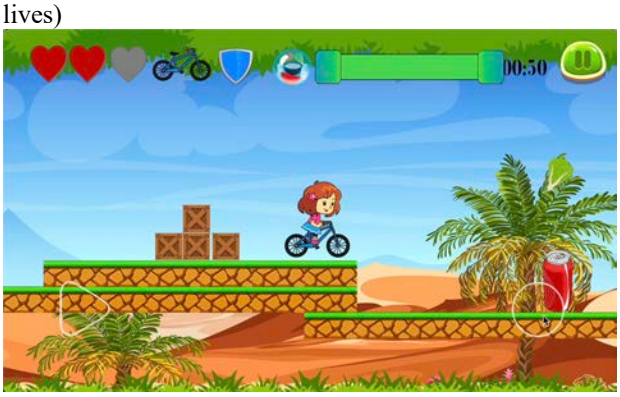
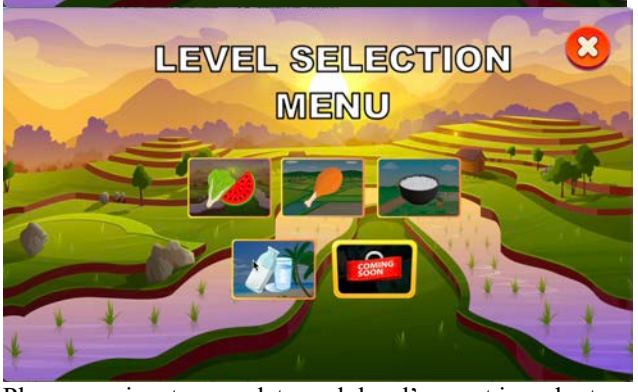
	During the gameplay, if the player manage to collect 'healthy food' items as points, positive feedback will be initiated on screen.  The player will be prompted with positive feedback once they managed to complete the game quest for each level.  The player will be prompted with positive feedback even when they unable to complete the game quest for every level.
Win states	 A power-up give the player a shield to protect the them from enemies and obstacles, preventing the deduction of lives.  Another power-up is riding a bicycle which will speed up the player's movement towards the end flag post.

Rewards	 Scores or points were given as rewards at the end screen after the player completed each level. Besides that, the Malaysian Healthy Plate (MHP) category shown will be unlocked based on each level.

c) Dynamics

The Dynamics of game elements in this category include Constraints and Progression. The game prototype presents various constraints, such as the main obstacles of bricks, boxes, and saw blades. Additionally, players must jump when they encounter holes that could deduct their lives. Furthermore, the time limit displayed at the top of the game screen provides a time-based challenge, urging the player to reach the flag post within the allotted time. The game prototype also incorporates progression as a key game element. A progress bar is implemented to visually represent the time constraint as the player advances through the gameplay. This progress bar challenges the player to complete each quest within the allotted time. Additionally, progression in the game is demonstrated by the player's ability to finish levels and achieve the goals provided. As the player completes each level, they are then led to the next level with new objectives to accomplish, further enhancing the progression and gameplay experience. Table 5.9 below shows the screenshots and description of the game elements under Dynamics category.

Table 5.9
Game Elements Under Dynamics Category

Game elements	Screenshots and description
Constraints	 The player falls off in the hole and lose lives (heart-shaped lives)  Obstacles such as boxes, bricks and saw blades including the 'unhealthy food' such as candy, burger and coke were the constraints in proceeding in the gameplay.
Progression	  Player requires to complete each level's quest in order to unlock each levels in order to progress. 1st image shows only level 1 is unlocked, whilst 2nd image shows all levels

	were unlocked when player managed to complete all levels.

5.2.4 Game Flow

The game prototype was designed to provide a seamless and engaging user experience, with a focus on storyboarding and expert review findings that would help to enhance the overall game flow. Figure 5.9 below shows the game prototype flowchart. The rectangle in flowchart below is represented by screens on the game interface, while the direction of an arrow indicates the ability for the player to transition from one screen to another. The game flow necessitates that players successfully finish each level before advancing to the next level, until game over. For example, upon completing Level 1 of the game, the Level 2 button will be unlocked, enabling the player to proceed to Level 2. Nevertheless, if the player failed to complete Level 1, the Level 2 button will remain locked, preventing the player from advancing to the subsequent level. The game comprises four levels, which the player must complete in sequence to attain the game's objectives.

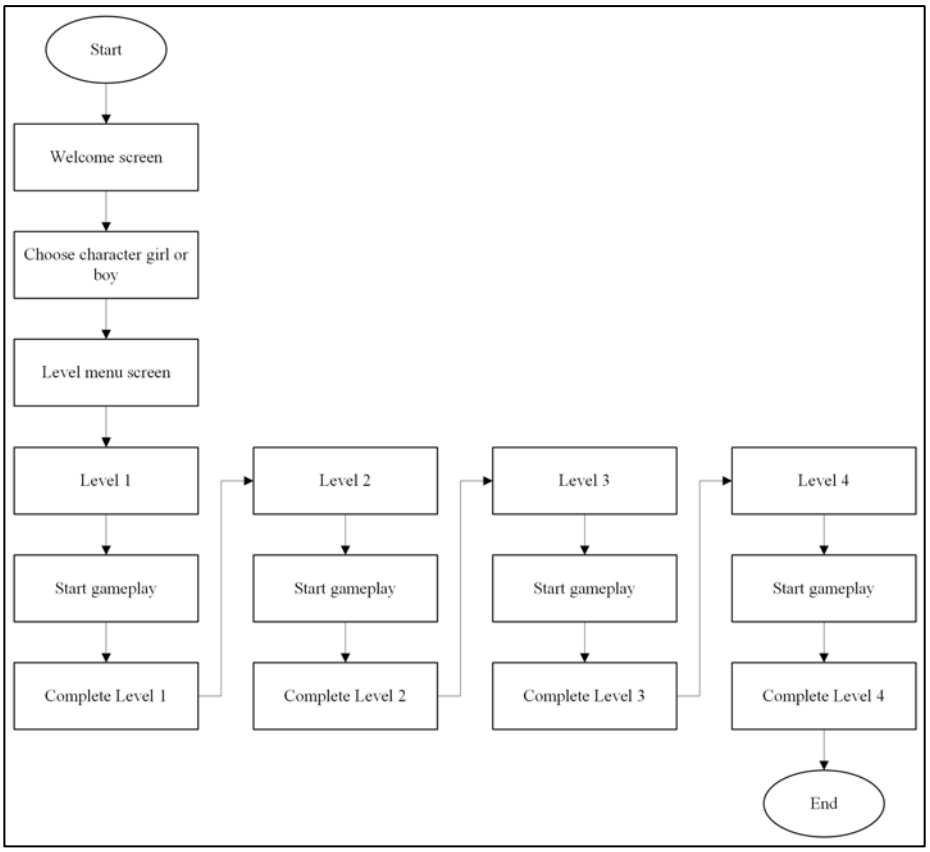


Figure 5.9 Game Prototype Flowchart

5.3 Experimental Study

The experimental study represents the concluding phase of this research study, during which the evaluation of the game prototype was carried out based on the serious game framework put forth earlier. The data collection on the game's effectiveness, pertaining to quality factors such as usability, player experience, and perceived learning, was performed. To collect the data, questionnaires were utilized after the participants played the game prototype. In this section, a comprehensive discussion of the experimental study conducted and the findings pertaining to the effectiveness of the game prototype are further elucidated.

5.3.1 Demographic Background

To evaluate the effectiveness of the game prototype developed based on the serious game framework promoting obesity awareness, 45 participants were involved in this experimental study. The 45 participants were of age range 7 to 18 years old.

Figure 5.10 Experimental Study Session

Quantitative and qualitative data analysis were conducted to answer the third research question. The data were collected and analysed based on the quality factors of the game prototype namely, usability, player experience and perceived learning. Various statistical analyses were performed during this experimental study such as, descriptive statistics on the game prototype effectiveness. Besides that, correlation analysis was conducted to find the correlation between domains.

Table 5.10
Demographic Information

		Frequency	Percentage (%)
Gender	Male	18	40%
	Female	27	60%
Age	7-12 years old	13	28.9%
	13-18 years old	32	71.1%
Frequency with which the participants play digital game	Never	3	6.7%
	Rarely: from time to time	12	26.7%
	Monthly: at least once a month	5	11.1%
	Weekly: at least once a week	15	33.3%
	Daily: everyday	10	22.2%

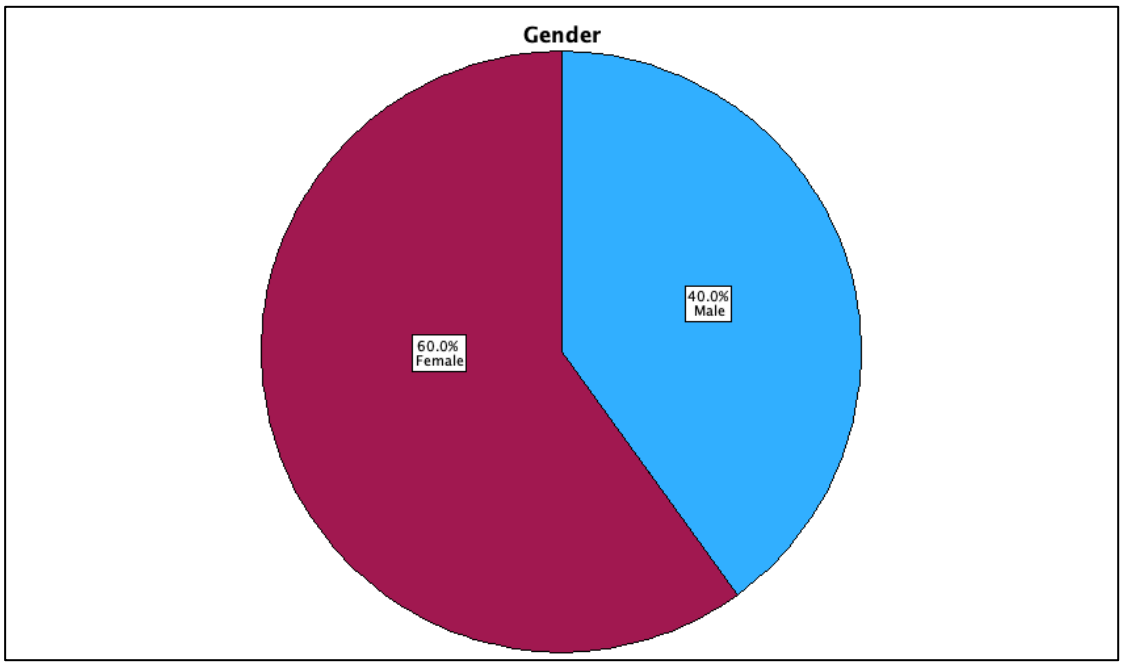


Figure 5.11 Gender Frequency Percentage

Table 5.10 above shows for the overall demographic information for the experimental study. The demographics of the participants are presented in pie chart for gender frequency percentage (Figure 5.11), age frequency percentage (Figure 5.12), and frequency of playing games percentage (Figure 5.13). Out of 45 children that participated in the experimental study, 40% were male and the rest are female.

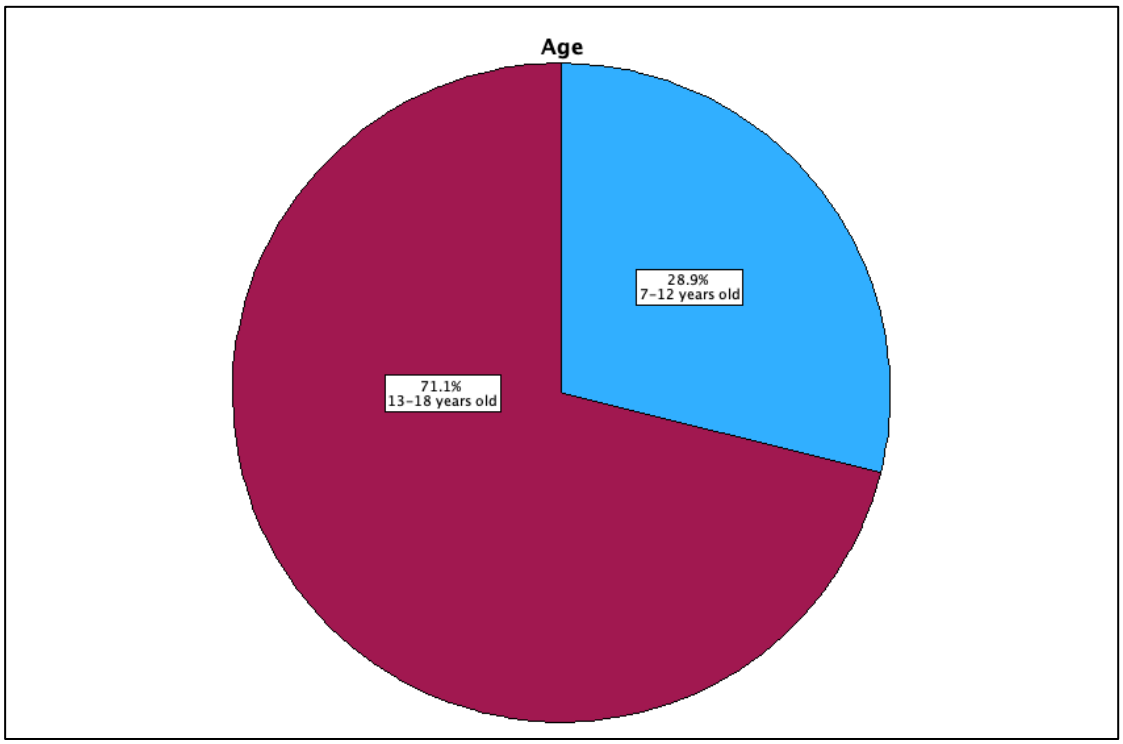


Figure 5.12 Age Frequency Percentage

Besides that, the age group were classified between two categories, that are of 7 to 12 years old which is considered primary school students in Malaysia, and the next category is individuals aged between 13 to 18 years, which is considered secondary school students in Malaysia. Only 28.89% participants involved are those from the age group 7 to 12 years, whereas a 71.11% of those involved were aged 13 to 18 years. Consequently, all students under the age of 18 were regarded as children and participated in this study.

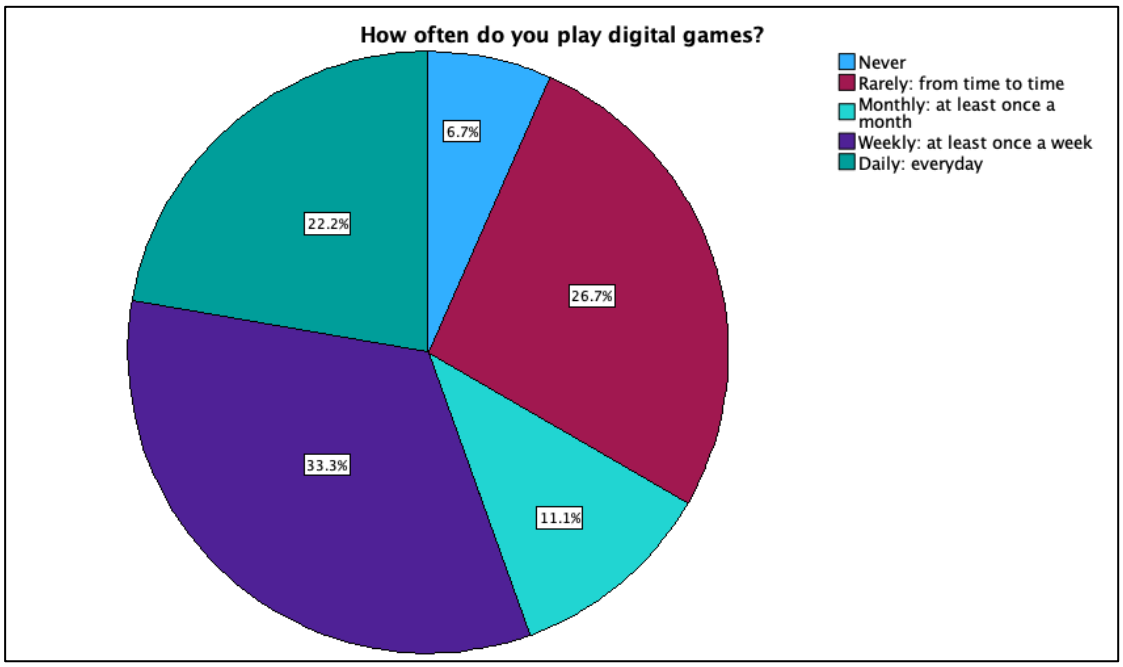


Figure 5.13 Frequency of Playing Games Percentage

Furthermore, the frequency with which the participants play game has quite a widespread and discrepancy, whereby most participants played game at least once a week with 33.33%, 26,67% participants played game rarely, and 22.22% played daily. Only 11.11% participants played once a month, and 6.67% participants never played game. The high number of participants played game in either, daily basis or once a while show how much familiarity of the participants with digital game nowadays.

5.3.2 Findings of Game Prototype Evaluation

A Likert scale quality measurement is performed on MEEGA+ model. The three-quality factor addressed in this model are usability, player experience and perceived learning. For each quality factor, a set of dimensions is used. The MEEGA+ model contains 18 questions in the Likert Scale described as positive answers (strongly agree and agree=happy face), negative answers (strongly disagree and disagree=unhappy face) and neutral (neutral/ indifferent=straight face). To calculate the mean score and the standard deviation of each question, we give five points to strongly agree, four points to agree, three points to neutral/ indifferent, two points to disagree and one point to strongly disagree.

5.3.2.1 Descriptive Analysis

a) Quality Factor – Usability

Figure 5.14 presents the usability of the game based on the participants' evaluation whereas Table 5.13 statistically detailed the descriptive statistic for usability dimensions.

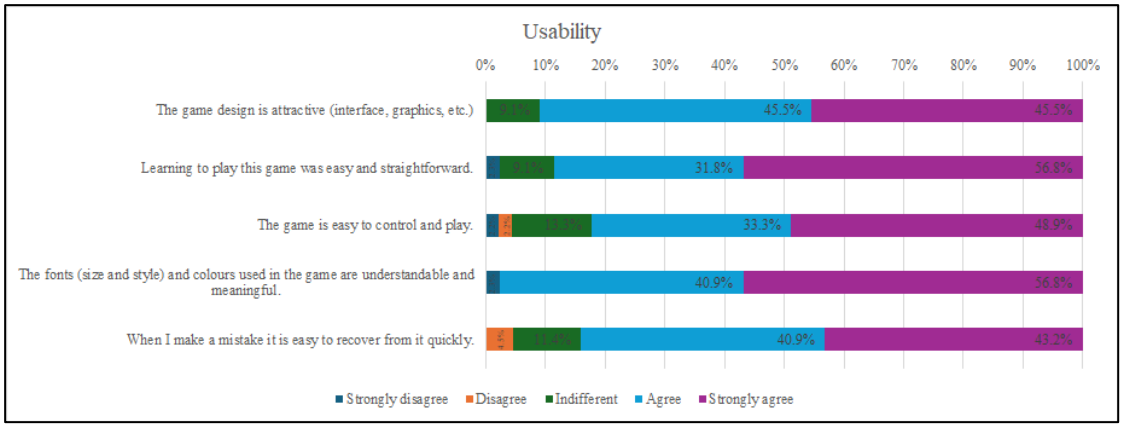


Figure 5.14 Findings on Usability of the Game Prototype

Table 5.11
Descriptive Statistic for Usability Dimension

	N	Minimum	Maximum	Mean	Std. Deviation
1. The game design is attractive (interface graphics sounds character).	**44**	**3**	**5**	**4.36**	**.650**
2. Learning to play this game was easy and straightforward.	**44**	**1**	**5**	**4.41**	**.844**
3. The game is easy to control and play.	**45**	**1**	**5**	**4.24**	**.933**
4. The fonts (size and style) and colours used in the game are understandable and meaningful.	**44**	**1**	**5**	**4.50**	**.731**
5. When I make a mistake it is easy to recover from it quickly.	**44**	**2**	**5**	**4.23**	**.831**
Valid N (listwise)	**42**				

Based on the findings presented in Figure 5.14, aesthetically, almost half of the participants strongly agree and agree on the attractiveness of the game design, and only 9.1% of the participants indifferent in their opinions of the game aesthetics. In terms of learnability in the game design, 56.8% strongly agree on the games easy and

straightforward method in playing the game, whereas 31.8% agree, 9.1% felt indifferent, and 2.3% strongly disagree with it. In terms of operability, high percentage of participants strongly agree and agree (strongly agree=48.9% and agree 33.3%) with the statement of the game easiness to play and control, whereas 13.3 % felt indifferent and 2.2% strongly disagree and disagree. The statement: "fonts and colours used in the game are understandable and meaningful" also had a high percentage number of participants that strongly agree and agree (strongly agree=56.8% and agree=40.9%) whilst only 2.3% strongly disagree with it. Finally, in terms of making recovery after making mistakes in the game, many participants strongly agree and agree (strongly agree=43.2%, agree=40.9%), whilst 11.4% felt indifferent and only 4.5% disagree with it. Overall, most participants agree on the game's usability.

b) Quality Factor – Player Experience

Figure 5.15 presents the findings of player experience with *FitFuel Frenzy* whereas Table 5.12 detailed out the descriptive statistic for player experience dimension.

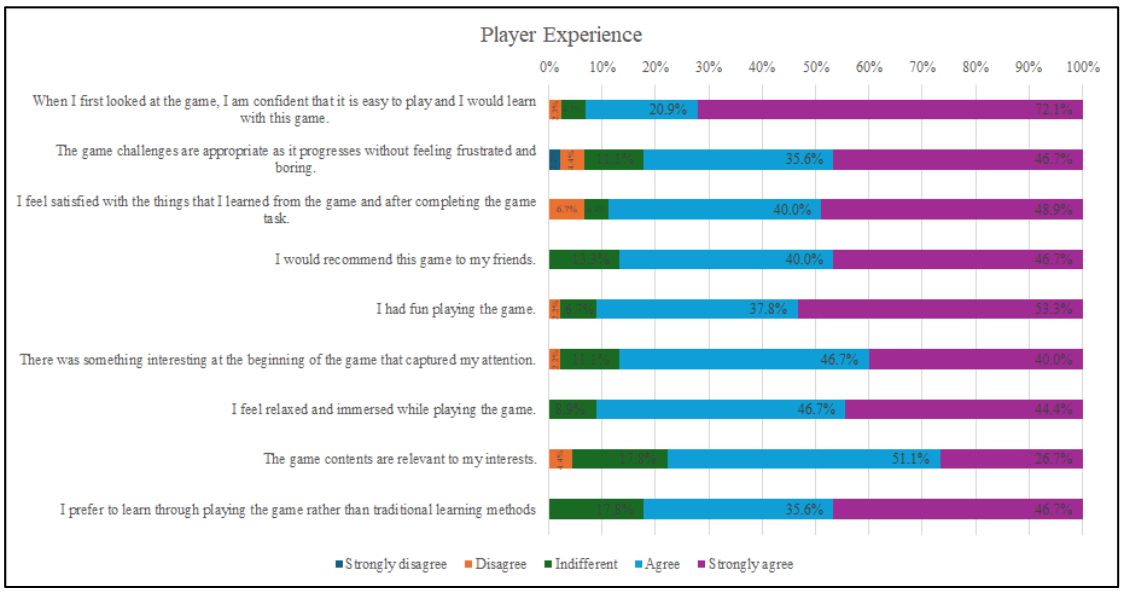


Figure 5.15 Findings on Player Experience of the Game Prototype

Table 5.12
Descriptive Statistic for Player Experience Dimension

	N	Minimum	Maximum	Mean	Std. Deviation
6. When I first looked at the game I am confident that it is easy to play and I would learn with this game.	**43**	**2**	**5**	**4.63**	**.691**
7. The game challenges are appropriate as it progresses without feeling frustrated and boring.	**45**	**1**	**5**	**4.20**	**.968**
8. I feel satisfied with the things I learned from the game and after completing the game task.	**45**	**2**	**5**	**4.31**	**.848**
9. I would recommend this game to my friends.	**45**	**3**	**5**	**4.33**	**.707**
10. I had fun playing the game.	**45**	**2**	**5**	**4.42**	**.723**
11. There was something interesting at the beginning of the game that captured my attention.	**45**	**2**	**5**	**4.24**	**.743**
12. I feel relaxed and immersed while playing the game.	**45**	**3**	**5**	**4.36**	**.645**
13. The game contents are relevant to my interest.	**45**	**2**	**5**	**4.00**	**.798**
14. I prefer to learn through playing the game rather than traditional learning methods.	**45**	**3**	**5**	**4.29**	**.757**
Valid N (listwise)	**43**				

The confidence level in playing the game is positively correlated with the initial impression of playing it, with a significant number of participants (72.1%) expressing strong agreement, and an additional 20.9% agreeing. Furthermore, a substantial portion of participants (93%) reported having confidence while playing the game, with only 4.7% feeling indifferent and 2.3% disagreeing with the statement. A considerable proportion of participants (46.7% strongly agree and 35.6% agree) indicated that they found the game challenge to be suitable, as it progressed without causing frustration or tedium. Nevertheless, a considerable number of participants were indifferent to the challenge implemented in the game (11.1%), and a small proportion of participants (4.4% disagree and 2.2% strongly disagree) did not find the challenge in the game to be suitable.

Majority of the participants (strongly agree=48.9% and agree=40%) feel satisfied with the things they learned on the game and after the completed the game

tasks. Only small number participants felt indifferent and feel unsatisfied (indifferent=4.4% and disagree=6.7%). Besides that, 86.7% participants strongly agree and agree (strongly agree=46.7% and agree 40%) to recommend the game *FitFuel Frenzy* to their friends. Only 13.3% felt indifferent. A vast majority of participants (strongly agree=53.3% and agree=37.8%) that they had fun playing the game. Whereas 6.7% of them felt indifferent and 2.2% disagree. In terms of first impression, 86.7% of them strongly agree and agree with it (strongly agree=40% and agree=46.7%) where the beginning of the game captures participants' attention, whereas 11.1% of the participants felt indifferent and 2.2% disagree with it. Besides that, a vast majority percentage of participants felt relaxed and immersed while playing the game (strongly agree=44.4% and agree=46.7%), while only 8.9% felt indifferent.

In addition, 77.8% participants strongly agree and agree (strongly agree=26.7% and agree=51.1%) with the relevancy of the game content to their interest. 17.8% of the participants felt indifferent and 4.4% of them disagree. Moreover, many participants also strongly agree and agree (strongly agree=46.7% and agree=35.6%) that they prefer learning through playing the game rather than through conventional methods. However, 17.8% of them felt indifferent. Overall, each category in the player experience dimension suggested high number of participants agreed that the game is engaging, enjoyable, immersive, and motivating.

c) Quality Factor – Perceived Learning

Perceived learning is another quality factor measured in this game efficacy. Figure 5.16 shows the findings on perceived learning of the game prototype whereas Table 5.13 detailed out the descriptive statistic for perceived learning dimension.

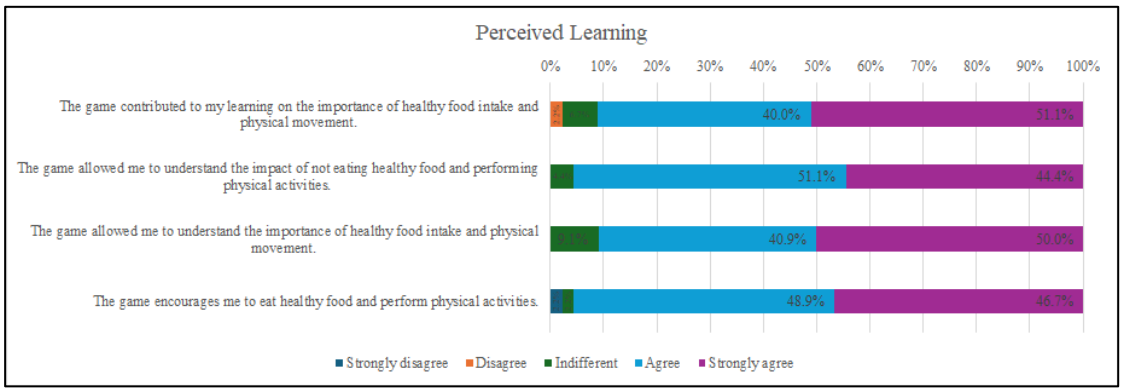


Figure 5.16 Findings on Perceived Learning of the Game Prototype

Table 5.13
Descriptive Statistic for Perceived Learning Dimension

	N	Minimum	Maximum	Mean	Std. Deviation
15. The game contributed to my learning on the importance of healthy food intake and physical movement.	**45**	**2**	**5**	**4.40**	**.720**
16. The game allowed me to understand the impact of not eating healthy food and performing physical activities.	**45**	**3**	**5**	**4.40**	**.580**
17. The game allowed me to understand the importance of healthy food intake and physical movement.	**44**	**3**	**5**	**4.41**	**.658**
18. The game encourages me to eat healthy food and perform physical activities.	**45**	**1**	**5**	**4.38**	**.747**
Valid N (listwise)	**44**				

The expected learning outcomes of this game is where the last category is referring to. High number of participants strongly agree and agree (strongly agree=51.1% and agree=40%) that the game contributed to their learning of the importance of taking healthy food and physical activity. 6.7% felt indifferent and 2.2% disagree with it. Additionally, majority of participants also strongly agree and agree that the game allowed them to understand the impact of not eating healthy food and performing physical activity (strongly agree=44.4% and agree=51.1%). Whereas 4.4% felt indifferent. In addition, 91% of the participants strongly agree and agree (strongly agree=50% and agree=40.9%) that the game give them understanding of the importance of healthy food intake and performing physical activity. However, only 9.1% felt indifferent. Finally, vast majority number of participants with 96.6% strongly agree and agree (strongly agree=46.7% and agree=48.9%) that the game encourages them to eat

healthily and perform physical activities. However, 2.2% of the participants felt indifferent and another 2.2% strongly disagree. Overall, most participants agreed that they learned valuable information regarding the importance of taking healthy food and performing physical activity.

Table 5.14
Mean Values for Usability, Player Experience, and Perceived Learning Domains

Dimensions	Mean values
Usability	4.348
Player experience	4.308
Perceived learning	4.397

In conclusion, among all the dimensions, perceived learning had the highest mean value of 4.39, while the player experience dimension had the lowest mean value of 4.30. Meanwhile, the usability dimension had a mean value of 4.34. However, all dimensions exhibited similar mean values, with no significant differences. This suggests that overall, all three dimensions are considered to have high mean values, with participants largely agreeing that perceived learning indicates players felt they gained valuable information from the game, particularly in promoting obesity awareness through gameplay. Additionally, the player experience dimension suggests that the game is enjoyable, immersive, and motivating, while the usability dimension indicates the game is easy to use, navigate, and comprehend. Thus, the high mean values across all three dimensions indicate that the game is well-designed, engaging, and educationally effective from the players' perspective.

5.3.2.2 Comments and Recommendation from the Participants

After playing the platform-based game *FitFuel Frenzy*, participants provided diverse feedback, highlighting both strengths and areas for improvement. Several participants suggested enhancing the gameplay experience by increasing the game speed and adding more levels, worlds, and boosts to introduce more challenges and fun. Customizable characters, pet-unlocking levels, and additional maps were also recommended to make the game more engaging and adventurous. Some participants found the controls, particularly the jumping button and character movement, difficult to manage, prompting suggestions for simplifying or improving them. While a few felt the

game was perfect and enjoyable, others noted that it was more suitable for younger children rather than teenagers and could benefit from higher difficulty levels. Educationally, the game was praised for its role in teaching healthy living and weight management, with suggestions to add more healthy foods as points and a tutorial for younger audiences. Overall, the game was perceived as fun and meaningful, particularly for children facing obesity, though some participants felt it could be made more addictive and challenging.

5.3.2.3 Correlation Analysis

A correlation analysis using Spearman's Rank Correlation Coefficient was conducted to test that the game prototype significantly promotes obesity awareness across three domains: usability, player experience, and perceived learning (see Table 5.15). Spearman's rho (ρ) was chosen due to the ordinal nature of the questionnaire data and to assess the strength and direction of the monotonic relationships between the game's effectiveness and obesity awareness. The analysis examined the correlation between the game's usability and player experience, yielding a Spearman's rho of 0.858, which is a very strong positive correlation and statistically significant. Similarly, the correlation between usability and perceived learning which indicates the obesity awareness in this study resulted in a Spearman's rho of 0.704, indicating a strong positive relationship and statistically significant. This shows that as participants find the game more usable, their perception of learning about obesity awareness increases. The result is statistically significant, suggesting a real relationship between these two variables. Lastly, the correlation between player experience and perceived learning produced a Spearman's rho of 0.639, demonstrating a strong positive correlation and statistically significant.

Overall, the findings, suggest that there is a statistically significant strong positive correlation between usability, player experience, and perceived learning domains. These results provide evidence that the game's usability and learning components have a meaningful impact on promoting obesity awareness, though further investigation is needed to fully understand each domain and its roles towards obesity awareness. Additionally, the positive strong correlation in the perceived learning domain suggests that as players perceive higher learning from the game, they also report higher awareness of obesity.

Therefore, based on the results from the Spearman's correlation analysis that was employed it is concludes as the following:

a) As the usability's game increases, player experience in game increases as well, which reflects a positive relationship.
b) As the usability's game increases, perceived learning (obesity awareness) increases as well, which reflects a positive relationship.
c) As the player experience in game increases, perceived learning (obesity awareness) increases as well, which reflects a positive relationship.

These results suggested that most participants in this study agreed that these domains were needed to enhance and improve obesity awareness in serious game.

Table 5.15
Correlation Analysis Between Usability, Player Experience, and Perceived Learning (Using Mean Value)

			Usability	**Player experience**	**Perceived learning**
Spearman's rho	**Usability**	**Correlation Coefficient**	1.000	.858**	.704**
		Sig. (2-tailed)	-	<.001	<.001
		N	42	41	41
	Player experience	**Correlation Coefficient**	.858**	1.000	.639**
		Sig. (2-tailed)	<.001	-	<.001
		N	41	43	42
	Perceived learning	**Correlation Coefficient**	.704**	.639**	1.000
		Sig. (2-tailed)	<.001	<.001	-
		N	41	42	44

**. Correlation is significant at the 0.01 level (2-tailed)

5.3.3 Discussion of Game Prototype Evaluation

The descriptive findings reveal highly positive perceptions of usability, player experience, and perceived learning, indicating that the pattern aligns with the three domains measured. Overall, the high mean values for all three domains suggest that participants largely agreed that players felt they gained valuable information from the game, which promotes obesity awareness. Additionally, the game is considered enjoyable, immersive, motivating, easy to use, navigate, and comprehend.

5.3.3.1 Usability

The descriptive findings reveal highly positive perceptions of usability. This pattern aligns with broader research, indicating that when usability components such as aesthetics, ease of learning, and ease of control are robust, users report higher satisfaction and engagement with the game (Daud et al., 2024; Moosa et al., 2020; Xinogalos & Satratzemi, 2022).

High agreement on the attractiveness of the game design, along with meaningful and readable fonts and colours, suggests that the visual elements effectively support engagement and comprehension, rather than merely serving as decoration (Karakasis & Xinogalos, 2020; Xinogalos & Satratzemi, 2022). Similar findings in other educational games link positive aesthetic ratings to enhanced user experience and satisfaction (Espinosa-Curiel et al., 2022). Furthermore, the very high ratings for ease of learning and ease of play or control suggest that the interaction is intuitive, with players quickly grasping the rules and controls (Phutela et al., 2022; Xinogalos & Satratzemi, 2022). There is also similar patterns that show most users learn quickly and clear early levels on their first attempt, which could be seen as evidence of good learnability and operability in other serious games (Phutela et al., 2022). The small proportion of users who are either indifferent or disagree may indicate a subgroup needing clearer onboarding, additional examples, or scaffolding, as noted in other educational games where pre-knowledge demands were identified as a weakness (Karakasis & Xinogalos, 2020).

Moreover, there is high agreement in the dimension of ease of recovery from mistakes, indicating that the game provides users with clear feedback and ways to correct errors, a crucial aspect of usability in learning environments (Karakasis & Xinogalos, 2020; Phutela et al., 2022). This allows for learning support by enabling experimentation without severe penalties.

Overall, the response pattern supports the claim that the game is highly usable, being perceived as attractive, easy to learn, easy to control, visually clear, and forgiving of mistakes. These strong positive ratings are linked to higher satisfaction and learning potential in educational games, aligning with MEEGA+ (Daud et al., 2024). The small neutral/negative minorities highlight opportunities for refinement in onboarding and support but do not undermine the generally strong usability profile.

5.3.3.2 Player Experience

The descriptive findings reveal a highly positive player experience characterized by strong confidence, appropriate challenge, high satisfaction, enjoyment, immersion, and a preference over traditional learning methods. The strong link between positive first impressions and confidence indicates that the game is both manageable and engaging. In evaluations of serious games, early indicators of difficulty and structure consistently bolster confidence and perceived controllability, which in turn enhance motivation and engagement (Idrissi et al., 2022; Xinogalos & Satratzemi, 2022). Reviews of previous studies highlight that player competence, where individuals feel capable and effective, is a fundamental psychological need that fuels intrinsic motivation and sustained engagement (Buil et al., 2019; Daud et al., 2024; Plass et al., 2015). When games are perceived as comprehensible and winnable, learners are more inclined to persist and exert effort (Buil et al., 2019; Daud et al., 2024). Consequently, the high confidence ratings suggest that the game aligns with the principles of competence support in self-determination theory (Buil et al., 2019), as well as with the motivation component in the proposed framework.

Furthermore, most participants deemed the challenge to be appropriate. Research suggests that a well-calibrated challenge is a strong predictor of engagement and learning, as tasks that are too easy can lead to boredom, while those that are too difficult may cause frustration (Abdul Jabbar & Felicia, 2015; Xinogalos & Satratzemi, 2022; Yu et al., 2020). Meta-analyses and reviews indicate that challenges that escalate at an appropriate pace enhance learning retention and engagement in educational games (Yu et al., 2020). High levels of enjoyment, relaxation, and immersion are typical indicators of effective gameplay engagement, both emotionally and cognitively (Abdul Jabbar & Felicia, 2015; Alexiou & Schippers, 2018; Connolly et al., 2012). Reviews of serious games and digital game-based learning describe engagement as a combination of enjoyment, focused attention, and absorption in the activity; suggesting that these states are linked to improved learning and more positive attitudes toward the subject (Abdul Jabbar & Felicia, 2015; Connolly et al., 2012; Wouters et al., 2013; Yu et al., 2020). Only a small group expressed indifference or negativity toward the challenge. According to Alexiou & Schippers (2018), this highlights that players' differing personality traits can cause the same difficulty curve to feel "too easy" for some and

"too hard" for others. This suggests that refinement through difficulty options or adaptive challenges is needed, rather than a fundamental design flaw.

High satisfaction with learning and a strong willingness to recommend the game align with findings that satisfaction and perceived usefulness are key outcomes of successful serious games (Connolly et al., 2012; Idrissi et al., 2022; Wouters et al., 2013; Yu et al., 2020). Studies utilizing MEEGA+ indicate that satisfaction items such as "I feel satisfied with what I learned" and "I would recommend this game" are typically high when usability and player experience are strong (Idrissi et al., 2022; Xinogalos & Satratzemi, 2022). The perceived relevance of content to learners' interests is another significant driver of motivation and engagement in educational games, as demonstrated in these studies by (Idrissi et al., 2022; Moosa et al., 2020; Plass et al., 2015). Consequently, based on findings, three quarters agreed that the game is relevant, with many preferring it to conventional methods, suggesting that *FitFuel Frenzy* effectively connects its content to players' lives and preferences. This supports evidence that serious games can enhance attitudes toward learning, engagement, and satisfaction compared to traditional instruction (Wouters et al., 2013; Yu et al., 2020).

The finding that many participants prefer learning through the game over conventional methods aligns well with broader evidence. Meta-analyses and reviews indicate that, on average, serious games modestly outperform traditional instruction in learning outcomes and often score higher on motivation, engagement, and satisfaction (Abdul Jabbar & Felicia, 2015; Wouters et al., 2013; Yu et al., 2020). This also demonstrates that when games satisfy competence and autonomy, they foster intrinsic motivation, engagement, and perceived learning (Buil et al., 2019; Idrissi et al., 2022; Moosa et al., 2020). Therefore, the findings support the view that *FitFuel Frenzy* is not only usable but also pedagogically appealing, likely to encourage repeated use and positive attitudes toward the targeted health behaviours.

Overall, these findings demonstrate how the player experience domain can predict objective learning, behaviour change, or health outcomes, as previous research has linked motivation and engagement to enhanced skills and knowledge acquisition (Buil et al., 2019; Idrissi et al., 2022; Wouters et al., 2013; Yu et al., 2020). Simultaneously, the presence of a small group of indifferent and disagreeing participants underscores the potential for personalization to better cater to diverse player types and preferences (Abdul Jabbar & Felicia, 2015; Alexiou & Schippers, 2018; Plass et al., 2015).

5.3.3.3 Perceived Learning

The descriptive results under Perceived Learning strongly indicate that *FitFuel Frenzy* successfully achieved its health-education objectives, which include understanding healthy eating and physical activity, recognizing the consequences of unhealthy habits, and feeling motivated to change behaviour.

Over 90% of participants agree that the game helped them grasp the importance of healthy food and physical activity and the impact of neglecting healthy habits, with only a very small minority expressing indifference or disagreement. This pattern reflects findings from serious games in health education, where games often enhance health knowledge, attitudes, and intentions toward healthier behaviours, particularly in nutrition and physical activity contexts (Damaševičius et al., 2023; Moosa et al., 2020). Meta-reviews of serious games and gamification in health report that many interventions targeting diet and activity improve knowledge and attitudes, often showing positive trends in behaviour change, such as increased fruit and vegetable intake, better snacking choices, and more physical activity (Damaševičius et al., 2023). A scoping review of food-education games similarly found that serious games can enhance children's understanding of healthy foods and foster more positive attitudes toward fruits and vegetables (Damaševičius et al., 2023). From a game-based learning perspective, the strong perceived learning aligns with the notion that effective serious games integrate content with meaningful choices, feedback, and challenges, enabling learners to construct conceptual and procedural knowledge in an engaging manner (Abdul Jabbar & Felicia, 2015; Alexiou & Schippers, 2018; Plass et al., 2015).

The most striking result is that approximately 97% agree the game encourages them to eat healthily and be physically active. This is notable because transitioning from "I learned something…" to "I feel encouraged to act differently" signifies a shift from cognitive to motivational and behavioural intention outcomes. Studies based on self-determination theory of serious games and exergames indicate that when games fulfil players' needs for competence and autonomy, intrinsic motivation and intentions for future health behaviour are enhanced (Buil et al., 2019; Peng et al., 2012). Experimental research with a self-determination theory-guided exergame found that features supporting competence and autonomy increased enjoyment, motivation for future play, self-efficacy for exercise, and the likelihood of recommending the game (Peng et al., 2012). Thus, the high agreement on "the game encourages me to eat healthily and be

active" and on recommending the game aligns with this mechanism. Reviews of health-focused serious games also report that games can be effective tools for promoting behaviour change, including better dietary choices and increased physical activity, although studies suggest the need for follow-up data to confirm that intentions translate into sustained behaviour (Damaševičius et al., 2023; Moosa et al., 2020). Thus, the findings suggest a strong perceived readiness and intention, which is a necessary precursor to actual change.

Thus, the descriptive analysis indicates that *FitFuel Frenzy* has a significant perceived learning impact on children, with learners reporting an understanding of both the benefits of healthy behaviours and the risks associated with unhealthy habits. Furthermore, children feel motivated to incorporate the knowledge they acquire from gameplay into their daily life. In the domain of perceived learning, many serious games, particularly those focused on health, often demonstrate high levels of perceived learning and motivation when usability and player experience are robust (Abdul Jabbar & Felicia, 2015; Damaševičius et al., 2023; Idrissi et al., 2022; Moosa et al., 2020; Xinogalos & Satratzemi, 2022). However, while perceived learning and intentions are significant, it is essential to verify objective learning gains and actual behavioural changes through tests, logs, or follow-up assessments (Abdul Jabbar & Felicia, 2015; Connolly et al., 2012; Damaševičius et al., 2023; Wouters et al., 2013; Yu et al., 2020).

5.3.3.4 Evaluation of Relationship Between Usability, Player Experience, and Perceived Learning

The correlation findings indicate a strong association between usability and player experience with higher perceived learning or perceived awareness, aligning well with research on serious games and game-based learning.

The relationships between usability and player experience domains suggest that when a game is easier to use, players report a more positive overall experience, including greater engagement, enjoyment, and immersion. Reviews of serious and educational games consistently demonstrate that good usability is essential for a positive user experience and sustained engagement, as usability issues can distract from learning and disrupt immersion (Abdul Jabbar & Felicia, 2015; Connolly et al., 2012; Da Silva et al., 2025).

Furthermore, the relationship between usability and perceived learning suggests that when a game is more user-friendly, players feel they learn more about obesity and healthy lifestyles. Systematic reviews highlight that usability, clarity of feedback, and intuitive interaction are critical success factors for achieving learning outcomes in serious games (Aster et al., 2024; Connolly et al., 2012; Ravyse et al., 2017; Verschueren et al., 2019). When players can focus their cognitive resources on content rather than on how to operate the game, knowledge acquisition and awareness are enhanced (Plass et al., 2015; Wouters et al., 2013). Thus, the statistically significant results support the interpretation of a real, practically important association, although it is acknowledged that correlation does not prove causation.

In addition, the relationship between player experience and perceived learning suggests that more enjoyable, engaging, and immersive gameplay is associated with a stronger perception of learning about obesity. Meta-analyses and reviews indicate that engagement and enjoyment often predict knowledge gains and positive health-related outcomes in serious games (Abdul Jabbar & Felicia, 2015; Connolly et al., 2012; Lamas et al., 2023; Wouters et al., 2013). For instance, in a nutrition-education game, enjoyment and user-experience scores were significant predictors of learning (Lamas et al., 2023). A systematic review of games centred on promoting a healthy diet and physical activity indicates that these games can influence nutritional knowledge and behaviours, provided they are engaging and based on solid design principles (Baranowski et al., 2008; Damaševičius et al., 2023).

Thus, correlation analysis supports the notion that the findings align with these studies where usability and engaging player experiences facilitate cognitive and motivational processes that drive learning and awareness (Alexiou & Schippers, 2018; Da Silva et al., 2025; Plass et al., 2015; Wouters et al., 2013). Additionally, similar relationships between usability, player experience, and learning are reported in serious games addressing diet, physical activity, obesity, diabetes, and other health domains (Baranowski et al., 2008; Connolly et al., 2012; Damaševičius et al., 2023; Lamas et al., 2023; Moosa et al., 2020).

5.4 Summary

This chapter describes the process involved in designing and developing a game prototype named *FitFuel Frenzy*, a platform-based serious game. The game prototype

was designed based on the proposed serious game framework, as detailed in previous chapter and in this chapter. The development of the game prototype was to achieve the third objective of this study. The game prototype was then evaluated with the target participants to validate the proposed game framework. Based on the evaluation, the data related to the quality factors of the game prototype were gathered by using an adapted instrument named MEEGA+. The primary purpose of this tool was to measure the effectiveness of the game prototype developed for the purpose of creating obesity awareness. The measurements through the adapted MEEGA+ instrument were comprised of three domains that are: (1) usability, (2) player experience, and (3) perceived learning. The outcomes indicate a significant percentage of children who perceive that the game is effective in promoting awareness of health and obesity. Furthermore, they recognize the consequences of failing to engage in physical activities and consuming unhealthy foods on their lives and wellbeing. These findings emphasize the significance of the game prototype in enhancing the children's understanding of obesity awareness and promoting a healthy lifestyle. The following chapter will further discuss and conclude on the research objectives achieved through out the research study.

CHAPTER 6
DISCUSSION AND CONCLUSION

6.1 Introduction

This chapter discusses the overall work of this research study. This chapter presents the findings that are align with the research objectives and research questions. Moreover, this chapter also emphasizes the study's contributions, implications, acknowledges the limitations and suggests future research recommendations, and ultimately reaches conclusions based on the findings of this study.

6.2 Research Questions and Objectives Revisited

The main aim of this study is to propose serious game framework that promotes obesity awareness among children. The following sub-sections will delve into the research objectives related to this research study.

6.2.1 Research Objective 1: To Determine the Suitable Components and Elements for a Serious Game Framework Promoting Obesity Awareness

The first objective of this research objective is to determine the suitable components and elements for a serious game framework promoting obesity awareness. To achieve the first objective, four phases of a proposed serious game framework construction were accomplished. The phases involved literature search to analyse and review existing frameworks and models relevant to the game design process to identify suitable components for the proposed work. Analysis was conducted using content analysis. The findings found suitable game components through grouping methods performed with six frameworks related to game design process which then included in the game context of the proposed framework. In addition, the proposed framework was constructed based on Information-Motivation-Behaviour Skills (IMB) model which serves as the framework backbone. The constructs of IMB model were maintained with the additional term change for two particular constructs, which are 'Information: Game context' and 'Self-Efficacy' The other constructs are namely 'Motivation' and

‘Outcomes’. The components found based on the content analysis are ‘Purpose’, ‘Narrative’, ‘Contents’, ‘Aesthetics’, and ‘Game elements’.

Then, a systematic review was conducted to analyse and determine the relevant suitable game elements in serious game interventions that promote health and obesity awareness using statistical analysis. The outcomes were finding suitable game elements to be included in the game context based on the game taxonomy by Werbach & Hunter (2012). The elements found are ‘Points’, ‘Quest’, ‘Avatar’, ‘Achievement’, ‘Challenges’, ‘Feedback’, ‘Win states’, ‘Rewards’, ‘Constraints’, and ‘Progression’. Consequently, all these activities involved had successfully identified the components and game elements suitable for serious game framework in promoting obesity awareness. The details of the proposed framework are described in Chapter 4.

6.2.2 Research Objective 2: To Construct a Serious Game Framework Promoting Obesity Awareness

The second objective of this research objective is to construct a serious game framework promoting obesity awareness. The detailed explanation was described in Chapter 4. To achieve the second research objective, the process of mapping and integration were conducted to synthesize the findings from the previous methods performed (literature search and systematic review), and to develop the initial proposed framework. The integration was justified through the intra- and inter- grouping of the components from the frameworks, as well as the outcomes from game elements.

The initial validation through expert review using statistical and content analysis method, where the proposed framework components were reviewed and validated by the experts in the field of game design and health nutrition. The proposed framework was being commented, and changes were made based on the feedback given by the experts. The main changes incorporated were in terms of name-change, such as ‘Self-efficacy’ construct was changed to ‘Behaviour skills’ with the inclusion of ‘Skills and self-efficacy’ sub-construct. ‘Motivation’ construct includes the ‘Internal motivation’, whereas ‘Outcomes’ was changed to ‘Perceived outcomes’ with the inclusion of ‘Cognitive and behavioural change’ sub-construct. The improved and final version of the proposed framework was applied to assess the framework by constructing a game prototype to evaluate it.

Consequently, the novelty of the proposed framework lies in its multidimensional synthesis. While previous models concentrate on maintaining game elements and mechanics during the game design process, they often struggle to balance entertainment with behavioural outcomes. For instance, although Thompson et al. (2010) is deeply rooted in behavioural science, it has been criticized for lacking a seamless, built-in debriefing mechanism to ensure learning transfer to the real world. Conversely, Mitgutsch & Alvarado (2012) offer an excellent assessment tool (SGDA) for identifying design conflicts but do not provide a blueprint for creating behaviour change themselves. Thus, the newly proposed framework bridges the gap between behaviour and design by incorporating the IMB model, which ensures that Information, Motivation, and Behavioural Skills are directly integrated into the game mechanics. This framework fills the void by providing foundational taxonomies and mapping specific game components to the IMB model domains, offering a specialized roadmap for obesity awareness intervention in serious game design.

6.2.3 Research Objective 3: To Evaluate the Effectiveness of Game Prototype Based on Serious Game Framework in Meeting the Multi-Dimensional Quality Factors of Usability, Player Experience, and Perceived Learning for Obesity Awareness

The final objective of this research study is to evaluate the effectiveness of game prototype developed based on the serious game framework promoting obesity awareness. Thus, a game prototype was developed based on the proposed serious game framework named *FitFuel Frenzy*. The game prototype was developed to validate the proposed serious game framework. The game prototype was designed and developed based on Analysis-Design-Development-Implementation-Evaluation (ADDIE) model which consists of five phases: analysis, design, development, implementation, and evaluation. The game aims to educate children on the importance of healthy eating and performing physical activities to prevent obesity in future. It is a platform-based type serious game that facilitates fun engagement while also gaining knowledge awareness on healthy lifestyle. Next, experimental study was conducted with children as the target participants to evaluate the effectiveness of the serious game prototype in improving their knowledge in obesity awareness and promote behaviour change. The evaluation was conducted based on an adapted instrument named MEEGA+ model. The

experimental was conducted with 45 participants which are children at a tuition centre in Ipoh, Perak, Malaysia. The evaluation is to determine the effectiveness of the game prototype based on the quality factors which focus on the usability, player experience, and perceived learning. Based on the findings, it is found that participants find the game usable, hence the perception of learning about obesity awareness increases. Overall, the findings suggest a statistically significant strong positive correlation between usability, player experience, and perceived learning domains. The findings also suggested that majority of the participants found the game prototype effective in disseminating awareness in health and obesity issue. The detailed explanation was described in Chapter 5.

6.3 Research Contributions

This research study investigates the development of a serious game framework aimed at promoting obesity awareness. It makes substantial contributions across multiple domains, including theoretical, practical, educational, methodological, social and health, as well as technological aspects. Theoretically, the integration of behavioural theories, such as the IMB model as framework guidelines, and the implementation supplementary theories like SCT, SDT, and TPB into game design, exemplifies how theoretical models can be operationalized in game-based interventions. Additionally, incorporating game components and elements into the IMB model provides insights into the existing model, allowing for its extension or refinement. Furthermore, the framework offers a structured model that guides the development of game-based health interventions, addressing the gap in designing theory-driven, focused awareness serious games.

In terms of practical contributions, the framework serves as a tool for health educators and practitioners, offering a ready-to-use framework that can be applied in schools, NGOs, or health agencies for curriculum design or community programs. Moreover, the framework can be considered a reusable development guide, enabling game developers to reuse or adapt it to create similar interventions for other health awareness topics, such as diabetes, mental health, and smoking. The educational contribution of this initiative lies in its provision of an innovative learning medium that introduces a child-friendly and engaging tool. This tool facilitates enjoyable learning experiences on topics such as health and social awareness in an accessible manner.

Furthermore, the development of a serious game that promotes obesity awareness effectively bridges the concepts of learning and play, demonstrating how such games can deliver educational outcomes and foster positive perceived behavioural changes in children.

From a methodological perspective, the serious game developed based on a specific framework contributes to a validated evaluation approach. Through experimental design and the measurement of domains such as usability, player experience, and perceived learning, this framework offers a validated method for evaluating serious games. Additionally, the integration of mixed methods, including content analysis, systematic analysis, expert reviews, and experimental research, exemplifies a robust research methodology for serious game-based health interventions. In terms of social and health contributions, the initiative empowers children to become health advocates by enhancing their awareness and enabling them to make informed health decisions. This empowerment extends to influencing their social circles, including families and friends. Moreover, the game serves as an early intervention tool, offering a preventive solution during critical developmental years such as from the age of 7 to 18, thereby potentially reducing future health risks associated with obesity. It also functions as a digital tool promoting health equity, capable of reaching diverse populations, including underserved or rural communities, thus helping to bridge gaps in health education.

In terms of technological contributions, the developed serious game exemplifies how digital technologies can be strategically utilized to address real-world issues such as childhood obesity. Additionally, the framework developed contributes to a modular and replicable approach for integrating game design principles, behavioural theory, and learning outcomes into a cohesive system. Consequently, the contributions made in these domains establish a comprehensive system that operationalizes behaviour change models, such as the IMB model, and expands theoretical understanding within the digital health context. This framework offers a practical tool for educators, game designers, and health practitioners in providing an engaging and age-appropriate medium for raising obesity awareness. Furthermore, it demonstrates a validated mixed-methods approach to evaluating serious games, empowers children, supports early intervention, and promotes health equity. It also advances the development of serious games for public health education.

In addition, serious game is targeting on one of the SDG agenda of *Good Health and Well-Being* by promoting healthy diets, encouraging physical activity, and improving obesity knowledge and behaviours in children. Within the broader SDG framework, obesity is recognized as central to achieving the agenda, particularly in reducing premature mortality from NCDs through prevention and treatment, making it a key component of the global development agenda. Additionally, it indirectly supports the SDG agenda of *Quality Education* by employing game-based, theory-driven health education, such as the IMB model and behaviour change theories, as effective learning tools. Consequently, this framework, based on the IMB model, incorporates structured health information, motivational elements, and behaviour-skill practice through game mechanics, aligning with the SDG goals of prevention, health literacy, and lifelong healthy behaviours.

In the context of Malaysia, and in alignment with the MADANI goals, the framework emphasizes well-being and compassion by focusing on children's health and prevention through game-based interventions. Additionally, early prevention of obesity helps reduce the future burden of non-communicable diseases and lowers health system costs, thereby supporting sustainable national development. Furthermore, incorporating mobile and game-based strategies into the obesity framework aligns with MADANI's emphasis on digital innovation. Consequently, the serious game framework for raising obesity awareness among children operationalizes both the SDG and MADANI goals by employing a theory-driven, digital, child-focused approach to health literacy, prevention, and sustainable well-being.

6.4 Research Implications

In this research study, the primary objective is the development of a serious game framework aimed at promoting obesity awareness. This framework holds significant implications not only for game designers and educators but also for public health policymakers and researchers. Firstly, the framework provides interactive, age-appropriate learning experiences. Traditional methods of health education often fail to engage children meaningfully. Children are more likely to retain knowledge and comprehend concepts related to balanced diets and the importance of physical activity, suggesting that cognitive gains could be sustained and have a long-term impact if they acquire basic health and obesity awareness during early childhood.

Moreover, it fosters the development of health-related skills in children, enabling them not only to retrieve information from the game but also to practice decision-making, differentiate between healthy and unhealthy food choices, and identify healthy habits to enhance their lifestyle. This strengthens behavioural skills and self-efficacy, leading to more confident health choices. In terms of social health policies, the framework is highly beneficial in informing public health and educational policies. The game framework offers evidence-based guidance for integrating digital tools into school curricula or community programs. The results could influence health education policies, potentially leading to the adoption of digital interventions in national health campaigns. Finally, it empowers children as agents of change. As children engage with the game and internalize health concepts, they may influence the behaviours of their families and friends, potentially impacting the broader community and not just individual change.

In summary, in the context of health education, the framework makes learning engaging, memorable, and child-friendly. Implementing theoretical applications within the framework brings models like IMB into practical use. Additionally, the focus on behaviour change in this research study fosters real-life skill development and healthy habits. In terms of public health policy, it provides an evidence base for broader adoption in schools or campaigns. Finally, the game design and research encourage the development of reusable, scalable, and evaluable intervention frameworks.

6.5 Limitations and Recommendations for Future Research

This research study had identified several limitations that require improvement. Initially, the proposed framework utilized the IMB model as a guideline, with the primary objective of altering health behaviour outcomes. However, the model embedded within the game framework is an older model that has been in existence since 2003. Although the model may have some slight disadvantages due to its age, it is still beneficial and relevant today, especially in the field of health and education. Besides that, the model is renowned for its effectiveness in health-related promotion, making it well-suited for intended behaviour change purposes, which is a crucial aspect of this research study. However, it is recommended that the model chosen as the backbone be based on a comprehensive model or framework that encompasses both behaviour change and game design processes. In addition, the present framework could benefit

from the incorporation of additional relevant and comprehensive game components and elements. The process of extracting and integrating from diverse frameworks, models, and game taxonomies could be more systematic and targeted towards serious game design and the needs of children in technology design.

Furthermore, a limitation that has been identified is the reliance on expert review during the initial validation and storyboard review processes, which involved only six and three experts for each process. Although it was deemed sufficient based on Rubio et al. (2003) findings, it would be optimal to involve more than six experts, as doing so could potentially yield more promising results with a diverse range of experiences among the reviewers. Moreover, the learning content included in the game prototype focuses solely on two main components: the importance of consuming healthy food and the significance of engaging in physical activities. However, incorporating an additional component, such as emotional skills (Silva, 2015), may likely result in a more comprehensive guide that addresses behaviour change and enhances knowledge of health and obesity awareness. Other limitation identified is only children were recruited as target participants. However, the game platform can be enhanced and tailored to address the needs of adulthood, as these age ranges are critical in terms of understanding weight and healthy lifestyle choices. Additionally, these age group also has a higher likelihood of experiencing health problems and diseases. Finally, the variation in the age range of participants in the experimental study could be attributed to the fact that the children were recruited from a tuition centre. Therefore, if a larger sample size could be obtained from a school, for instance, more diverse results might be obtained.

In conclusion, the study highlighted several limitations and offered recommendations. The framework relied on an older theoretical model and incorporated only a limited number of game components and elements. The expert review process involved a small group of participants, and the learning content was exclusively focused on healthy food and physical activities. Additionally, the study was limited to child participants, with the sample size and age range restricted by recruitment from a tuition centre. Future research could address these limitations and implement the recommendations to enhance the development of the serious game framework.

6.6 Summary

This research study aimed to develop a serious game framework that promotes obesity awareness among children. The selected components and game elements in the serious game framework were considered and initially validated through expert review and then through experimental study. Based on the findings obtained in this study, it is evident that the proposed framework offers several advantages, including:

a) The proposed serious game framework is useful as guidelines for designers, developers, researchers and educators to develop serious game that focused on health and obesity awareness.
b) The proposed serious game framework is beneficial for fostering awareness of obesity and health as it facilitates knowledge acquisition and promotes behavioural change, whether the impact is immediate or long-term.

This study demonstrated that incorporating a serious game framework for obesity awareness among children is feasible. Despite limitations, recommendations for future work were discussed. The empirical findings obtained from this study showed that the game design process incorporating selected components and elements in the framework was effective in enhancing game usability, player experience, and perceived learning. It is hoped that the proposed framework can serve as a guide for designers, developers, researchers, and educators in their respective fields. Additionally, the study's findings indicated that the game prototype developed based on the proposed framework may contribute to health behaviour change and enhance obesity awareness, potentially yielding long-term benefits for individuals.

REFERENCES

Abdul Jabbar, A. I., & Felicia, P. (2015). Gameplay Engagement and Learning in Game-Based Learning: A Systematic Review. *Review of Educational Research*, *85*(4), 740–779. https://doi.org/10.3102/0034654315577210

Abdusselam, M. S. (2020). The Effect of Serious Games on the Awareness of Energy Sources Consumption. *International Technology and Education Journal*, *4*(1), 36–42. https://10.71410/ESApub.ITEJ.2020.5

Adaji, I. (2022). Serious Games for Healthy Nutrition. A Systematic Literature Review. *International Journal of Serious Games*, *9*(1), 3–16. https://doi.org/10.17083/ijsg.v9i1.466

Affenito, S. G., Franko, D. L., Striegel-Moore, R. H., & Thompson, D. (2012). Behavioral Determinants of Obesity: Research Findings and Policy Implications. *Journal of Obesity*, *2012*, 1–4. https://doi.org/10.1155/2012/150732

Ahadzadeh, A. S., Pahlevan Sharif, S., Ong, F. S., & Khong, K. W. (2015). Integrating Health Belief Model and Technology Acceptance Model: An Investigation of Health-Related Internet Use. *Journal of Medical Internet Research*, *17*(2), e45. https://doi.org/10.2196/jmir.3564

Ahmad, M. (2019). Categorizing Game Design Elements into Educational Game Design Fundamentals. In *Game Design and Intelligent Interaction* (pp. 1–17). https://www.intechopen.com/chapters/70106

Al-Awamreh, K., Alkhawaldeh, A., Aloush, S., Alrimawi, I., Al Qadire, M., Suliman, M., Al-Azzam, M., Khraisat, O., Khatatbeh, M., & ALBashtawy, M. (2019). Prevention Strategies and Guidelines to Manage Obesity in Children and Young People. *International Journal of Pediatrics*, *7*(9). https://doi.org/10.22038/ijp.2019.40813.3447

Aleven, V., Myers, E., Easterday, M., & Ogan, A. (2010). Toward a Framework for the Analysis and Design of Educational Games. *2010 Third IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning*, 69–76. https://doi.org/10.1109/DIGITEL.2010.55

Alexiou, A., & Schippers, M. C. (2018). Digital game elements, user experience and learning: A conceptual framework. *Education and Information Technologies*, *23*(6), 2545–2567. https://doi.org/10.1007/s10639-018-9730-6

Alhassan, M., Scholtz, B., & Merwe, M. V. D. (2020). Usability Evaluations of a Water Quality Awareness Game. *Americas Conference on Information Systems*. https://aisel.aisnet.org/amcis2020/sig_green/sig_green/7

Aliabadi, N., Carballo-Dieguez, A., Bakken, S., Rojas, M., Brown, W., Carry, M., Mosley, J. P., Gelaude, D., & Schnall, R. (2015). Using the Information-Motivation-Behavioral Skills Model to Guide the Development of an HIV Prevention Smartphone Application for High-Risk MSM. *AIDS Education and Prevention*, *27*(6), 522–537. https://doi.org/10.1521/aeap.2015.27.6.522

Alnaqbi, F., Alzahmi, S., Alharmoozi, A., Alshehhi, F., Zia, M. T., Ouhbi, S., & Belkacem, A. N. (2021). A Novel Cooperative Game for Reinforcing Obesity Awareness Amongst Children in UAE. In A. Zimmermann, R. J. Howlett, & L. C. Jain (Eds), *Human Centred Intelligent Systems* (Vol. 189, pp. 53–63). Springer Singapore. https://doi.org/10.1007/978-981-15-5784-2_5

Alonso-Fernandez, C., Calvo, A., Freire, M., Martinez-Ortiz, I., & Fernandez-Manjon, B. (2017). Systematizing game learning analytics for serious games. *2017 IEEE Global Engineering Education Conference (EDUCON)*, 1111–1118. https://doi.org/10.1109/EDUCON.2017.7942988

AL-Qurishi, M. S., Mostafa, M. A., Alrakhami, M. S., & Alamri, A. M. (2014). StarsRace: A mobile collaborative seriuos game for obesity. *2014 IEEE International Conference on Multimedia and Expo Workshops (ICMEW)*, 1–5. https://doi.org/10.1109/ICMEW.2014.6890673

Alvis, L. (2015). *Designing Games to Effect Awareness on Children's Poverty*. Malmö University.

Amresh, A., Sinha, M., Salla, R., & Birr, R. (2016). Design, Implementation and Evaluation of a Game-Based Intervention Targeting Latino Children for Improving Obesity Outcomes. *IEEE International Conference on Serious Games and Applications for Health (SeGAH)*, 1–8. https://doi.org/10.1109/SeGAH.2016.7586280

Anderson, T., Prue, G., McDowell, G., Stark, P., Brown Wilson, C., Graham Wisener, L., Kerr, H., Caughers, G., Rogers, K., Cook, L., Craig, S., Alanazi, A., & Mitchell, G. (2024). Co-design and evaluation of a digital serious game to promote public awareness about pancreatic cancer. *BMC Public Health*, *24*(1), 570. https://doi.org/10.1186/s12889-024-18050-7

Annetta, L. A. (2010). The “I’s” Have It: A Framework for Serious Educational Game Design. *Review of General Psychology*, *14*(2), 105–113. https://doi.org/10.1037/a0018985

Appiah, E., & Cronje, J. (2012). Thumbnail sketches on idea development: The drawing board vs computer generation. *Art, Design & Communication in Higher Education*, *11*, 49–61. https://doi.org/10.1386/adch.11.1.49_1

Aris, P. N. M., Nor, N. S. A. M., & Othman, A. (2024). KIDDIESAFE APPLICATIONS: GAME-BASED LEARNING OF HEALTH EDUCATION AWARENESS AMONG PRIMARY SCHOOL STUDENTS. *Journal of Creative Industry and Sustainable Culture*, *3*, 37–45. https://doi.org/10.32890/jcisc2024.3.3

Arnab, S., Lim, T., Carvalho, M. B., Bellotti, F., Freitas, S. de, Louchart, S., Suttie, N., Berta, R., & Gloria, A. D. (2015). Mapping learning and game mechanics for serious games analysis. *British Journal of Educational Technology*, *46*(2), 391–411. https://doi.org/10.1111/bjet.12113

Asadzadeh, A., Shahrokhi, H., Shalchi, B., Khamnian, Z., & Rezaei-Hachesu, P. (2024). Serious educational games for children: A comprehensive framework. *Heliyon*, *10*(6), e28108. https://doi.org/10.1016/j.heliyon.2024.e28108

Aster, A., Laupichler, M. C., Zimmer, S., & Raupach, T. (2024). Game design elements of serious games in the education of medical and healthcare professions: A mixed-methods systematic review of underlying theories and teaching effectiveness. *Advances in Health Sciences Education*, *29*(5), 1825–1848. https://doi.org/10.1007/s10459-024-10327-1

Balderas-Arteaga, N., Mendez, K., Gonzalez-Rocha, A., Pacheco-Miranda, S., Bonvecchio, A., & Denova-Gutiérrez, E. (2024). Healthy lifestyle interventions within the curriculum in school-age children: Systematic review and meta-analysis. *Health Promotion International*, *39*(2), daae020. https://doi.org/10.1093/heapro/daae020

Barab, S. A., Gresalfi, M., & Ingram-Goble, A. (2011). Transformational Play: Using Games to Position Person, Content, and Context. *Educational Researcher*, *39*, 525–536. https://doi.org/10.3102/0013189X10386593

Baranowski, T., Buday, R., Thompson, D., & Baranowski, J. (2008). Playing for Real. Video Games and Stories for Health-Related Behavior Change. *American*

Journal of Preventive Medicine, *34*, 74–82. https://doi.org/10.1016/j.amepre.2007.09.027

Baranowski, T., Ryan, C., Hoyos-Cespedes, A., & Lu, A. S. (2019). Nutrition Education and Dietary Behavior Change Games: A Scoping Review. *Games for Health Journal*, *8*(3), 153–176. https://doi.org/10.1089/g4h.2018.0070

Bartholmae, M. (2016). *The Information-Motivation-Behavioral Skills Model: An Examination of Obesity Prevention Behavioral Change in Children Who Participated In The Afterschool Program Virginia Beach Let's Move*. https://doi.org/10.25777/xv08-0b09

Baykal, G., Eriksson, E., & Torgersson, O. (2023). *Collaboration in Co-located Collaborative Digital Games—Towards a Quadripartite Taxonomy* (p. 6). https://doi.org/10.1145/3544549.3585760

Belghali, M., Statsenko, Y., & Al-Za'abi, A. (2021). Improving Serious Games to Tackle Childhood Obesity. *Frontiers in Psychology*, *12*, 657289. https://doi.org/10.3389/fpsyg.2021.657289

Bellotti, F., Kapralos, B., Lee, K., Moreno-Ger, P., & Berta, R. (2013). Assessment in and of Serious Games: An Overview. *Advances in Human-Computer Interaction*, *2013*, 1–11. https://doi.org/10.1155/2013/136864

BERNAMA. (2023, August 23). *THE MALAYSIA MADANI FRAMEWORK: HOW OTHER COUNTRIES VIEW THE FRAMEWORK*. BERNAMA. https://www.bernama.com/en/thoughts/news.php?id=2218766

Bernecker, K., & Ninaus, M. (2021). No Pain, no Gain? Investigating motivational mechanisms of game elements in cognitive tasks. *Computers in Human Behavior*, *114*. https://doi.org/10.1016/j.chb.2020.106542

Bettinghaus, E. P. (1986). Health Promotion and the Knowledge-Attitude-Behavior-Continuum. In *Preventive Medicine* (Vol. 15, pp. 475–491). https://hrcc.cas.msu.edu/throwback-thursdays/Health%20Promotion%20and%20the%20Knowledge-Attitude-Behavior-Continuum.pdf

Bogost, I. (2007). *Persuasive games: The expressive power of videogames*. The MIT Press.

Bowen, E., Walker, K., Mawer, M., Holdsworth, E., Sorbring, E., Helsing, B., Bolin, A., Leen, E., Held, P., Awouters, V., & Jans, S. (2014). "It's like you're actually playing as yourself": Development and preliminary evaluation of 'Green Acres

High', a serious game-based primary intervention to combat adolescent dating violence. *Psychosocial Intervention*, *23*(1), 43–55. https://doi.org/10.5093/in2014a5

Braad, E., Žavcer, G., & Sandovar, A. (2016). Processes and Models for Serious Game Design and Development. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): 9970 LNCS* (pp. 92–118). https://doi.org/10.1007/978-3-319-46152-6_5

Brewer, N. T., & Rimer, B. K. (2008). PERSPECTIVES ON HEALTH BEHAVIOR THEORIES THAT FOCUS ON INDIVIDUALS. In *Health Behavior and Health Education* (Vol. 4).

Bridle, C., Riemsma, R. P., Pattenden, J., Sowden, A. J., Mather, L., Watt, I. S., & Walker, A. (2005). Systematic review of the effectiveness of health behavior interventions based on the transtheoretical model. *Psychology & Health*, *20*(3), 283–301. https://doi.org/10.1080/08870440512331333997

Brom, C., Bromová, E., & Pergel, M. (2012). Towards a Brewery Educational Game: Would Existence of a Game Goal Improve Learning? In M. Herrlich, R. Malaka, & M. Masuch (Eds), *Entertainment Computing—ICEC 2012* (Vol. 7522, pp. 389–392). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-33542-6_35

Brox, E., Fernandez-Luque, L., & Tøllefsen, T. (2011). Healthy Gaming – Video Game Design to promote Health. *Applied Clinical Informatics*, *02*(02), 128–142. https://doi.org/10.4338/ACI-2010-10-R-0060

Brynen, R. (2022, July 19). A critical look at serious game design. *PAXsims*. https://paxsims.wordpress.com/2022/07/19/a-critical-look-at-serious-game-design/

Buil, I., Catalán, S., & Martínez, E. (2019). Encouraging intrinsic motivation in management training: The use of business simulation games. *The International Journal of Management Education*, *17*(2), 162–171. https://doi.org/10.1016/j.ijme.2019.02.002

Burgers, C., Eden, A., Van Engelenburg, M. D., & Buningh, S. (2015). How feedback boosts motivation and play in a brain-training game. *Computers in Human Behavior*, *48*, 94–103. https://doi.org/10.1016/j.chb.2015.01.038

Butt, N. A., Sherin, S., Khan, M. U., Jilani, A. A., & Iqbal, M. Z. (2023). *Deriving and Evaluating a Detailed Taxonomy of Game Bugs* (arXiv:2311.16645). arXiv. https://doi.org/10.48550/arXiv.2311.16645

Buttfield-Addison, P., Manning, J., & Nugent, T. (2016). A better recipe for game jams: Using the Mechanics Dynamics Aesthetics framework for planning. *Proceedings of the International Conference on Game Jams, Hackathons, and Game Creation Events*, 30–33. https://doi.org/10.1145/2897167.2897183

Calcaterra, V., Vandoni, M., Marin, L., Pellino, V. C., Rossi, V., Gatti, A., Patanè, P., Cavallo, C., Re, F., Albanese, I., Silvestri, D., Nunzio, A. D., & Zuccotti, G. (2023). Exergames to Limit Weight Gain and to Fight Sedentarism in Children and Adolescents with Obesity. *Children*, *10*(6). https://doi.org/10.3390/children10060928

Carpenter, C. J. (2010). A Meta-Analysis of the Effectiveness of Health Belief Model Variables in Predicting Behavior. *Health Communication*, *25*, 661–669. https://doi.org/10.1080/10410236.2010.521906

Caserman, P., Hoffmann, K., Müller, P., Schaub, M., Straßburg, K., Wiemeyer, J., Bruder, R., & Göbel, S. (2020). Quality Criteria for Serious Games: Serious Part, Game Part, and Balance. *JMIR Serious Games*, *8*(3), e19037. https://doi.org/10.2196/19037

Chai, C. W. E., Lau, B. T., Tee, M. K. T., & Al Mahmud, A. (2022). Evaluating a serious game to improve childhood cancer patients' treatment adherence. *DIGITAL HEALTH*, *8*, 20552076221134457. https://doi.org/10.1177/20552076221134457

Chang, S. J., Choi, S., Kim, S.-A., & Song, M. (2014). Intervention Strategies Based on Information-Motivation-Behavioral Skills Model for Health Behavior Change: A Systematic Review. *Asian Nursing Research*, *8*(3), 172–181. https://doi.org/10.1016/j.anr.2014.08.002

Che Abdul Rahim, N., Ahmad, M. H., Siew Man, C., Zainuddin, A. A., Rodzlan Hasani, W. S., Ganapathy, S. S., & Ahmad, N. A. (2022). Factors Influencing the Levels of Awareness on Malaysian Healthy Plate Concept among Rural Adults in Malaysia. *International Journal of Environmental Research and Public Health*, *19*(10), 6257. https://doi.org/10.3390/ijerph19106257

Cheek, C., Fleming, T., Lucassen, M. F. G., Bridgman, H., Stasiak, K., Shepherd, M., & Orpin, P. (2015). Integrating health behavior theory and design elements in serious games. *JMIR Mental Health*, *2*(2). https://doi.org/10.2196/mental.4133

Chen, T., Stewart, M., Bai, Z., Chen, E., Dabbish, L., & Hammer, J. (2020). Hacked Time: Design and Evaluation of a Self-Efficacy Based Cybersecurity Game. *Proceedings of the 2020 ACM Designing Interactive Systems Conference, DIS '20*, 1737–1749. https://doi.org/10.1145/3357236.3395522

Chow, C. Y., Riantiningtyas, R. R., Kanstrup, M. B., Papavasileiou, M., Liem, G., & Olsen, A. (2020). *Can games change children's eating behaviour? A review of gamification and serious games*. https://doi.org/10.1016/j.foodqual.2019.103823

Clark, R. C., & Mayer, R. E. (2003). [Review of *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*, by W. Thalheimer]. *Performance Improvement*, *42*(5), 41–43. https://doi.org/10.1002/pfi.4930420510

CodeBlue. (2023, December 25). NHSI 2023: Over 53% Of Screened Malaysians Overweight Or Obese. *CodeBlue*. https://codeblue.galencentre.org/2023/12/nhsi-2023-over-53-of-screened-malaysians-overweight-or-obese/

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education*, *59*(2), 661–686. https://doi.org/10.1016/j.compedu.2012.03.004

Convention on the Rights of the Child, 3 (1989). https://treaties.un.org/doc/Treaties/1990/09/19900902%2003-14%20AM/Ch_IV_11p.pdf

Cormio, L., Agostinelli, T., & Mengoni, M. (2025). A unified framework to catalogue and classify digital games based on interaction design and validation through clustering techniques. *Multimedia Tools and Applications*, *84*(15), 15479–15499. https://doi.org/10.1007/s11042-024-19614-w

Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Experience*.

Da Silva, F., De Araújo, W., De Campos, T., & Da Silva, T. (2025). Method for Evaluating the Quality of Serious Games in Medical Education: *Proceedings of*

the 27th International Conference on Enterprise Information Systems, 605–613. https://doi.org/10.5220/0013433800003929

Damaševičius, R., Maskeliūnas, R., & Blažauskas, T. (2023). Serious Games and Gamification in Healthcare: A Meta-Review. *Information*, *14*(2), Article 2. https://doi.org/10.3390/info14020105

Daud, S., Abu Yazid, Z., Md Taib, N., Othman, M. Z., & Osman, I. (2024). Evaluating the Impact of Usability Components on User Satisfaction in Educational Board Games using the MEEGA+ Framework. *Information Management and Business Review*, *16*(2(I)), 195–206. https://doi.org/10.22610/imbr.v16i2(I).3821

Dawes, J. (2008). Do Data Characteristics Change According to the Number of Scale Points Used? An Experiment Using 5 Point, 7 Point and 10 Point Scales. *International Journal of Market Research*, *50*. https://doi.org/10.1177/147078530805000106

de Freitas, S. I. (2006). Using games and simulations for supporting learning. *Learning, Media and Technology*, *31*(4), 343–358. https://doi.org/10.1080/17439880601021967

De Lope, R. P., & Medina-Medina, N. (2017). A Comprehensive Taxonomy for Serious Games. *Journal of Educational Computing Research*, *55*(5), 629–672. https://doi.org/10.1177/0735633116681301

de Visser, K., Bouwer, A., & Swartjes, I. (2025). *Designing Meaningful AI-Generated Dialogue: The Behaviour- Driven Conditional Prompting Framework for Serious Games*. https://10.34190/ecgbl.19.1.4182

Denzin, N. K., & Lincoln, Y. S. (2018). *The SAGE Handbook of Qualitative Research* (5th edn).

DeSmet, A., Van Ryckeghem, D., Compernolle, S., Baranowski, T., Thompson, D., Crombez, G., Poels, K., Van Lippevelde, W., Bastiaensens, S., Van Cleemput, K., Vandebosch, H., & De Bourdeaudhuij, I. (2014). A meta-analysis of serious digital games for healthy lifestyle promotion. *Preventive Medicine*, *69*, 95–107. https://doi.org/10.1016/j.ypmed.2014.08.026

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining 'gamification'. *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek 2011*, 9–15. https://doi.org/10.1145/2181037.2181040

Dias, J. D., Domingues, A. N., Tibes, C. M., Zem-Mascarenhas, S. H., & Fonseca, L. M. M. (2018). Serious games as an educational strategy to control childhood obesity: A systematic literature review. *Revista Latino-Americana de Enfermagem*, *26*(0). https://doi.org/10.1590/1518-8345.2509.3036

Dias, J. D., Mekaro, M. S., Cheng Lu, J. K., Otsuka, J. L., Fonseca, L. M. M., & Zem-Mascarenhas, S. H. (2016). Serious game development as a strategy for health promotion and tackling childhood obesity. *Revista Latino-Americana de Enfermagem*, *24*(0). https://doi.org/10.1590/1518-8345.1015.2759

Djaouti, D., Alvarez, J., Jessel, J.-P., & Rampnoux, O. (2011). Origins of Serious Games. In M. Ma, A. Oikonomou, & L. C. Jain (Eds), *Serious Games and Edutainment Applications* (pp. 25–43). Springer London. https://doi.org/10.1007/978-1-4471-2161-9_3

Dsouza, J. P., Van den Broucke, S., Pattanshetty, S., & Dhoore, W. (2021). The application of health behavior theories to promote cervical cancer screening uptake. *Public Health Nursing*, *38*(6), 1039–1079. https://doi.org/10.1111/phn.12944

Ehret, P. J., Hodges, H. E., Kuehl, C., Brick, C., Mueller, S., & Anderson, S. E. (2021). Systematic Review of Household Water Conservation Interventions Using the Information–Motivation–Behavioral Skills Model. *Environment and Behavior*, *53*(5), 485–519. https://doi.org/10.1177/0013916519896868

Ellsworth, D., Ernst, J., & Snelling, A. (2015). A mobile farmers' market brings nutrition education to low-income students. *Health Education*, *115*, 171–177. https://doi.org/10.1108/HE-03-2014-0031

Epstein, D. S., Zemski, A., Enticott, J., & Barton, C. (2021). Tabletop Board Game Elements and Gamification Interventions for Health Behavior Change: Realist Review and Proposal of a Game Design Framework. *JMIR Serious Games*, *9*(1), e23302. https://doi.org/10.2196/23302

Espinosa-Curiel, I. E., Pozas-Bogarin, E. E., Hernández-Arvizu, M., Navarro-Jiménez, M. E., Delgado-Pérez, E. E., Martínez-Miranda, J., & Pérez-Espinosa, H. (2022). HelperFriend, a Serious Game for Promoting Healthy Lifestyle Behaviors in Children: Design and Pilot Study. *JMIR Serious Games*, *10*(2). https://doi.org/10.2196/33412

Espinosa-Curiel, I. E., Pozas-Bogarin, E. E., Lozano-Salas, J. L., Martínez-Miranda, J., Delgado-Pérez, E. E., & Estrada-Zamarron, L. S. (2020). Nutritional Education

and Promotion of Healthy Eating Behaviors Among Mexican Children Through Video Games: Design and Pilot Test of FoodRateMaster. *JMIR Serious Games*, *8*(2), e16431. https://doi.org/10.2196/16431

Fadhil, A., & Villafiorita, A. (2017). An Adaptive Learning with Gamification & Conversational UIs: The Rise of CiboPoliBot. *Adjunct Publication of the 25th Conference on User Modeling, Adaptation and Personalization*, 408–412. https://doi.org/10.1145/3099023.3099112

Farooq, A., Jeske, D., & Isoaho, J. (2019). Predicting Students' Security Behavior Using Information-Motivation-Behavioral Skills Model. In G. Dhillon, F. Karlsson, K. Hedström, & A. Zúquete (Eds), *ICT Systems Security and Privacy Protection* (Vol. 562, pp. 238–252). Springer International Publishing. https://doi.org/10.1007/978-3-030-22312-0_17

Fernando, M. C. G., Garcia, M. B., Solomo, M. V., & Lagman, A. (2019). Trash Attack: A 2D Action Puzzle Video Game to Promote Environmental Awareness and Waste Segregation Behavior. *International Journal of Simulation: Systems, Science & Technology*. https://doi.org/10.5013/IJSSST.a.20.S2.24

Ferro, L. S. (2021). The Game Element and Mechanic (GEM) framework: A structural approach for implementing game elements and mechanics into game experiences. *Entertainment Computing*, *36*(July 2020), 100375–100375. https://doi.org/10.1016/j.entcom.2020.100375

Ferron, M., & Massa, P. (2013). Transtheoretical model for designing technologies supporting an active lifestyle. *Proceedings of the Biannual Conference of the Italian Chapter of SIGCHI*, 1–8. https://doi.org/10.1145/2499149.2499158

Fisher, J. D., & Fisher, W. A. (1992). Changing AIDS-risk behavior. *Psychological Bulletin*, *111*(3), 455–474. https://doi.org/10.1037/0033-2909.111.3.455

Fisher, W. A., Fisher, J. D., & Harman, J. (2003). The Information-Motivation-Behavioral Skills Model: A General Social Psychological Approach to Understanding and Promoting Health Behavior. *Social Psychological Foundations of Health and Illness*, (December 2017), 82–106. https://doi.org/10.1002/9780470753552.ch4

Fu, F.-L., & Yu, S.-C. (2008). Three Layered Thinking Model for Designing Web-Based Educational Games. In *Advances in Web Based Learning—ICWL 2008* (Vol. 5145, pp. 265–274). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-85033-5_26

Fu, K. K., Yang, M. C., & Wood, K. L. (2016). Design Principles: Literature Review, Analysis, and Future Directions. *Journal of Mechanical Design*, *138*(10), 101103. https://doi.org/10.1115/1.4034105

Gabriel, S. (2018). How to analyze the potential of digital games for human rights education. *Revista Lusofona de Educacao*, *41*(41), 29–43. https://doi.org/10.24140/issn.1645-7250.rle41.02

Galgouranas, S., & Xinogalos, S. (2018). jAVANT-GARDE: A Cross-Platform Serious Game for an Introduction to Programming With Java. *Simul. Gaming*, *49*(6), 751–767. https://doi.org/10.1177/1046878118789976

Garde, A., Umedaly, A., Abulnaga, S. M., Robertson, L., Junker, A., Chanoine, J. P., Ansermino, J. M., & Dumont, G. A. (2015). Assessment of a Mobile Game ("MobileKids Monster Manor") to Promote Physical Activity Among Children. *Games for Health Journal*, *4*(2), 149–158. https://doi.org/10.1089/g4h.2014.0095

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, Motivation, and Learning: A Research and Practice Model. *Simulation & Gaming*, *33*(4), 441–467. https://doi.org/10.1177/1046878102238607

Gee, J. P. (2003). *What video games have to teach us about learning and literacy* (1. paperback ed). Palgrave Macmillan.

Geerts, D., Nouwen, M., van Beek, E., Slegers, K., Chocron Miranda, F., & Bleumers, L. (2019). Using the SGDA Framework to Design and Evaluate Research Games. *Simulation and Gaming*, *50*(3), 272–301. https://doi.org/10.1177/1046878118808826

Ghergulescu, I., & Muntean, C. H. (2014). Motivation Monitoring and Assessment Extension for Input-Process-Outcome Game Model: *International Journal of Game-Based Learning*, *4*(2), 15–35. https://doi.org/10.4018/ijgbl.2014040102

Glebas, F. (2009). *Directing the Story* (Vol. 1). http://archive.org/details/DirectingTheStory

Göbel, S. (Ed.). (2016). *Serious Games Application Examples*. Springer International Publishing. https://doi.org/10.1007/978-3-319-40612-1

Gonçalves, F., Carvalho, V., & Matos, D. (2020). Development of a Serious Game to fight Childhood Obesity: "Barty". *IEEE Global Engineering Education Conference (EDUCON)*, 1641–1646. https://doi.org/10.1109/EDUCON45650.2020.9125408

Graafland, M., Schraagen, J. M., & Schijven, M. (2012). Systematic review of serious games for medical education and surgical skills training. *The British Journal of Surgery*, *99*, 1322–1330. https://doi.org/10.1002/bjs.8819

Grant, S., & Betts, B. (2013). Encouraging user behaviour with achievements: An empirical study. *2013 10th Working Conference on Mining Software Repositories (MSR)*, 65–68. https://doi.org/10.1109/MSR.2013.6624007

Gresse Von Wangenheim, C., Petri, G., & Ferreti Borgatto, A. (2020). MEEGA+KIDS: A Model for the Evaluation of Games for Computing Education in Secondary School. *RENOTE*, *18*(1). https://doi.org/10.22456/1679-1916.105938

Gresse Von Wangenheim, C., Petri, G., & Ferreti Borgatto, A. (2025). Using MEEGA/MEEGA+ for the Evaluation of Educational Games: A Retrospective. *Revista Brasileira de Informática Na Educação*, *33*, 943–971. https://doi.org/10.5753/rbie.2025.5148

Griffiths, M., & Nuyens, F. (2017). An Overview of Structural Characteristics in Problematic Video Game Playing. *Current Addiction Reviews*, *4*. https://doi.org/10.1007/s40429-017-0162-y

Hammady, R., & Arnab, S. (2022). Serious Gaming for Behaviour Change: A Systematic Review. *Information*, *13*(3), 142. https://doi.org/10.3390/info13030142

Hassan, H., Sade, A. B., & Rahman, M. S. (2018). Obesity and overweight issues could undermine Malaysia's competitiveness. *International Journal of Human Rights in Healthcare*, *11*(3), 204–213. https://doi.org/10.1108/IJHRH-09-2017-0050

Higgs, J., & Flowerday, S. (2024). Towards definitive categories for online video game money laundering. *Journal of Money Laundering Control*, *27*(6), 1051–1062. https://doi.org/10.1108/JMLC-12-2023-0193

Howe, L. D., Firestone, R., Tilling, K., & Lawlor, D. A. (Eds). (2015). Chapter 2: Trajectories and Transitions in Childhood and Adolescent Obesity. In *A Life Course Perspective on Health Trajectories and Transitions* (Vol. 4). Springer International Publishing. https://doi.org/10.1007/978-3-319-20484-0

Howell, P. D., Martin, L. D., Salehian, H., Lee, C., Eastman, K. M., & Kim, J. (2016). *Analyzing taste preferences from crowdsourced food entries*. 131–140. https://doi.org/10.1145/2896338.2896358

Hunicke, R., LeBlanc, M., & Zubek, R. (2004). *MDA: A Formal Approach to Game Design and Game Research*.

Ibrahim, R., & Jaafar, A. (2009). Educational games (EG) design framework: Combination of game design, pedagogy and content modeling. *2009 International Conference on Electrical Engineering and Informatics*, 293–298. https://doi.org/10.1109/ICEEI.2009.5254771

Idrissi, W. E. M. E., EL Kababi Ghizlane Chemsi, K., & Radid, M. (2022). The Impact of Serious Game on the Nursing Students' Learning, Behavioral Engagement and Motivation. *International Journal of Emerging Technologies in Learning*, *17*(1), 18–35. https://doi.org/10.3991/ijet.v17i01.26857

Ihsan, S. N., Kadir, T. A. A., Benedict, R., & Abdullah, A. R. (2020). Preventive Self-Care Serious Games for Diabetes: A Game Design. *IOP Conference Series: Materials Science and Engineering*, *769*(1), 012058. https://doi.org/10.1088/1757-899X/769/1/012058

IJsselsteijn, W. A., de Kort, Y. A. W., & Poels, K. (2013). *The Game Experience Questionnaire*. Technische Universiteit Eindhoven.

Isa, W. M. W., Zin, N. A. M., Rosdi, F., & Sarim, H. M. (2019). Serious Game Design for Terengganu Brassware Craft Heritage. *2019 IEEE Conference on Graphics and Media (GAME)*, 13–17. https://doi.org/10.1109/GAME47560.2019.8980774

Jayachandran, K., Chilakamarri, S., Coelho, D., & Mueller, Dr. K. (2017). A Virtual Reality Grocery Shopping Game to Improve Awareness for Healthy Foods in Young Adults. *13th International Conference and Expo on Emerging Technologies for a Smarter World (CEWIT)*, 1–5. https://doi.org/10.1109/CEWIT.2017.8263138

Jeldres, M. R., Costa, E. D., & Nadim, T. F. (2023). A review of Lawshe's method for calculating content validity in the social sciences. *Frontiers in Education*, *8*. https://doi.org/10.3389/feduc.2023.1271335

Jordan, P. W., Thomas, B., McClelland, I. L., & Weerdmeester, B. (Eds). (1996). *SUS: A 'Quick and Dirty' Usability Scale* (0 edn, pp. 207–212). CRC Press. https://doi.org/10.1201/9781498710411-35

Kalichman, S., Malow, R., Dévieux, J., Stein, J. A., & Piedman, F. (2005). HIV Risk Reduction for Substance Using Seriously Mentally Ill Adults: Test of the Information-Motivation-Behavior Skills (IMB) Model. *Community Mental Health Journal*, *41*(3), 277–290. https://doi.org/10.1007/s10597-005-5002-1

Kalimuthu, I., Karpudewan, M., & Baharudin, S. M. (2023). An Interdisciplinary and Immersive Real-Time Learning Experience in Adolescent Nutrition Education Through Augmented Reality Integrated With Science, Technology, Engineering, and Mathematics. *Journal of Nutrition Education and Behavior*, *55*(12), 914–923. https://doi.org/10.1016/j.jneb.2023.10.002

Karakasis, C., & Xinogalos, S. (2020). BlocklyScript: Design and Pilot Evaluation of an RPG Platform Game for Cultivating Computational Thinking Skills to Young Students. *Informatics in Education*, *19*(4), 641–668. https://doi.org/10.15388/infedu.2020.28

Kato, P., Cole, S., Bradlyn, D., & Pollock, B. (2008). A Video Game Improves Behavioral Outcomes in Adolescents and Young Adults With Cancer: A Randomized Trial. *Pediatrics*, *122*, e305-17. https://doi.org/10.1542/peds.2007-3134

Kayed, J., Akl, T., Massoud, C., Margossian, C., Fayad, H., Fares, G., Felefly, T., & Rihana, S. (2024). Serious game for radiotherapy training. *BMC Medical Education*, *24*. https://doi.org/10.1186/s12909-024-05430-1

Khaldi, A., Bouzidi, R., & Nader, F. (2023). Gamification of e-learning in higher education: A systematic literature review. *Smart Learning Environments*, *10*(1), 10. https://doi.org/10.1186/s40561-023-00227-z

Khowaja, K. (2017). *A SERIOUS GAME DESIGN FRAMEWORK FOR VOCABULARY LEARNING OF CHILDREN WITH AUTISM*. UNIVERSITY OF MALAYA.

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education*, *8*(1), 13–24. https://doi.org/10.1016/j.iheduc.2004.12.001

Kim, J., & Park, H.-A. (2012). Development of a Health Information Technology Acceptance Model Using Consumers' Health Behavior Intention. *Journal of Medical Internet Research*, *14*(5), e133. https://doi.org/10.2196/jmir.2143

Kim, S. L., Suk, H. J., Kang, J. H., Jung, J. M., Laine, T. H., & Westlin, J. (2014). Using Unity 3D to facilitate mobile augmented reality game development. *2014 IEEE World Forum on Internet of Things (WF-IoT)*, 21–26. https://doi.org/10.1109/WF-IoT.2014.6803110

King, D., Delfabbro, P., & Griffiths, M. (2010). Video Game Structural Characteristics: A New Psychological Taxonomy. *International Journal of Mental Health and Addiction*, *8*(1), 90–106. https://doi.org/10.1007/s11469-009-9206-4

Klabbers, J. H. G. (2003, January 1). The gaming landscape: A taxonomy for classifying games and simulations. *Proceedings of DiGRA 2003 Conference: Level Up*. Proceedings of DiGRA 2003 Conference: Level Up. https://doi.org/10.26503/dl.v2003i1.61

Kleinman, E., Preetham, N., Teng, Z., Bryant, A., & Seif El-Nasr, M. (2021). 'What Happened Here!?' A Taxonomy for User Interaction with Spatio-Temporal Game Data Visualization. *Proceedings of the ACM on Human-Computer Interaction*, *5*(CHI PLAY), 1–27. https://doi.org/10.1145/3474687

Kumar, R. (2011). *Research Methodology—A Step-by-Step Guide for Beginners (3rd Edition)* (3rd edn). SAGE Publications.

Lamas, S., Rebelo, S., Da Costa, S., Sousa, H., Zagalo, N., & Pinto, E. (2023). The Influence of Serious Games in the Promotion of Healthy Diet and Physical Activity Health: A Systematic Review. *Nutrients*, *15*(6), 1399. https://doi.org/10.3390/nu15061399

Landers, R. N., Armstrong, M. B., & Collmus, A. B. (2017). How to Use Game Elements to Enhance Learning: Applications of the Theory of Gamified Learning. In M. Ma & A. Oikonomou (Eds), *Serious Games and Edutainment Applications* (pp. 457–483). Springer International Publishing. https://doi.org/10.1007/978-3-319-51645-5_21

Larsen, R. (2009). The Contributions of Positive and Negative Affect to Emotional Well-Being. In *Psychological Topics* (Vol. 18, pp. 247–266).

Lee, P. Y., & Lau, K. W. (2018). A Digital Games Design for Children Health Promotion and Education in Hong Kong. *Proceedings of the 2018 The 3rd International Conference on Information and Education Innovations - ICIEI 2018*, 1–5. https://doi.org/10.1145/3234825.3234826

Lewis-Evans, B. (2013, August 27). Dopamine and games – Liking, learning, or wanting to play? *Game Developer*. https://www.gamedeveloper.com/game-platforms/dopamine-and-games-liking-learning-or-wanting-to-play-

Lima, T., Barbosa, B., Niquini, C., Araujo, C., & Lana, R. (2017). Playing against dengue design and development of a serious game to help tackling dengue. *2017 IEEE 5th International Conference on Serious Games and Applications for Health (SeGAH)*, 1–8. https://doi.org/10.1109/SeGAH.2017.7939294

Limone, P., Messina, G., & Toto, G. A. (2022). Serious games and eating behaviors: A systematic review of the last 5 years (2018–2022). *Frontiers in Nutrition*, *9*. https://doi.org/10.3389/fnut.2022.978793

Lindberg, R., Seo, J., & Laine, T. H. (2016). Enhancing Physical Education with Exergames and Wearable Technology. *IEEE Transactions on Learning Technologies*, *9*(4), 328–341. https://doi.org/10.1109/TLT.2016.2556671

Liu, M., Guan, X., Guo, X., He, Y., Liu, Z., Ni, S., & Wu, Y. (2024). Impact of Serious Games on Body Composition, Physical Activity, and Dietary Change in Children and Adolescents: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Nutrients*, *16*(9). https://doi.org/10.3390/nu16091290

Liu, S., Reynolds, B. L., Thomas, N., & Soyoof, A. (2024). The Use of Digital Technologies to Develop Young Children's Language and Literacy Skills: A Systematic Review. *Sage Open*, *14*(1), 21582440241230850. https://doi.org/10.1177/21582440241230850

Luz, S., Masoodian, M., Cesario, R. R., & Cesario, M. (2016). Using a serious game to promote community-based awareness and prevention of neglected tropical diseases. *Entertainment Computing*, *15*, 43–55. https://doi.org/10.1016/j.entcom.2015.11.001

Ma, Y., Yu, B., Bekker, T., Hu, J., & Vos, S. (2020). FitBirds: Designing Heart Rate Feedback for Playful and Social Physical Education. *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society*, 1–4. https://doi.org/10.1145/3419249.3421243

Mack, I., Reiband, N., Etges, C., Eichhorn, S., Schaeffeler, N., Zurstiege, G., Gawrilow, C., Weimer, K., Peeraully, R., Teufel, M., Blumenstock, G., Giel, K. E., Junne, F., & Zipfel, S. (2020). The Kids Obesity Prevention Program: Cluster Randomized Controlled Trial to Evaluate a Serious Game for the Prevention and Treatment of Childhood Obesity. *Journal of Medical Internet Research*, *22*(4), e15725. https://doi.org/10.2196/15725

Mahari, H. (2024, July 18). Malaysia sees rise in childhood stunting and obesity rates. *NST Online*. https://www.nst.com.my/news/nation/2024/07/1078112/malaysia-sees-rise-childhood-stunting-and-obesity-rates

Majumdar, D., Koch, P. A., Lee, H., Contento, I. R., Islas-Ramos, A. D. L., & Fu, D. (2013). "Creature-101": A Serious Game to Promote Energy Balance-Related

Behaviors Among Middle School Adolescents. *Games for Health Journal*, *2*(5), 280–290. https://doi.org/10.1089/g4h.2013.0045

Małgorzata, P.-W., & Joanna, R. (2015). *A SERIOUS GAME RAISING AWARENESS AND EXPERIENCE OF DEPRESSION*.

Malone, T. W., & Lepper, M. R. (1987). Making Learning Fun: A Taxonomy of Intrinsic Motivations for Learning. In R. E. Snow & M. J. Farr (Eds), *Aptitude, Learning, and Instruction Volume 3: Conative and Affective Process Analyses*. Lawrence Erlbaum Associates. https://pressbooks.pub/learningenvironmentsdesign/chapter/malone-lepper-making-learning-fun-a-taxonomy-of-intrinsic-motivations-for-learning/

Marchetti, D., Fraticelli, F., Polcini, F., Fulcheri, M., Mohn, A. A., & Vitacolonna, E. (2018). A school educational intervention based on a serious game to promote a healthy lifestyle. *Mediterranean Journal of Clinical Psychology*, *Vol 6*, No 3 (2018). https://doi.org/10.6092/2282-1619/2018.6.1877

Maxim, R. I., & Arnedo-Moreno, J. (2025). Identifying Key Principles and Commonalities in Digital Serious Game Design Frameworks: Scoping Review. *JMIR Serious Games*, *13*, e54075. https://doi.org/10.2196/54075

Mayer, R. E. (2002). *Multimedia learning* (p. 139).

Mayr, S., Ledit, L., Petta, P., Eichenberg, C., & Sindelar, B. (2016). A serious game to treat childhood obesity. *2016 IEEE International Conference on Serious Games and Applications for Health (SeGAH)*, 1–6. https://doi.org/10.1109/SeGAH.2016.7586258

McGonigal, J. (2011). *Reality Is Broken. Why Games Make Us Better and How They Can Change the World*. The Penguin Press. https://hci.stanford.edu/courses/cs047n/readings/Reality_is_Broken.pdf

Michael, D., & Chen, S. (2006). *Serious games: Games that educate, train, and inform*. Thomson Course Technology.

Michael, S., Katrakazas, P., Petronoulou, O., Anastasiou, A., Iliopoulou, D., & Dionisios Koutsouris, D. (2018). NutritionBuddy: A Childhood Obesity Serious Game. *2018 Second World Conference on Smart Trends in Systems, Security and Sustainability (WorldS4)*, 5–8. https://doi.org/10.1109/WorldS4.2018.8611473

Minkkinen, T. (2016). *Basics of Platform Games*.

Mitgutsch, K., & Alvarado, N. (2012). *Purposeful by design?: A serious game design assessment framework*. 121–128. https://doi.org/10.1145/2282338.2282364

Mohamad, U., Nordin, A. I., & Ahmad, A. (2020). THE CONCEPTUAL MODEL OF AN APPLICATION TO INCREASE PUBLIC AWARENESS ON ANTIBIOTIC RESISTANCE. *Journal of Information System and Technology Management*, *5*, 33–45. https://doi.org/10.35631/JISTM.518004

Mohamed, M. A. S., AbouKhatwa, M. M., Saifullah, A. A., Syahmi, M. H., Mosaad, M., Elrggal, M. E., Dehele, I. S., & Elnaem, M. H. (2022). Risk Factors, Clinical Consequences, Prevention, and Treatment of Childhood Obesity. *Children*, *9*(12), 1975. https://doi.org/10.3390/children9121975

Mohd Daud, S. K. W., Mustaffa, F., & Hussain, H. (2017). Thumbnail Sketches Usage in Organizing Idea for Typography Design. *International Journal of Education and Learning Systems*, *2*, 59–65.

Möller, S., Schmidt, S., & Beyer, J. (2013). Gaming taxonomy: An overview of concepts and evaluation methods for computer gaming QoE. *2013 Fifth International Workshop on Quality of Multimedia Experience (QoMEX)*, 236–241. https://doi.org/10.1109/QoMEX.2013.6603243

Moosa, A. M., Al-Maadeed, N., Saleh, M., Al-Maadeed, S. A., & Aljaam, J. M. (2020). Designing a Mobile Serious Game for Raising Awareness of Diabetic Children. *IEEE Access*, *8*, 222876–222889. https://doi.org/10.1109/ACCESS.2020.3043840

Muhammad, R., Md Nor, N., Ikram, E. H. K., Habidin, N. F., Mohd Yusof, N., Abdullah, N., & Md Sharif, M. S. (2021). Intuitive Eating Behavior and Obesity among Adolescents in Malaysia. *International Journal of Academic Research in Business and Social Sciences*, *11*(8), Pages 311-316. https://doi.org/10.6007/IJARBSS/v11-i8/10733

Mulcahy, R. F., McAndrew, R., Russell Bennett, R., & lacobucci, D. (2021). "Game on!" Pushing consumer buttons to change sustainable behavior: A gamification field study. *European Journal of Marketing*, *55*(10), 2593–2619. https://doi.org/10.1108/EJM-05-2020-0341

Must, A., & Strauss, R. (1999). Risks and consequences of childhood and adolescent obesity. *International Journal of Obesity*, *23*, S2–S11. https://doi.org/10.1038/sj.ijo.0800852

Nasharuddin, N. A., Marlisah, E., Nazan, A. I. N. M., Jalil, H. Ab., Ismail, I. A., Ma'arof, A. M., & Salim, S. S. (2019). Body Mass Index Awareness using Game-based Learning in Malaysia: Game Design and Initial User Experiences. *2019 11th Computer Science and Electronic Engineering (CEEC)*, 90–95. https://doi.org/10.1109/CEEC47804.2019.8974325

National Institutes of Health (NIH). (2019). *National Health and Morbidity Survey 2019: Non-communicable diseases, healthcare demand and health literacy*. https://iptk.moh.gov.my/images/technical_report/2020/FactSheet_BI_AUG2020.pdf

Naul, E., & Liu, M. (2020). Why Story Matters: A Review of Narrative in Serious Games. *Journal of Educational Computing Research*, *58*(3), 687–707. https://doi.org/10.1177/0735633119859904

Ng, B.-Y., Kankanhalli, A., & Xu, Y. (Calvin). (2009). Studying users' computer security behavior: A health belief perspective. *Decision Support Systems*, *46*(4), 815–825. https://doi.org/10.1016/j.dss.2008.11.010

Nguyen, B. H., & Le, H. N. Q. (2024). Investigation on information security awareness based on KAB model: The moderating role of age and education level. *Information & Computer Security*, *32*(5), 598–612. https://doi.org/10.1108/ICS-09-2023-0152

Nilsen, P. (2015). Making sense of implementation theories, models and frameworks. *Implementation Science*, *10*(1), 53. https://doi.org/10.1186/s13012-015-0242-0

Nunnally, J. C. (1978). *Psychometric Theory* (2nd edn).

Nutrition Society of Malaysia. (2016). *NutriWeb*. http://www.nutriweb.org.my

Offermann, P., Levina, O., Schönherr, M., & Bub, U. (2009). Outline of a design science research process. *Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology - DESRIST '09*, 1. https://doi.org/10.1145/1555619.1555629

Oliveira, M. L. de, Castagnoli, J. de L., Machado, K. M. C., Soares, J. M., Teixeira, F., Schiessel, D. L., Santos, E. F. dos, & Novello, D. (2022). Interdisciplinary Educational Interventions Improve Knowledge of Eating, Nutrition, and Physical Activity of Elementary Students. *Nutrients*, *14*(14). https://doi.org/10.3390/nu14142827

Orji, R. O. (2014). *DESIGN FOR BEHAVIOUR CHANGE: A MODEL-DRIVEN APPROACH FOR TAILORING PERSUASIVE TECHNOLOGIES*. University of Saskatchewan Saskatoon.

Osborn, C. Y., & Egede, L. E. (2010). Validation of an Information–Motivation–Behavioral Skills model of diabetes self-care (IMB-DSC). *Patient Education and Counseling*, *79*(1), 49–54. https://doi.org/10.1016/j.pec.2009.07.016

Osman, I., Md Taib, Norraeffa, Abu Yazid, Z., Daud, S., & Othman, M. Z. (2024). *Exploring the Usability and Engagement of Students in an Educational Board Game on Personal Financial Planning*. *16*(1). https://doi.org/10.22610/imbr.v16i1(I).3662

Paganin, G., Margheritti, S., Farhane-Medina, N. Z., Simbula, S., & Mazzetti, G. (2023). Health, Stress and Technologies: Integrating Technology Acceptance and Health Belief Models for Smartphone-Based Stress Intervention. *Healthcare*, *11*(23), 3030. https://doi.org/10.3390/healthcare11233030

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Systematic Reviews*, *10*(1), 89. https://doi.org/10.1186/s13643-021-01626-4

Palaus, M., Viejo-Sobera, R., Redolar-Ripoll, D., & Marrón, E. M. (2020). Cognitive Enhancement via Neuromodulation and Video Games: Synergistic Effects? *Frontiers in Human Neuroscience*, *14*, 235. https://doi.org/10.3389/fnhum.2020.00235

Pan, W. K. M. (2024). The application of behavioral change theories in addressing vaccine hesitancy: A Literature Review. *Public Health Nursing*, *41*(2), 318–324. https://doi.org/10.1111/phn.13280

Parakkat, A. D., Bondi Pundarikaksha, U., & Muthuganapathy, R. (2018). A Delaunay triangulation based approach for cleaning rough sketches. *Computers & Graphics*, *74*, 171–181. https://doi.org/10.1016/j.cag.2018.05.011

Parreiras, M., Marques, P., & Xexéo, G. (2023). A Taxonomy of Game Balancing Elements. In *Anais Estendidos do Simpósio Brasileiro de Jogos e Entretenimento Digital (SBGames)* (p. 11). https://doi.org/10.5753/sbgames_estendido.2023.233888

Pell, C., Allotey, P., Evans, N., Hardon, A., Imelda, J. D., Soyiri, I., Reidpath, D. D., & The SEACO Team. (2016). Coming of age, becoming obese: A cross-sectional analysis of obesity among adolescents and young adults in Malaysia. *BMC Public Health*, *16*(1), 1082. https://doi.org/10.1186/s12889-016-3746-x

Peng, W., Lin, J.-H. T., Pfeiffer, K., & Winn, B. (2012). Need Satisfaction Supportive Game Features as Motivational Determinants: An Experimental Study of a Self-Determination Theory Guided Exergame. *Media Psychology - MEDIA PSYCHOL*, *15*, 175–196. https://doi.org/10.1080/15213269.2012.673850

Pengpid, S., & Peltzer, K. (2016). OVERWEIGHT, OBESITY AND ASSOCIATED FACTORS AMONG 13-15 YEARS OLD STUDENTS IN THE ASSOCIATION OF SOUTHEAST ASIAN NATIONS MEMBER COUNTRIES, 2007-2014. *Southeast Asian J Trop Med Public Health*, *47*(2), 250–262.

Pereira, G., Prada, R., & Paiva, A. (2015). Disaster Prevention Social Awareness: The Stop Disasters! Case Study. *2014 6th International Conference on Games and Virtual Worlds for Serious Applications, VS-GAMES 2014*. https://doi.org/10.1109/VS-Games.2014.7012155

Petri, G., Wangenheim, C. G. von, & Borgatto, A. F. (2016). *MEEGA+: An Evolution of a Model for the Evaluation of Educational Games* (Technical Report INCoD/GQS.03.2016.E).

Petri, G., Wangenheim, C. G. von, & Borgatto, A. F. (2018). *MEEGA+: A Method for the Evaluation of Educational Games for Computing Education* (INCoD/GQS.05.2018.E). www.incod.ufsc.br

Phutela, N., Chowdary, A. N., Anchlia, S., Jaisinghani, D., & Gabrani, G. (2022). Unlock Me: A Real-World Driven Smartphone Game to Stimulate COVID-19 Awareness. *International Journal of Human-Computer Studies*, *164*, 102818. https://doi.org/10.1016/j.ijhcs.2022.102818

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of Game-Based Learning. *Educational Psychologist*, *50*(4), 258–283. https://doi.org/10.1080/00461520.2015.1122533

Prensky, M. (2001). *Digital Game-Based Learning*. McGraw-Hill.

Prochaska, J. O., & DiClemente, C. C. (1983). Stages and Processes of Self-Change of Smoking: Toward An Integrative Model of Change. *Journal of Consulting and*

Clinical Psychology, *51*(3), 390–395. https://doi.org/10.1037//0022-006x.51.3.390

Prochaska, J. O., & Velicer, W. F. (1997). The Transtheoretical Model of Health Behavior Change. *American Journal of Health Promotion*, *12*(1), 38–48. https://doi.org/10.4278/0890-1171-12.1.38

Rahmat, R. A. A. O. K., Osman, K., & Bakar, N. A. (2012). Educational Computer Game Design Model for Malaysian Science and Technology Classroom. *Proceedings of the 11th WSEAS International Conference on Software Engineering, Parallel and Distributed Systems, and Proceedings of the 9th WSEAS International Conference on Engineering Education*, 156–162.

Rai, N., & Thapa, B. (2015). *A STUDY ON PURPOSIVE SAMPLING METHOD IN RESEARCH*. Kathmandu School of Law. https://www.slideshare.net/slideshow/a-study-on-purposive-sampling-method-in-research/259644680#2

Randall, N., Joshi, S., & Liu, X. (2018). *Health-e-Eater: Dinnertime Companion Robot and Magic Plate for Improving Eating Habits in Children from Low-Income Families*. 361–362. https://doi.org/10.1145/3173386.3177828

Rao, V. (2013). A Framework for Evaluating Behavior Change Interventions through Gaming. In D. Reidsma, H. Katayose, & A. Nijholt (Eds), *Advances in Computer Entertainment* (Vol. 8253, pp. 368–379). Springer International Publishing. https://doi.org/10.1007/978-3-319-03161-3_27

Ravyse, W. S., Seugnet Blignaut, A., Leendertz, V., & Woolner, A. (2017). Success factors for serious games to enhance learning: A systematic review. *Virtual Reality*, *21*(1), 31–58. https://doi.org/10.1007/s10055-016-0298-4

Rebolledo-Mendez, G., Avramides, K., De Freitas, S., & Memarzia, K. (2009). Societal impact of a Serious Game on raising public awareness: The case of FloodSim. *Proceedings of the 2009 ACM SIGGRAPH Symposium on Video Games*, 173–173. https://doi.org/10.1145/1581073.1581076

Reeves, S., Poh, B. K., Essau, C., Summerbell, C., Cheah, W. L., Koh, D., Lee, J. A. C., Ruzita, A. T., & Gibson, E. L. (2018). ToyBox Study Malaysia: Improving healthy energy balance and obesity-related behaviours among pre-schoolers in Malaysia. *Nutrition Bulletin*, *43*(3), 290–295. https://doi.org/10.1111/nbu.12340

Rehbein, F., King, D. L., Staudt, A., Hayer, T., & Rumpf, H.-J. (2021). Contribution of Game Genre and Structural Game Characteristics to the Risk of Problem Gaming and Gaming Disorder: A Systematic Review. *Current Addiction Reports*, *8*(2), 263–281. https://doi.org/10.1007/s40429-021-00367-7

Ren, K., Mohd, N., Ali, K., Bandi, S., & Ismail, F. (2022). Design Phase of Gamification Framework for Hazard Identification Training in Construction Industry. *International Journal of Interactive Mobile Technologies (iJIM)*, *16*, 113–128. https://doi.org/10.3991/ijim.v16i02.27405

Ribeiro, S. M., Basso, M. B., Massignan, C., & Leal, S. C. (2023). Playful educational interventions in children and adolescents' health literacy: A systematic review. *Health Promotion International*, *38*(4), daad089. https://doi.org/10.1093/heapro/daad089

Robles, T. D. J. A., Rodriguez, B. A. M., Irazoqui, B. J. B., Rodriguez, F. J. A., & Bringas, J. A. S. (2020). Analysis and Design of a serious game to support children with obesity in Mexico: Proposal of the serious game, Run Boy Go! *2020 3rd International Conference of Inclusive Technology and Education (CONTIE)*, 145–153. https://doi.org/10.1109/CONTIE51334.2020.00035

Roedavan, R., Siradj, Y., & Stefany, S. (2023). Educational Game Scenario Model Based On Imperative Game Goal Typology. *Journal of Games, Game Art, and Gamification*, *8*(1), 18–23. https://doi.org/10.21512/jggag.v8i1.9497

Roscoe, J. T. (1975). Fundamental Research Statistics for the Behavioral Sciences. *Journal of the American Statistical Association*, *66*(333), 224. https://doi.org/10.2307/2284880

Rubio, D. M., Berg-Weger, M., Tebb, S. S., Lee, E. S., & Rauch, S. (2003). Objectifying content validity: Conducting a content validity study in social work research. *Social Work Research*, *27*(2), 94–104. https://doi.org/10.1093/swr/27.2.94

Saad, S., Al-Sager, M. O., Al-Maadeed, N., & AIJa'am, J. M. (2018). Play, Learn and Eat Healthy Food: A Mobile Game for Children to Fight Obesity. *2018 International Conference on Computer and Applications (ICCA)*, 369–376. https://doi.org/10.1109/COMAPP.2018.8460418

Saini, N., & Hodgins, D. (2023). Investigating gaming structural features associated with gaming disorder and proposing a revised taxonomical model: A scoping review. *Journal of Behavioral Addictions*, *12*. https://doi.org/10.1556/2006.2023.00019

Saksono, H., Ranade, A., Kamarthi, G., Castaneda-Sceppa, C., Hoffman, J. A., Wirth, C., & Parker, A. G. (2015). Spaceship Launch: Designing a Collaborative Exergame for Families. *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*, 1776–1787. https://doi.org/10.1145/2675133.2675159

Salam, M. M., Yousuf, R., Salam, M. W., & Haque, M. (2023). Obesity and Overweight: A Global Public Health Issue. *Advances in Human Biology*, *13*(1), 154–156. https://doi.org/10.4103/aihb.aihb_106_22

Saleme, P., Dietrich, T., Pang, B., & Parkinson, J. (2021). Design of a Digital Game Intervention to Promote Socio-Emotional Skills and Prosocial Behavior in Children. *Multimodal Technologies and Interaction*, *5*(10), 58. https://doi.org/10.3390/mti5100058

Samadi, M., Phillips, C., & Klarkowski, M. (2024). Space Oddity: A Demonstration of the Self-Efficacy Game Elements Framework. *Companion Proceedings of the 2024 Annual Symposium on Computer-Human Interaction in Play, CHI PLAY Companion '24*, 249–255. https://doi.org/10.1145/3665463.3678793

Sarasmita, M. A., Lee, Y.-H., Chan, F.-Y., & Chen, H.-Y. (2024). Digital Serious Games to Promote Behavior Change in Children With Chronic Diseases: Scoping Review and Development of a Self-Management Learning Framework. *Journal of Medical Internet Research*, *26*(1), e49692. https://doi.org/10.2196/49692

Schöbel, S. M., Janson, A., & Söllner, M. (2020). Capturing the complexity of gamification elements: A holistic approach for analysing existing and deriving novel gamification designs. *European Journal of Information Systems*, *29*(6), 641–668. https://doi.org/10.1080/0960085X.2020.1796531

SDG Roadmap for Malaysia. Phase II: 2021-2025. (2024). The Ministry of Economy. https://www.ekonomi.gov.my/sites/default/files/2024-09/SDGRoadmapforMalaysia_Phase2%282021-2025%29.pdf

Sekaran, U., & Bougie, R. (2010). *Research Methods for Business. A Skill-Building Approach* (5th edn). John Wiley & Sons Ltd. https://9afi.com/storage/daftar/onTXVlzEDQNtC4khg3Yklhj0g5V5wyFsQqNDZOpL.pdf

Sekhavat, Y. A. (2019). A Rewarding Framework for Multiplayer Serious Games based on Competitive Reinforcement. *2019 IEEE 7th International Conference on*

Serious Games and Applications for Health (SeGAH), 1–8. https://doi.org/10.1109/SeGAH.2019.8882473

Serrano, K. J., Yu, M., Riley, W. T., Patel, V., Hughes, P., Marchesini, K., & Atienza, A. A. (2016). Willingness to Exchange Health Information via Mobile Devices: Findings From a Population-Based Survey. *The Annals of Family Medicine*, *14*(1), 34–40. https://doi.org/10.1370/afm.1888

Sharma, M. (2015). *Multi-theory model (MTM) for health behavior change* [Unpublished manuscript].

Sharmin, S., Bhattacharjee, A., Sadik, R., Patre, P., Koiler, R., Getchell, N., & Barmaki, R. L. (2023). *Insights into Cognitive Engagement: Comparing the Effectiveness of Game-Based and Video-Based Learning*. https://doi.org/10.48550/arXiv.2307.13637

Shrestha, R., & Copenhaver, M. (2015). Long-Term Effects of Childhood Risk Factors on Cardiovascular Health During Adulthood. *Clinical Medicine Reviews in Vascular Health*, *7*, 1–5. https://doi.org/10.4137/CMRVH.S29964

Silva, I. (2015). Importance of emotional regulation in obesity and weight loss treatment. *Fractal : Revista de Psicologia*, *27*(3), 286–290. https://doi.org/10.1590/1984-0292/1503

Sim, G., & Horton, M. (2012). Investigating children's opinions of games: Fun Toolkit vs. This or That. *Proceedings of the 11th International Conference on Interaction Design and Children*, 70–77. https://doi.org/10.1145/2307096.2307105

Smith, P. A., & Bowers, C. (2015). Serious Games and the Technology of Engaging Information. In M. Khosrow-Pour, D.B.A. (Ed.), *Advances in Information Quality and Management* (pp. 2591–2599). IGI Global. https://doi.org/10.4018/978-1-4666-5888-2.ch252

Song, M., & Zhang, S. (2008). EFM: A Model for Educational Game Design. In Z. Pan, X. Zhang, A. El Rhalibi, W. Woo, & Y. Li (Eds), *Technologies for E-Learning and Digital Entertainment* (pp. 509–517). Springer. https://doi.org/10.1007/978-3-540-69736-7_54

Sqire, K. (2005). Changing the Game: What Happens When Video Games Enter the Classroom? *Innovate: Journal of Online Education*, *1*(5).

Starks, K. (2014). Cognitive behavioral game design: A unified model for designing serious games. *Frontiers in Psychology*, *5*. https://doi.org/10.3389/fpsyg.2014.00028

Starks, K. (2024). Playful PHI: Using Cognitive Behavioral Game Design (CBGD) to Create a COVID-19 Prevention Game, Vaccine Nation. *The International Journal of Games and Social Impact*, *2*(1), Article 1. https://doi.org/10.24140/ijgsi.v2.n1.05

Stokols, D. (1996). Translating Social Ecological Theory Into Guidelines for Community Health Promotion. *American Journal of Health Promotion : AJHP*, *10*, 282–298. https://doi.org/10.4278/0890-1171-10.4.282

Susi, T., Johannesson, M., & Backlund, P. (2007). *Serious Games—An Overview* (HS-IKI-TR-07-001).

Swearingen, K. L., & Swearingen, S. L. (2018). Games and Storytelling for Design Foundations. *National Conference on the Beginning Design Student*, *34*(1), Article 1. https://journals.uc.edu/index.php/ncbds/article/view/787

Tan, P. H., Ling, siew-woei, & Yee, T. (2007). *Adaptive digital game-based learning framework* (p. 146). https://doi.org/10.1145/1306813.1306844

Tang, Z., Zhang, P., Li, Y., & Hansen, P. (2024). Tell me what to do first: How behavioural skills drive users' intention to adopt online health information. *The Electronic Library*, *42*(5), 811–826. (world). https://doi.org/10.1108/EL-12-2023-0296

Taylor, C., Upton, P., & Upton, D. (2015). Increasing primary school children's fruit and vegetable consumption: A review of the food dudes programme. *Health Education*, *115*, 178–196. https://doi.org/10.1108/HE-02-2014-0005

Teddlie, C., & Yu, F. (2007). Mixed Methods Sampling: A Typology With Examples. *Journal of Mixed Methods Research*, *1*(1), 77–100. https://doi.org/10.1177/1558689806292430

Tee, E. S. (2017). New ways to fight obesity. *New Straits Times*. https://www.nst.com.my/opinion/columnists/2017/09/277813/new-ways-fight-obesity

Thompson, D. (2012). Designing Serious Video Games for Health Behavior Change: Current Status and Future Directions. *Journal of Diabetes Science and Technology*, *6*(4), 807–811. https://doi.org/10.1177/193229681200600411

Thompson, D., Baranowski, T., & Buday, R. (2010). Conceptual Model for the Design of a Serious Video Game Promoting Self-Management among Youth with Type 1 Diabetes. *Journal of Diabetes Science and Technology*, *4*(3), 744–749. https://doi.org/10.1177/193229681000400331

Thompson, D., Baranowski, T., Buday, R., Baranowski, J., Thompson, V., Jago, R., & Griffith, M. J. (2010). Serious Video Games for Health: How Behavioral Science Guided the Development of a Serious Video Game. *Simulation & Gaming*, *41*(4), 587–606. https://doi.org/10.1177/1046878108328087

Toda, A. M., Klock, A. C. T., Oliveira, W., Palomino, P. T., Rodrigues, L., Shi, L., Bittencourt, I., Gasparini, I., Isotani, S., & Cristea, A. I. (2019). Analysing gamification elements in educational environments using an existing Gamification taxonomy. *Smart Learning Environments*, *6*(1). https://doi.org/10.1186/s40561-019-0106-1

Toda, A., Oliveira, W., Klock, A., Toledo Palomino, P., Pimenta, M., Gasparini, I., Shi, L., Bittencourt, I., Isotani, S., & Cristea, A. (2019). *A Taxonomy of Game Elements for Gamification in Educational Contexts: Proposal and Evaluation*. https://doi.org/10.1109/ICALT.2019.00028

Tori, A. A., Tori, R., & Nunes, F. D. L. D. S. (2022). Serious Game Design in Health Education: A Systematic Review. *IEEE Transactions on Learning Technologies*, *15*(6), 827–846. https://doi.org/10.1109/TLT.2022.3200583

Trochim, W. M. K. (2001). *Research Methods Knowledge Base*. https://www.semanticscholar.org/paper/Research-methods-knowledge-base-Trochim-Donnelly/d8e92b6d6ea66fdfcf3546b33ab0ad5649aaf597

Tsiotras, D., & Xinogalos, S. (2021). Investigating the Perceived Player Experience and Short-term Learning of the Text-based Java Programming Serious Game "Rise of the Java Emperor". *Informatics in Education*, *20*(1), 153–170. https://doi.org/10.15388/infedu.2021.08

Vajid, A., & Bashir, S. (2024). DETERMINANTS OF CHILDHOOD OBESITY: A REGRESSION ANALYSIS OF SOCIOECONOMIC AND ENVIRONMENTAL FACTORS. *EPRA International Journal of Research & Development (IJRD)*, 65–72. https://doi.org/10.36713/epra16754

Verma, R. K., Chua, G., & David, S. R. (2013). Obesity and Overweight Management in Malaysia and Singapore: Progress on Right Track. *JOURNAL OF CLINICAL*

AND DIAGNOSTIC RESEARCH. https://doi.org/10.7860/JCDR/2013/7860.3883

Verschueren, S., Buffel, C., & Stichele, G. V. (2019). Developing Theory-Driven, Evidence-Based Serious Games for Health: Framework Based on Research Community Insights. *JMIR Serious Games*, *7*(2), e11565. https://doi.org/10.2196/11565

Vondikakis, I., Politi, E., Chronis, C., Dimitrakopoulos, G., Georgoulis, M., Saltaouras, G., Kontogianni, M., Nikitas, C., Kassari, P., Charmandari, E., Kouris, I., Kakkos, I., Mpromis, K., Matsopoulos, G., & Koutsouris, D. (2025). Behavioral Change Through Serious Gaming Approaches for Childhood Obesity Interventions. In E. Andrikopoulou, P. Gallos, T. N. Arvanitis, R. Austin, A. Benis, R. Cornet, P. Chatzistergos, A. Dejaco, L. Dusseljee-Peute, A. Mohasseb, P. Natsiavas, H. Nakkas, & P. Scott (Eds), *Studies in Health Technology and Informatics*. IOS Press. https://doi.org/10.3233/SHTI250298

Vondikakis, I., Politi, E., Goulis, D., Dimitrakopoulos, G., Georgoulis, M., Saltaouras, G., Kontogianni, M., Brisimi, T., Logothetis, M., Kakoulidis, H., Prasinos, M., Anastasiou, A., Kakkos, I., Vellidou, E., Matsopoulos, G., & Koutsouris, D. (2025). Integrated Framework for Managing Childhood Obesity Based on Biobanks, AI Tools and Methods, and Serious Games. *Electronics*, *14*(10). https://doi.org/10.3390/electronics14102053

Walsh, J., Senn, T., Scott-Sheldon, L., Vanable, P., & Carey, M. (2011). Predicting Condom Use Using the Information-Motivation-Behavioral Skills (IMB) Model: A Multivariate Latent Growth Curve Analysis. *Annals of Behavioral Medicine : A Publication of the Society of Behavioral Medicine*, *42*, 235–244. https://doi.org/10.1007/s12160-011-9284-y

Walters, R., Leslie, S., Polson, R., Cusack, T., & Gorely, T. (2020). Establishing the efficacy of interventions to improve health literacy and health behaviours: A systematic review. *BMC Public Health*, *20*. https://doi.org/10.1186/s12889-020-08991-0

Wang, P. A. (2010). Information security knowledge and behavior: An adapted model of technology acceptance. *2010 2nd International Conference on Education Technology and Computer*, *2*, V2-364-V2-367. https://doi.org/10.1109/ICETC.2010.5529366

Wang, Y., Bian, Y., Song, Y., Huang, R., Gai, W., Liu, J., Yang, C., & Meng, X. (2020). Exer-Learning: A New Genre Combines Learning, Exercise and Fun for Children. *Procedia Computer Science*, *174*, 735–745. https://doi.org/10.1016/j.procs.2020.06.150

Watt, K., & Smith, T. (2021). Research-Based Game Design for Serious Games. *Simulation & Gaming*. https://doi.org/10.1177/1046878121100

Werbach, K., & Hunter, D. (2012). *For the Win How Game Thinking Can Revolutionize Your Business*. https://online.fliphtml5.com/ndhs/wtqf/

Westlin, J., & Laine, T. H. (2014). *Short paper: Calory Battle AR: An extensible mobile augmented reality exergame platform*. 171–172. https://doi.org/10.1109/WF-IoT.2014.6803144

Wilkinson, P. (2016). A Brief History of Serious Games. In R. Dörner, S. Göbel, M. Kickmeier-Rust, M. Masuch, & K. Zweig (Eds), *Entertainment Computing and Serious Games* (Vol. 9970, pp. 17–41). Springer International Publishing. https://doi.org/10.1007/978-3-319-46152-6_2

Winn, W., & Jackson, R. (1999). Fourteen Propositions About Educational Uses of Virtual Reality. In *Educational Technology* (Vol. 39, pp. 5–14). Educational Technology Publications, Inc. https://www.jstor.org/stable/44428537

Wolf, M. R., & Lenz, L. L. (2014). The economic effectiveness of serious games in the healthcare environment—Application and Evaluation of the Comparative Transformation Model (CTM). *2014 IEEE 3nd International Conference on Serious Games and Applications for Health (SeGAH)*, 1–8. https://doi.org/10.1109/SeGAH.2014.7067089

World Health Organization. (2020). *Child and Adolescent health and wellbeing*.

World Health Organization. (2024, March 1). *Obesity and overweight*. WHO. http://www.who.int/mediacentre/factsheets/fs311/en/#

Wouters, P., Van Der Spek, E. D., & Van Oostendorp, H. (2009). Current Practices in Serious Game Research: A Review from a Learning Outcomes Perspective. In T. Connolly, M. Stansfield, & L. Boyle (Eds), *Games-Based Learning Advancements for Multi-Sensory Human Computer Interfaces* (pp. 232–250). IGI Global. https://doi.org/10.4018/978-1-60566-360-9.ch014

Wouters, P., Van Nimwegen, C., Van Oostendorp, H., & Van Der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games.

Journal of Educational Psychology, *105*(2), 249–265. https://doi.org/10.1037/a0031311

Wu, X., Zhao, M., & Liao, H.-T. (2020). Integrating Health Belief Model, Technological Self-efficacy, and the PEN-3 cultural model: Conceptualizing the impact of culture and technology on health for advancing Sustainable Smart Health. *E3S Web of Conferences*, *218*, 02019. https://doi.org/10.1051/e3sconf/202021802019

Xinogalos, S., & Satratzemi, M. (2022). The Use of Educational Games in Programming Assignments: SQL Island as a Case Study. *Applied Sciences*, *12*(13), 6563. https://doi.org/10.3390/app12136563

Yang, E., Chang, S. J., Lee, K., & Ryu, H. (2019). EHEALTH PROGRAM BASED ON THE INFORMATION-MOTIVATION-BEHAVIORAL SKILLS MODEL FOR THE ELDERLY: A PILOT STUDY. *Innovation in Aging*, *3*(Supplement_1), S296. https://doi.org/10.1093/geroni/igz038.1088

You, H., Wang, Y.-Y., Zhang, C., Walker, A. N., Ge, J.-J., Zhao, S.-Q., & Peng, X.-Q. (2023). Empirical validation of the information-motivation-behavioral skills model of gestational weight management behavior: A framework for intervention. *BMC Public Health*, *23*(1), 130. https://doi.org/10.1186/s12889-023-15067-2

Yu, Z., Gao, M., & Wang, L. (2020). The Effect of Educational Games on Learning Outcomes, Student Motivation, Engagement and Satisfaction. *Journal of Educational Computing Research*, *59*(3), 522–546. https://doi.org/10.1177/0735633120969214

Yulina, S., & Hajar, D. (2017). *Kids Menu Care: An Application for Food Menu Scheduling with Caloric Balance*. 253–257. https://doi.org/10.1145/3176653.3176732

Yusoff, A., Crowder, R., Gilbert, L., & Wills, G. (2009). A Conceptual Framework for Serious Games. *2009 Ninth IEEE International Conference on Advanced Learning Technologies*, 21–23. https://doi.org/10.1109/ICALT.2009.19

Zainuddin, A. A., Manickam, M. A., Baharudin, A., Omar, A., Cheong, S. M., Ambak, R., Ahmad, M. H., & Ghaffar, S. A. (2014). Self-Perception of Body Weight Status and Weight Control Practices Among Adolescents in Malaysia. *Asia Pacific Journal of Public Health*, *26*(5_suppl), 18S-26S. https://doi.org/10.1177/1010539514542422

Zufri, T., Hilman, D., & Pratama, W. (2016). Character design as bridging tools of ideological message in game. *2016 1st International Conference on Game, Game Art, and Gamification (ICGGAG)*, 1–4. https://doi.org/10.1109/ICGGAG.2016.8052646

Zyda, M. (2005). From visual simulation to virtual reality to games. *Computer*, *38*(9), 25–32. https://doi.org/10.1109/MC.2005.297

APPENDICES

APPENDIX 1

Instrument for Expert Interviews (Preliminary Study)

Instrument for Preliminary Study

Part A: Expert's Demographic Information

1. Explain roughly about your profession as a Dietician?
2. How many years of experience/ practice being a Dietician?
3. What is your expertise?
4. What is your highest academic qualification?

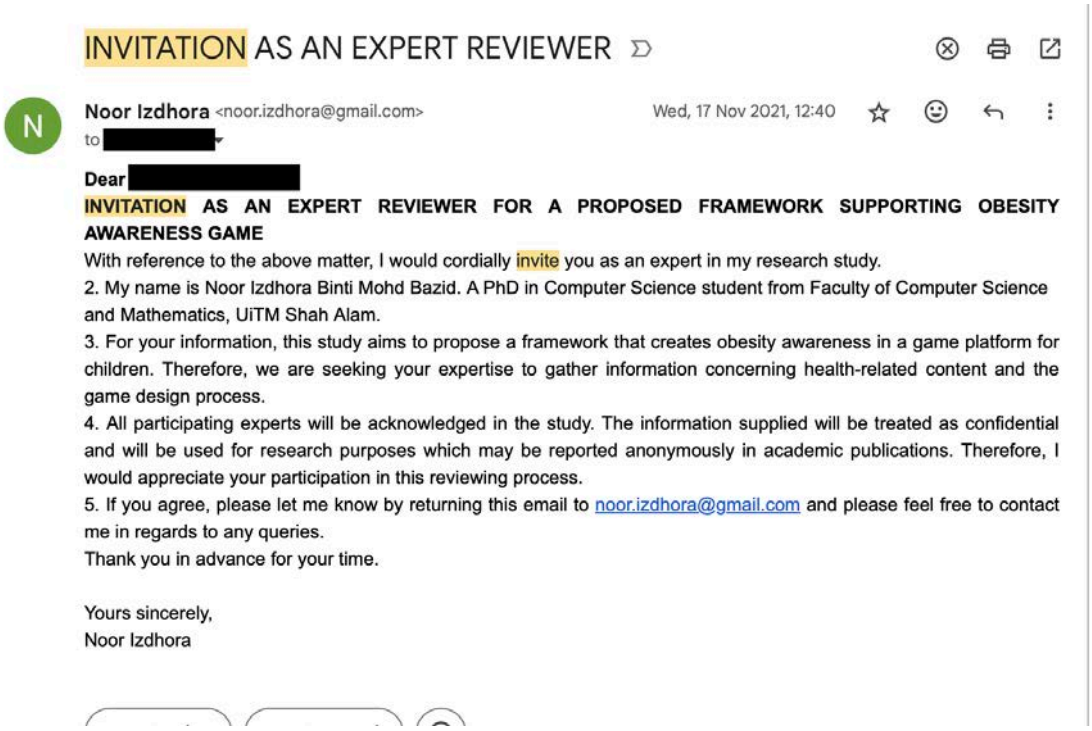
Part B: About Obesity and Health Issues

1. Causes and consequences for being obese.
    a. What is the reason for one being obese?
    b. What are the consequences of being obese?
2. Common treatment/ methods and measurement equipment for people with obesity
    a. What is the common treatment for people being obese?
    b. What is the common/ reliable measurement on measuring one's weight?
3. Previous experience/ research/ program on obesity
    a. What is your previous experience or research study or programs that are related to obesity?
    b. What is your known research study or program that are related to obesity?
4. Awareness in obesity
    a. What is the kind of program about obesity awareness involved?
    b. Does the program on obesity awareness in Malaysia enough/ gives impact to public?
    c. What need to be done to improve/ educate awareness in obesity among the public?
5. Technological advancement in creating awareness on obesity
    a. How can technology help in creating public awareness about obesity?
6. Content to create awareness in obesity (for children)
    a. What is the content needed in providing awareness in obesity?
    b. How do we include information regarding obesity and public awareness?

THANK YOU

APPENDIX 2

Invitation Email for Expert Review



INVITATION AS AN EXPERT REVIEWER

Noor Izdhora <noor.izdhora@gmail.com> Wed, 17 Nov 2021, 12:40

to [redacted]

Dear [redacted]

INVITATION AS AN EXPERT REVIEWER FOR A PROPOSED FRAMEWORK SUPPORTING OBESITY AWARENESS GAME

With reference to the above matter, I would cordially invite you as an expert in my research study.

2. My name is Noor Izdhora Binti Mohd Bazid. A PhD in Computer Science student from Faculty of Computer Science and Mathematics, UiTM Shah Alam.

3. For your information, this study aims to propose a framework that creates obesity awareness in a game platform for children. Therefore, we are seeking your expertise to gather information concerning health-related content and the game design process.

4. All participating experts will be acknowledged in the study. The information supplied will be treated as confidential and will be used for research purposes which may be reported anonymously in academic publications. Therefore, I would appreciate your participation in this reviewing process.

5. If you agree, please let me know by returning this email to noor.izdhora@gmail.com and please feel free to contact me in regards to any queries.

Thank you in advance for your time.

Yours sincerely,
Noor Izdhora

APPENDIX 3

Letter of Data Request for Expert Review

www.uitm.edu.my

UNIVERSITI TEKNOLOGI MARA | Fakulti Sains Komputer dan Matematik

Surat Kami : 100-FSKM(AKA.30/7) PG
Tarikh : 11 April 2022

KEPADA SESIAPA YANG BERKENAAN

Tuan/Puan

MEMOHON KEBENARAN MENDAPATKAN DATA

NAMA PELAJAR	:	**NOOR IZDHORA BINTI MOHD BAZID**
NO. PELAJAR	:	**2017794475**
NAMA PROGRAM	:	**CS950 - DOKTOR FALSAFAH (SAINS KOMPUTER)**
TAJUK PROJEK	:	***"A CONCEPTUAL FRAMEWORK SUPPORTING OBESITY AWARENESS IN SERIOUS GAME"***

Dengan segala hormatnya perkara di atas dirujuk.

2. Dengan ini disahkan bahawa penama di atas adalah pelajar program Doktor Falsafah (Sains Komputer) (CS950), Fakulti Sains Komputer dan Matematik, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia. Fakulti mengesahkan bahawa projek penyelidikan ini adalah bertujuan akademik semata-mata. Projek ini tiada sebarang tajaan, tidak mendapat mana-mana geran dan bukan projek konsultasi.

3. Sekiranya mempunyai sebarang pertanyaan, pihak tuan/puan boleh menghubungi **Noor Izdhora Binti Mohd Bazid** ditalian telefon: 019-4414070 atau emel: noor.izdhora@gmail.com.

Perhatian dan kerjasama pihak tuan/puan amat dihargai dan diucapkan berbanyak terima kasih.

Sekian.

"PRIHATIN RAKYAT: DARURAT MEMERANGI COVID-19"
"BERKHIDMAT UNTUK NEGARA"

Yang benar

DR SOFIANITA MUTALIB
Ketua Pusat Pengajian (Siswazah)

Azlin2021

Fakulti Sains Komputer dan Matematik
Universiti Teknologi MARA
40450 Shah Alam, Selangor, MALAYSIA
Tel: (+603) 5543 5329/5324/5304/5497/5396
Faks: (+603) 5543 5501
E-mel: *dekan@fskm.uitm.edu.my*

ISO 9001:2015 No. Sijil: 10120156

UiTM di hatiku

APPENDIX 4

Letter of Appointment for Expert Review

Fakulti
Sains Komputer
Dan Matematik

[redacted]
Senior Lecturer
Universiti Pendidikan Sultan Idris (UPSI)
35900 Tanjong Malim, Perak
MALAYSIA

YBhg. Tan Sri/Dato'/Datin/Prof./Dr.,

APPOINTMENT AS AN EXPERT REVIEWER FOR A PROPOSED FRAMEWORK SUPPORTING OBESITY AWARENESS IN SERIOUS GAME

Thank you for agreeing to involve as an expert reviewer in a doctoral study of this following student. Below are the details:

Student Name:	**Noor Izdhora Binti Mohd Bazid**
Student ID:	**2017794475**
Faculty:	**Faculty of Computer Science & Mathematics, University Teknologi MARA, Malaysia (UiTM)**
Research Title:	**A Conceptual Framework Supporting Obesity Awareness in Serious Game**
Main Supervisor:	**Dr Suzana Ahmad**
Co-Supervisors:	**Dr Norizan Mat Diah & Dr Siti Sabariah Buhari**

2. For your information, the student will use the framework for her research study and therefore need your expertise to review the proposed framework as stated in the reviewing form. The attached documents are as follow:

I. instrument01 – *Information document consists of demographic and research work explanation*
II. instrument02 – *Questionnaire document*
III. instrument03 – *The proposed framework document*

3. Kindly review and return the attached document(s) at your earliest convenience, preferably within two weeks' time. Your cooperation, time, and assistance are greatly appreciated.

Thank you.

Yours sincerely,

Suzana Ahmad

Dr Suzana Ahmad
Senior Lecturer
Faculty of Computer Science & Mathematics
Universiti Teknologi MARA Shah Alam
MALAYSIA

Fakulti Sains Komputer dan Matematik
Universiti Teknologi MARA
40450 Shah Alam, Selangor, MALAYSIA
Tel: (+603) 5543 5329/5324/5304/5497/5396
Faks: (+603) 5543 5501
E-mel: *dekan@fskm.uitm.edu.my*

APPENDIX 5

Approval letter from Ethics Committee (Expert Review)

www.uitm.edu.my

UNIVERSITI TEKNOLOGI MARA

Pejabat
Timbalan Naib Canselor
(Penyelidikan dan Inovasi)

Reference : 600-TNCPI(5/1/6)
Our reference : REC/12/2021 (MR/1117)
Date : 13 April 2022

Dr Suzana Ahmad
(Noor Izdhora binti Mohd Bazid - 2017794475)
Faculty of Computer and Mathematical Sciences
Universiti Teknologi MARA
40450 Shah Alam
SELANGOR

Dear Dr Suzana,

APPROVAL LETTER - UiTM RESEARCH ETHICS COMMITTEE

Thank you for submitting your research proposal to the Research Ethics Committee (REC). After considering your application, the Committee approved your proposal titled "Framework Supporting Obesity Knowledge Awareness Game" at the Faculty of Computer and Mathematical Sciences, UiTM.

Details of the approval are as follows:

Ref. number:	REC/12/2021 (MR/1117)
Approval Period:	13 April 2022 until 31 December 2022
Authorised personnel:	1. Dr Suzana Ahmad 2. Dr Norizan Mat Diah 3. Dr Siti Sabariah Buhari 4. Noor Izdhora binti Mohd Bazid

The UiTM Research Ethics Committee operates in accordance to the ICH Good Clinical Practice Guidelines, Malaysian Good Clinical Practice Guidelines and the Declaration of Helsinki. The approval of this project is conditional upon your continuing compliance with these guidelines and declaration.

We draw to your attention the requirement that a report on this research, must be submitted every 12 months from the date of the approval or on the completion of the project, whichever occurs first. Failure to submit reports will result in withdrawal of consent for the project to proceed. Amendments, if any, to the study documents are to be submitted to the REC for approval.

If you require further information, please contact the REC Secretariat at 03-55448069/03-55442794 or email at recsecretariat@uitm.edu.my.

Yours sincerely,

EMERITUS PROFESSOR DATO' DR RAYMOND AZMAN ALI
Chairman
UiTM Research Ethics Committee

c.c.: Dean, Faculty of Computer and Mathematical Sciences, UiTM

Universiti Teknologi MARA
Aras 3, Bangunan Wawasan
40450 Shah Alam, Selangor, MALAYSIA
Tel: (+603) 5544 2004/2255
Faks: (+603) 5544 2070

ISO 9001:2015 No. Sijil: 10120156

UiTM di hatiku

APPENDIX 6

Checklist Evaluation Review for Expert Review

Instrument for Expert Consultation (Evaluation Review)

Document No: 02	**EXPERT REVIEW:** **A CONCEPTUAL FRAMEWORK SUPPORTING OBESITY AWARENESS IN SERIOUS GAME** FACULTY OF COMPUTER AND MATHEMATICAL SCIENCES UNIVERSITI TEKNOLOGI MARA (UiTM)

Based on the proposed framework (as presented in the given attachment – *Document No:03*), please tick (√) the choice according to your perception and understanding.

INFORMATION					
GAME CONTEXT					
Components	**Description**	**Disagree**	**Uncertain**	**Agree**	**Comment (if any)**
Purpose	*-To foster obesity awareness among children.* *-To underscore the significance of healthy dietary habits and engaging in physical activities as pivotal elements for sustaining a healthful lifestyle.*				
→Aim	*-To educate players regarding the criticality and repercussions of maintaining a balanced diet and participating in physical exercises.*				
→Impact	*-Facilitation of player comprehension and assimilation of game content aimed at cultivating obesity awareness.* *-Encouragement of behavioural modification among players.*				
Contents	*-Dissemination of information, factual data, and insights concerning healthy and unhealthy dietary patterns.* *-Examination of sedentary versus active lifestyles.* *-Comprehensive coverage of topics pertinent to maintaining health, encompassing dietary choices and physical activity.* *-Integration of information focused on the core components of weight management and wellness: food consumption and physical exertion.*				
Game elements	*-Incorporation of game elements within the game context, such as goals, challenges, and progression.*				
→Components	*-Points, Quests (Goals), Avatar/ Character, Achievement*				
→Mechanics	*-Challenges, Feedback, Win states, Rewards*				
→Dynamics	*-Constraints, Progression*				
Narrative	*-Game environment characterized by both indoor and outdoor settings, featuring scenarios delineating healthy and unhealthy dietary habits*				

	alongside physical activity engagement. *-Player choice extends to the selection of a male or female child character.*				
Aesthetic	*-Integration of upbeat, cheerful background music to enhance gameplay ambiance.* *-Utilization of sound effects to reinforce reward mechanisms and provide feedback cues.* *-Visual representation characterized by cartoon-style graphics, encompassing backgrounds, objects, and characters, designed to captivate player engagement.*				

MOTIVATION				
Description	**Disagree**	**Uncertain**	**Agree**	**Comment (if any)**
-Presentation of information pertaining to obesity awareness serves as a catalyst for fostering motivation toward the initiation and sustained adherence to intended behavioural changes. *-Exemplary behavioural changes may include the adoption of practices such as increased consumption of fruits and vegetables, reduction in sugar intake, or engagement in outdoor walking.*				
SELF-EFFICACY				
Description	**Disagree**	**Uncertain**	**Agree**	**Comment (if any)**
-Individuals who are adequately informed and motivated, as facilitated by game participation, demonstrate enhanced efficacy in implementing behavioural modifications effectively.				
OUTCOMES				
Description	**Disagree**	**Uncertain**	**Agree**	**Comment (if any)**
-Integration of obesity awareness information within the game framework facilitates cognitive and behavioural transformations. *-By imparting knowledge and instilling motivation, the game empowers players to embark upon and sustain a health-oriented lifestyle characterized by prudent dietary choices and regular physical activity.*				

1) The connections and flows of all components are logical. Yes ☐ No ☐
2) The proposed framework is usable for designing and implementing a serious game in obesity awareness. Yes ☐ No ☐
3) Overall, the proposed framework is readable. Yes ☐ No ☐

4) Please write your further comments below:

Key words – learning content, perceptions, understanding, important, necessary, utilized, suffice

ADDITIONAL QUESTIONS

The questions are related to Learning Content in the proposed framework. Based on your perceptions and understandings, please comment:

Learning content

Purpose:

1) Does the integration of learning content and other elements important and necessary in designing and developing framework for obesity awareness game?

2) Does the implementation of learning content in mobile technology application environment important and necessary in designing and developing framework for obesity awareness game?

3) Does all integral elements including the learning content suitable/ relevant in designing and developing framework for obesity awareness game?

4) In your opinion, does all the integral elements in the proposed framework able to initiate/ maintain player's perceived behaviour-change?

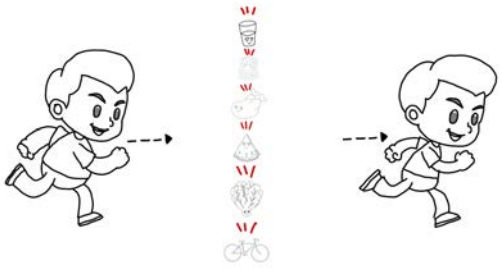
5) In your opinion, does the learning content in game implementation could evoke player's obesity awareness?

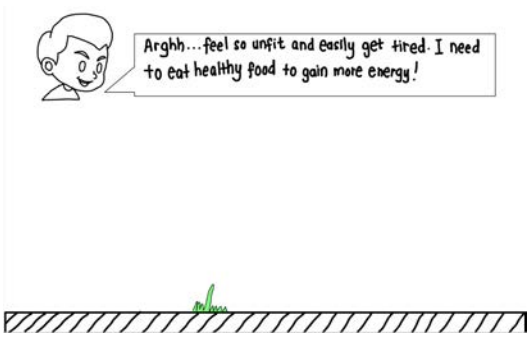
General comments/ Recommendations:

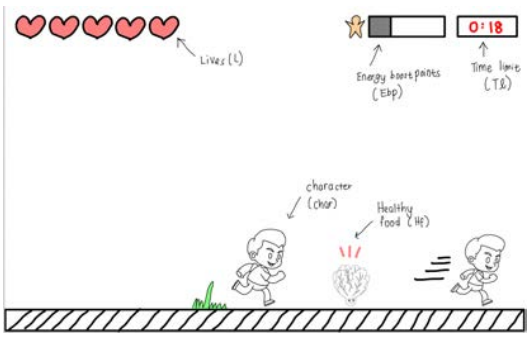
End of Questions. Thank you.

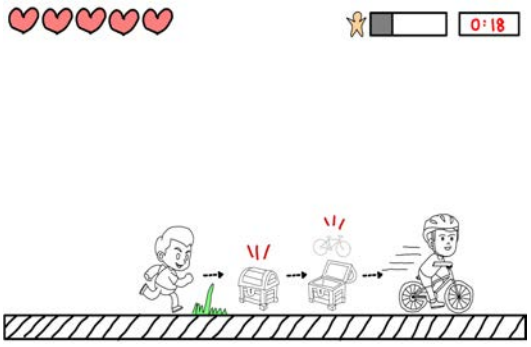
APPENDIX 7

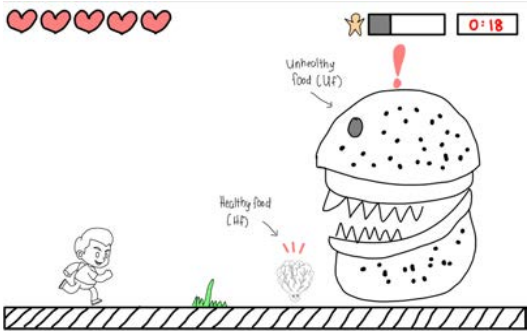
Screenshots of Rough Sketches

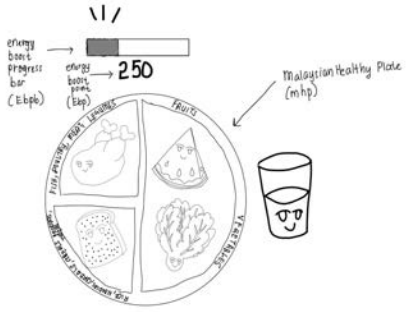












APPENDIX 8

Invitation Email for Stoyboard Review

Subject: INVITATION AS AN EXPERT REVIEWER

[redacted]

Dear [redacted]

INVITATION AS AN EXPERT REVIEWER FOR AN OBESITY AWARENESS GAME STORYBOARD EVALUATION

With reference to the above matter, I would cordially invite you as an expert in my research study.

2. My name is Noor Izdhora Binti Mohd Bazid. A PhD in Computer Science student from Faculty of Computer Science and Mathematics, UiTM Shah Alam.

3. For your information, one of the objective of my study is to validate a conceptual framework supporting obesity awareness in serious game for children. Therefore, we are seeking your expertise to gather information concerning the storyboard created based on the conceptual framework developed previously. The storyboard evaluation will be based on health-related content and the game design elements.

4. All participating experts will be acknowledged in the study. The information supplied will be treated as confidential and will be used for research purposes which may be reported anonymously in academic publications. Therefore, I would appreciate your participation in this reviewing process.

5. If you agree, please let me know by returning this email to noor.izdhora@gmail.com and please feel free to contact me in regards to any queries.
Thank you in advance for your time.

Yours sincerely,
Noor Izdhora

APPENDIX 9

Letter of Appointment for Storyboard Review

Fakulti
Sains Komputer
Dan Matematik

[redacted]
Nutritionist [redacted]
Klinik Kesihatan Telok Panglima Garang,
42500 Telok Panglima Garang, Selangor
MALAYSIA

YBhg. Tan Sri/Dato'/Datin/Prof./Dr.,

APPOINTMENT AS AN EXPERT REVIEWER FOR AN OBESITY AWARENESS GAME STORYBOARD GAME EVALUATION

Thank you for agreeing to involve as an expert reviewer in a doctoral study of this following student. Below are the details:

Student Name:	**Noor Izdhora Binti Mohd Bazid**
Student ID:	**2017794475**
Faculty:	**Faculty of Computer Science & Mathematics, Universiti Teknologi MARA, Malaysia (UiTM)**
Research Title:	**A Conceptual Framework Supporting Obesity Awareness in Serious Game**
Main Supervisor:	**Dr Suzana Ahmad**
Co-Supervisors:	**Dr Norizan Mat Diah & Dr Siti Sabariah Buhari**

2. For your information, the student will use the storyboard as a guideline to develop a game prototype for her research study and therefore need your expertise to evaluate the storyboard game as stated in the evaluation form. The attached documents are as follow:

I. **DOC1_CHECKLISTS.doc** – The checklist and evaluation form for obesity awareness game storyboard (to be filled by the experts)
II. **DOC2_STORYBOARD.pdf** – Labels with descriptions and a walkthrough of the gameplay in storyboard interfaces (expert's reference)
III. **DOC3_DESCRIPTION.pdf** – List of game elements involved in the design of storyboard with the descriptions (expert's reference)
IV. **DOC4_FORM.doc** – Demographic information and overall comment after evaluation (to be filled by the experts)

3. Kindly review and return the attached document(s) at your earliest convenience, preferably within two weeks' time. Your cooperation, time, and assistance are greatly appreciated.

Thank you.

Yours sincerely,

Suzana Ahmad

Dr Suzana Ahmad
Senior Lecturer
Faculty of Computer Science & Mathematics
Universiti Teknologi MARA Shah Alam
MALAYSIA

Fakulti Sains Komputer dan Matematik
Universiti Teknologi MARA
40450 Shah Alam, Selangor, MALAYSIA
Tel: (+603) 5543 5329/5324/5304/5497/5396
Faks: (+603) 5543 5501
E-mel: *dekan@fskm.uitm.edu.my*

APPENDIX 10

Checklist Evaluation Review for Storyboard Review

Document No: 01	**EXPERT REVIEW:** **OBESITY AWARENESS GAME STORYBOARD EVALUATION** FACULTY OF COMPUTER AND MATHEMATICAL SCIENCES UNIVERSITI TEKNOLOGI MARA (UiTM)

Dear YBhg. Tan Sri/Dato'/Datin/Prof./Dr.,

I am currently doing research titled ***"A Conceptual Framework Supporting Obesity Awareness in Serious Game"*** as my Postgraduate Doctoral study requirement.

One of the objective of this study is to test the conceptual framework supporting obesity awareness in a prototype serious game. Hence, the main purpose of this storyboard evaluation is to determine whether the game elements in the conceptual framework proposed were suitable to be implemented in the game prototype.

A brief overview of this game is detailed as follows:-

Target user of the game	6 to 18 years old
Primary genre	Adventure – Platform game
Name of the game	Healthy Land
Storyline	A boy character is in a Healthy Land. He wants to get fit and healthy. Thus, he needs to eat healthy food and perform physical activities in order to achieve the goals.
Goal of the game	To get as many points as possible to get fit and healthy through collecting the healthy food and performing physical activity (ride a bicycle) and to avoid the fast-food enemies. The ultimate goal is to get fit and be healthy.

In this document is the checklist of storyboard interfaces and checklist of game elements involved. For each of the following items, please give feedback whether you agree or disagree with the design of game elements in the storyboard interfaces. If you choose to agree or disagree, we would be very pleased if you can provide us with the reasoning behind your choices in the *comment* section.

*You can refer to the full list of game elements with the descriptions in the file named: ***DOC3_DESCRIPTION.docx*** and a walkthrough of the gameplay with full list of labels and the descriptions in the file named: ***DOC2_STORYBOARD.docx.***

Here is an example of performing the checklist of storyboard evaluation:

MAIN SCREEN					
Label	**Game Elements**	**Description**	**Agree**	**Disagree**	**Comment**
Mhp	Aesthetic, Narrative content, Feedbacks	Mhp is Malaysian Healthy Plate based on a "Quarter-Quarter-Half" by the Malaysia Health Ministry. It is a consumption of a quarter plate of grains; a quarter of proteins; and half a plate of fruits and vegatables. Plain water is also suggested to replace the intake of sugary drinks.	√		

Please refer to file named: ***DOC2_STORYBOARD.docx***

Please refer to file named: ***DOC3_DESCRIPTION.docx***

Thank you for spending your valuable time completing this "**Obesity Awareness Game Storyboard Evaluation**". Your input is important and will contribute to the success of the study. If there is any enquiry, do not hesitate to contact me at (noor.izdhora@gmail.com and 019-4414070).

Thank you.

Researcher:
Noor Izdhora Binti Mohd Bazid
Faculty of Computer Science & Mathematics
Universiti Teknologi MARA Shah Alam
MALAYSIA
[redacted]
noor.izdhora@gmail.com

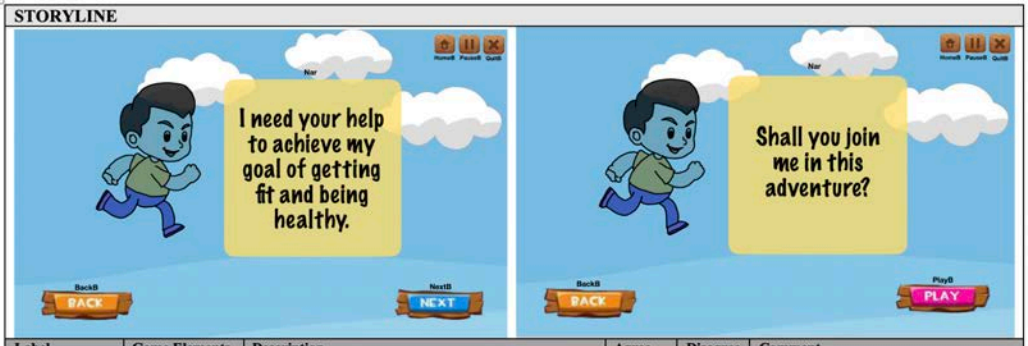
Supervisor:
Dr Suzana Ahmad
Dr Norizan Mat Diah
Dr Siti Sabariah Buhari

Table below shows the storyboard interfaces and checklist of game elements involved:-

MAIN SCREEN

Label	Game Elements	Description	Agree	Disagree	Comment
Ms	Aesthetic	The main screen shows the title of the game "Healthy Land" with image of the character running from a big-sized character image to a fit, thinner looking sized character. The background also includes images of healthy and unhealthy foods such as lettuce, watermelon, chicken, bread, burger and coke can. These objects will be the main objects of this gameplay.			

STORYLINE



Label	Game Elements	Description	Agree	Disagree	Comment
Nar	Narrative, Content, Goals (Aim)	The storyline will be presented in words that tells the player about the narrative of the game. The narrative is that the character is in a "Healthy Land" and the character is required to eat healthy foods and perform physical activities to get fit. The character also requested the player to join the adventure with him.			

LEVEL SELECTION SCREEN

Label	Game Elements	Description	Agree	Disagree	Comment
Lvl	Levels, Goals (Aim)	There will be a number of levels in the **LEVEL SELECTION SCREEN**. The level will be unlocked each time the player has reached certain benchmark for every level he/she plays.			

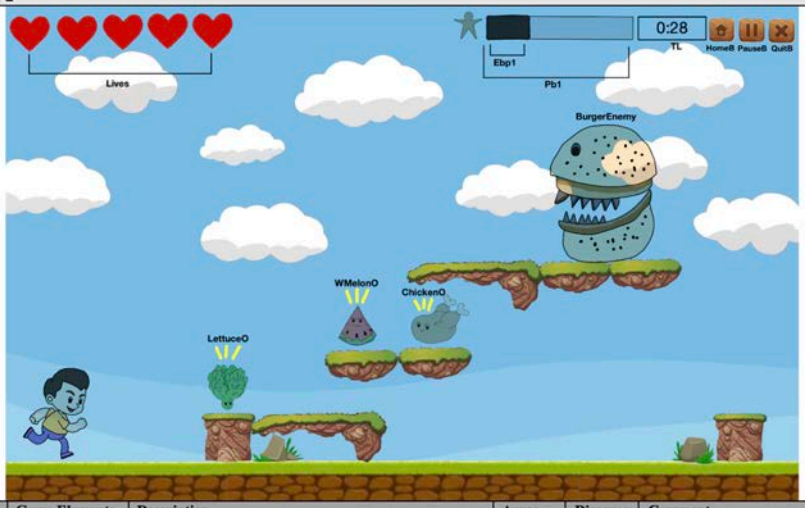
INITIAL SCREEN

Label	Game Elements	Description	Agree	Disagree	Comment
NarMsg1	Narrative, Content, Goals (Aim), Rules, Feedbacks	This bubble message will be pop out at the top of the interface in the **INITIAL SCREEN.** An image of the character with information and messages will appear. The information is about the short term goal of the particular level that the player is currently playing. It informs the player about the requirement to collect the *Energy boost points* that is the healthy foods and treasure chest. It will also reminds the player about the obstacle that he/she will encounter throughout the game. The bubble message will also includes motivational words to motivate the player before playing the game.			

INTERFACE 1

Label	Game Elements	Description	Agree	Disagree	Comment
CharBig	Character	The character is a big-sized male character. It will appear at the start of the game which is in the 1st level.			
CharFit	Character	The character will change to a thin, fit-sized male character when the player collects the *Energy boost points* throughout the game.			
Lives	Goals (Aim)	The heart-shaped icon represents the character's lives. The default lives given for the game is 5 lives. The lives will decreases or be removed 1 lives each time the player failed to defeats the fast-food enemy (burger and coke can) or static obstacles.			
Pb1	Goals (Aim), Rewards	Progress bar shows the progress of the *Energy boost points* collected by the player.			
Ebp1	Goals (Aim), Rewards	*Energy boost points* are points collected throughout the game played. The points included are healthy food objects and a treasure chest which contained a bicycle. Below shows the *Energy boost point* objects that the player needs to collect:- 1- Lettuce – Represents a Vegetable category in a Mhp (Malaysian Healthy Plate) by the Malaysia Healthy Ministry. 2- Watermelon – Represents a Fruit category in a Mhp (Malaysian Healthy Plate) by the Malaysia Healthy Ministry. 3- Chicken – Represents a Protein category in a Mhp (Malaysian Healthy Plate) by the Malaysia Healthy Ministry. 4- Bread – Represents a Whole Grain category in a Mhp (Malaysian Healthy Plate) by the Malaysia Healthy Ministry. 5- Water – Represents water drinking intake recommended by the Malaysia Health Ministry. 6- Bicycle in a treasure chest – Represents performing physical activities for active lifestyle.			
TL	Time limit (Constraints)	The time limit to play the game for each level varies as the level progresses. The time limit is longer as the level progresses.			
LettuceO	Goals (Aim), Rewards	Lettuce is an object that requires the player to collect as *Energy boost points* in the game. It represents a Vegetable category in a Mhp (Malaysian Healthy Plate) by the Malaysia Healthy Ministry.			

INTERFACE 2



Label	Game Elements	Description	Agree	Disagree	Comment
WMelonO	Goals (Aim), Rewards	Watermelon is an object that requires the player to collect as *Energy boost points* in the game. It represents a Fruit category in a Mhp (Malaysian Healthy Plate) by the Malaysia Healthy Ministry.			
ChickenO	Goals (Aim), Rewards	Chicken is an object that requires the player to collect as *Energy boost points* in the game. It represents a Protein category in a Mhp (Malaysian Healthy Plate) by the Malaysia Healthy Ministry.			
BurgerEnemy	Challenge	A big-sized burger is the obstacle in this game. It represents a fast food enemy. The player needs to jump over and avoid the Burger enemy in order to retain his/her Lives.			

INTERFACE 3

Label	Game Elements	Description	Agree	Disagree	Comment
BreadO	Goals (Aim), Rewards	Bread is an object that requires the player to collect as *Energy boost points* in the game. It represents a Whole Grain category in a Mhp (Malaysian Healthy Plate) by the Malaysia Healthy Ministry.			
WaterO	Goals (Aim), Rewards	Water in a glass is an object that requires the player to collect as *Energy boost points* in the game. It represents water drinking intake recommended by the Malaysia Health Ministry.			
CokeEnemy	Challenge	A big-sized coke can is the obstacle in this game. It represents a fast food enemy. The player needs to jump over and avoid the Coke can enemy in order to retain his/her Lives.			

INTERFACE 4

Label	Game Elements	Description	Agree	Disagree	Comment
TC	Goals (Aim), Rewards	A treasure chest needs to be collected by the player in order to get extra *Energy boost points.* Once opened, a bicycle will appears. The bicycle represents performing physical activities for healthy and active lifestyle			
TCBicycle	Goals (Aim), Rewards	Bicycle in a treasure chest. The bicycle is an object that requires the player to collect as *Energy boost points* in the game. It represents performing physical activities for healthy and active lifestyle.			
CharRide	Character, Narrative, Content	Once the treasure chest is opened and the bicycle has been retrieved, the character will be riding the bicycle and the speed/ pace is faster.			

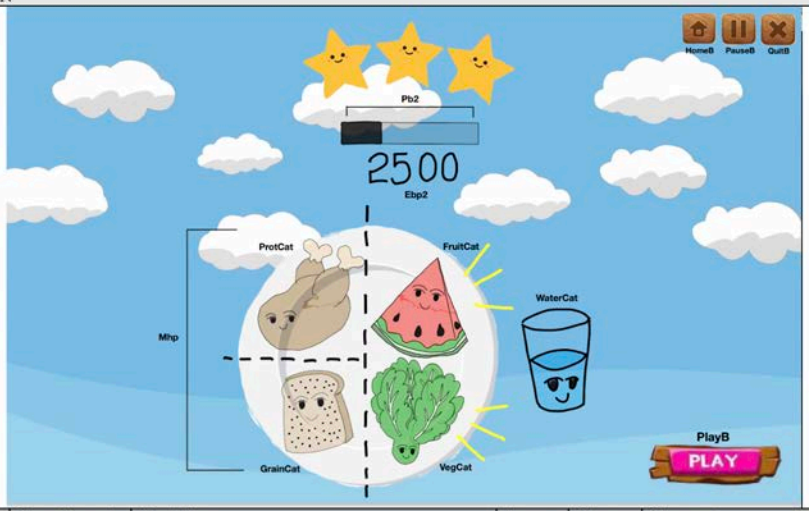
INTERFACE 5

Label	Game Elements	Description	Agree	Disagree	Comment
FlagP	Goals (Aim)	The flag is at the end of each game level. The goal is for the player to play and move the character until it reaches the final point (flag point).			

FINAL SCREEN

Label	Game Elements	Description	Agree	Disagree	Comment
NarMsg2	Narrative, Content, Goals (Aim), Rules, Feedbacks	This bubble message will be pop out at the top of the interface in the **FINAL SCREEN** when the player has reach the final point. An image of the character with motivational words will appear to encourage the player to improve his/her healthy lifestyle through healthy eating and performing physical activities.			

END SCREEN



Label	Game Elements	Description	Agree	Disagree	Comment
Pb2	Goals (Aim), Rewards	Progress bar shows the progress of the *Energy boost points* collected by the player.			
Ebp2	Goals (Aim), Rewards	The final *Energy boost points* is shown. This is points collected throughout the game played in each level. The points included are healthy food objects and a treasure chest which contained a bicycle.			

APPENDIX 11

Subject Information Sheet and Consent Form

REC 4 / 2020/BM Pind. 2(2020)

Research Ethics Committee
Research Management Centre
Universiti Teknologi MARA
40450 SHAH ALAM
Tel: 03-5544-8069, Faks: 03-5544-2096/2767

Subject Information Sheet

Research Title
A Conceptual Framework Supporting Obesity Awareness in Serious Game

Introduction of Research
The high number of people being obese in Malaysia shows lack of awareness among the public about the issue of obesity. Various programs and campaigns related to obesity health awareness have been implied by the government, private sectors and non-governmental organization (NGO) for the public including for school children. However, these do not deter the increasing number of people being obese in Malaysia. Hence, a game design framework supporting obesity knowledge awareness in serious game is designed and developed. Thus, the framework is then integrated in a game application for children.

Purpose of Research
1. To determine the suitable and most common game elements in serious games that support obesity awareness. 2. To construct a conceptual framework supporting obesity awareness in serious game. 3. To validate the conceptual framework supporting obesity awareness in serious game. 4. To measure the effectiveness of the game prototype based on the conceptual framework supporting obesity awareness in serious game.

Research Procedure
This research study will involve your children to play a game application designed to raise awareness in obesity. If you have given the consent to allow your child to be involved in this experiment, the procedure is as follows: 1. Your child will be briefed by the researchers in a group of participants at a school computer lab. 2. Your child will be playing the game application installed in smartphone/ desktop/ laptop provided by the researchers. 3. Once your child has done playing the game, s(he) will be given a questionnaire to be completed. 4. Next, the researchers will assist and ask your child to answer a few questions. 5. Debrief your child and other participants. 6. The researchers will distribute token of appreciation to your child once the study experiment has ended.

Participation in Research
Your child's participation in this research is entirely voluntary. Your child may refuse to take part in the study or withdraw him/her-self from participation in the research at any time without penalty.

Benefit of Research
Information obtained from this research will benefit the individuals, researchers, institution and community for the advancement of knowledge and future practice.

Research Risk
Your child is free to withdraw from the research study. If you are concerned about your child's responses or if you find your child's participation in the research study distressing, you should contact the researchers as soon as possible. We will discuss your concerns with you confidentially and suggest appropriate follow-up, if necessary. Participation in this research is entirely voluntary and anonymous; you may withdraw your child's participation and any identifiable data at any time, without prejudice.

Confidentiality

Your child's information will be kept confidential by the researchers and will not be made public unless disclosure is required by law. By signing this consent form, you will authorize the review of your child's records, analysis and use of the data arising from this research. If you have any question about this research or your rights, please contact Noor Izdhora at phone number: 019-4414070 or email: noor.izdhora@gmail.com

Consent Form[1]

To become a subject in the research, you or your legal guardian are required to sign this Consent Form
I herewith confirm that I have met the requirement of age and am capable of acting on behalf of myself / as
2 a legal guardian as follow:

1. I understand the nature and scope of the research being undertaken.
2. I have read and understood all the terms and conditions of my participation in the research.
3. All my questions relating to this research and my participation therein have been answered to my satisfaction.
4. I voluntarily agree to take part in this research, to follow the study procedures and to provide all necessary information to the investigators as requested.
5. I may at any time choose to withdraw from this research without giving any reason.
6. I have received a copy of the Subjects Information Sheet and Consent Form.
7. Except for damages resulting from negligent or malicious conduct of the researcher(s), I hereby release and discharge UiTM and all participating researchers from all liability associated with, arising out of, or related to my participation. I agree to hold them harmless from any harm or loss that may be incurred by me due to my participation in the research.

Name of Subject/Legally authorized representative (LAR)	Signature
I.C No	Date
Name of Witness[3]	Signature
I.C No	Date
Name of Consent Taker	Signature
I.C No	Date

[1] Original signed copy is to be retained by the Principal Investigator.
[2] Delete whichever is not applicable.
[3] A witness is only required for oral consent.

Name of Subject/Legally authorized representative (LAR)	Signature
I.C No	Date
Name of Witness[3]	Signature
I.C No	Date
Name of Consent Taker	Signature
I.C No	Date

[1] Original signed copy is to be retained by the Principal Investigator.
[2] Delete whichever is not applicable.
[3] A witness is only required for oral consent.

APPENDIX 12

Approval letter from Ethics Committee (Experimental Study)

UNIVERSITI TEKNOLOGI MARA
Pejabat
Timbalan Naib Canselor
(Penyelidikan dan Inovasi)

Reference : 600-TNCPI (5/1/6)
Our reference : REC/04/2023 (PG/MR/121)
Date : 10 April 2023

Dr Suzana binti Ahmad
(Noor Izdhora binti Mohd Bazid – 2017794475)
College of Computing, Informatics and Media
Universiti Teknologi MARA
40450 Shah Alam
SELANGOR

Dear Dr Suzana,

APPROVAL LETTER - UiTM RESEARCH ETHICS COMMITTEE

Thank you for submitting your research proposal to the Research Ethics Committee (REC). After considering your application, the Committee approved your proposal titled "A Conceptual Framework Supporting Obesity Awareness in Serious Game" at SK Sungai Ara, Penang.

Details of the approval are as follows:

Ref. number:	REC/04/2023 (PG/MR/121)
Approval Period:	10 April 2023 until 1 March 2024
Authorised personnel:	1. Dr Suzana binti Ahmad 2. Noor Izdhora binti Mohd Bazid 3. Dr Siti Sabariah binti Buhari 4. Dr Norizan binti Mat Diah

The UiTM Research Ethics Committee operates in accordance to the ICH Good Clinical Practice Guidelines, Malaysian Good Clinical Practice Guidelines and the Declaration of Helsinki. The approval of this project is conditional upon your continuing compliance with these guidelines and declaration.

We draw to your attention the requirement that a report on this research, must be submitted every 12 months from the date of the approval or on the completion of the project, whichever occurs first. Failure to submit reports will result in withdrawal of consent for the project to proceed. Amendments, if any, to the study documents are to be submitted to the REC for approval.

If you require further information, please contact the REC Secretariat at 03-55448069/03-55442794 or email at recsecretariat@uitm.edu.my.

Yours sincerely,

EMERITUS PROFESSOR DATO' DR RAYMOND AZMAN ALI
Chairman
UiTM Research Ethics Committee

c.c.: Dean, Faculty of Accountancy, UiTM

Universiti Teknologi MARA
Aras 3, Bangunan Wawasan
40450 Shah Alam, Selangor, MALAYSIA
Tel: (+603) 5544 2004/2255
Faks: (+603) 5544 2070

APPENDIX 13

Approval letter from Ethics Committee Ministry of Education (MOE) (Experimental Study)

KEMENTERIAN PENDIDIKAN MALAYSIA
BAHAGIAN PERANCANGAN DAN PENYELIDIKAN DASAR PENDIDIKAN
ARAS 1-4, BLOK E8
KOMPLEKS KERAJAAN PARCEL E
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62604 PUTRAJAYA

TEL : 0388846591
FAKS : 0388846579

Ruj. Kami : KPM.600-3/2/3-eras(17543)
Tarikh : 26 September 2023

NOOR IZDHORA BINTI MOHD BAZID
NO. KP : [redacted]

22, JALAN BAYAN MUTIARA 3,
D'RESIDENCE, BAYAN MUTIARA, 11900 BAYAN LEPAS
PULAU PINANG

Tuan,

KELULUSAN BERSYARAT UNTUK MENJALANKAN KAJIAN :
A CONCEPTUAL FRAMEWORK SUPPORTING OBESITY AWARENESS IN SERIOUS GAME

Perkara di atas adalah dirujuk.

2. Sukacita dimaklumkan bahawa permohonan tuan untuk menjalankan kajian seperti di bawah telah diluluskan dengan syarat :

" KELULUSAN DAN PENGUTIPAN DATA TERMASUK SECARA DALAM TALIAN (CONTOH: GOOGLE FORM) PERLU MENDAPATKAN KEBENARAN PENGARAH JPN DAN PERTIMBANGAN PENTADBIR SEKOLAH. PENGUTIPAN DATA MELIBATKAN MURID HENDAKLAH DILAKSANAKAN OLEH DENGAN BANTUAN GURU SEKOLAH BERKENAAN. PIHAK PENTADBIR SEKOLAH PERLU MENELITI KESESUAIAN MODUL YANG DIBANGUNKAN SEBELUM DIGUNAKAN OLEH MURID. "

3. Kelulusan adalah berdasarkan kepada kertas cadangan penyelidikan dan instrumen kajian yang dikemukakan oleh tuan kepada bahagian ini. Walau bagaimanapun kelulusan ini bergantung kepada kebenaran Jabatan Pendidikan Negeri dan Pengetua / Guru Besar yang berkenaan.

4. Surat kelulusan ini sah digunakan bermula dari **2 Oktober 2023** hingga **22 Mac 2024**

5. Tuan dikehendaki menyerahkan senaskhah laporan akhir kajian dalam bentuk *hardcopy* bersama salinan *softcopy* berformat pdf dalam CD kepada Bahagian ini.Tuan juga diingatkan supaya mendapat kebenaran terlebih dahulu daripada Bahagian ini sekiranya sebahagian atau sepenuhnya dapatan kajian tersebut hendak diterbitkan di mana-mana forum, seminar atau diumumkan kepada media massa.

Sekian untuk makluman dan tindakan tuan selanjutnya. Terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

Ketua Penolong Pengarah Kanan
Sektor Penyelidikan dan Penilaian Dasar
b.p. Pengarah
Bahagian Perancangan dan Penyelidikan Dasar Pendidikan
Kementerian Pendidikan Malaysia

salinan kepada:-

JABATAN PENDIDIKAN SELANGOR

* SURAT INI DIJANA OLEH KOMPUTER DAN TIADA TANDATANGAN DIPERLUKAN *

APPENDIX 14

Instrument Adapted from MEEGA+

Questionnaire for quality evaluation of serious game for obesity awareness

Please, help us improve the game by answering the following questions. All information is collected anonymously and will be used only in a summarized way in the context of this game evaluation.

Demographic Information	
Age:	☐ Below 6 years old ☐ 7-12 years old ☐ 13-18 years old
Gender:	☐ Male ☐ Female
How often do you play digital games?	☐ Never ☐ Rarely: from time to time ☐ Monthly: at least once a month ☐ Weekly: at least once a week ☐ Daily: every day

No.	Description	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	The game design is attractive (interface, graphics, sounds, character).					
2	Learning to play this game was easy and straightforward.					
3	The game is easy to control and play.					
4	The fonts (size and style) and colours used in the game are understandable and meaningful.					
5	When I make a mistake, it is easy to recover from it quickly.					
6	When I first looked at the game, I am confident that it is easy to play and I would learn with this game.					

7	The game challenges are appropriate as it progresses without feeling frustrated and boring.					
8	I feel satisfied with the things I learned from the game and after completing the game task.					
9	I would recommend this game to my friends.					
10	I had fun playing the game.					
11	There was something interesting at the beginning of the game that captured my attention.					
12	I feel relaxed and immersed while playing the game.					
13	The game contents are relevant to my interest.					
14	I prefer to learn through playing the game rather than traditional learning methods.					
15	The game contributed to my learning on the importance of healthy food intake and physical movement.					
16	The game allowed me to understand the impact of not eating healthy food and performing physical activities.					

17	The game allowed me to understand the importance of healthy food intake and physical movement.					
18	The game encourages me to eat healthy food and perform physical activities.					

Additional questions (optional)

1. Please tell me any suggestions to improve the game?

   _____
   _____
   _____
   _____

2. Any additional comments on the game?

   _____
   _____
   _____
   _____

Thank You

APPENDIX 15

Letter of Appreciation for Expert Review

UNIVERSITI TEKNOLOGI MARA
Fakulti
Sains Komputer
Dan Matematik

[redacted]
Senior Lecturer
Universiti Pendidikan Sultan Idris (UPSI)
35900 Tanjong Malim, Perak
MALAYSIA

YBhg. Tan Sri/Dato'/Datin/Prof./Dr.,

APPRECIATION FOR YOUR TIME AND EXPERTISE AS AN EXPERT REVIEWER

We would like to thank you for agreeing to involve as an expert reviewer in a doctoral study of this following student, previously. Below are the details:

Student Name:	**Noor Izdhora Binti Mohd Bazid**
Student ID:	**2017794475**
Faculty:	**Faculty of Computer Science & Mathematics, University Teknologi MARA, Malaysia (UiTM)**
Research Title:	**A Conceptual Framework Supporting Obesity Awareness in Serious Game**
Main Supervisor:	**Dr Suzana Ahmad**
Co-Supervisors:	**Dr Norizan Mat Diah & Dr Siti Sabariah Buhari**

2. We are sending our heartfelt appreciation for the time and professional help you have provided. It is with your expertise that we were able to further improve the conceptual framework for the research study. Thank you so much for generously sharing your time and expertise.

Thank you.

Yours sincerely,

SUZANA AHMAD, PhD
Senior Lecturer
Faculty of Computer & Mathematical Sciences
Universiti Teknologi MARA
40450, Shah Alam
Selangor

Dr Suzana Ahmad
Senior Lecturer
Faculty of Computer Science & Mathematics
Universiti Teknologi MARA Shah Alam
MALAYSIA

Fakulti Sains Komputer dan Matematik
Universiti Teknologi MARA
40450 Shah Alam, Selangor, MALAYSIA
Tel: (+603) 5543 5329/5324/5304/5497/5396
Faks: (+603) 5543 5501
E-mel: *dekan@fskm.uitm.edu.my*

APPENDIX 16

Letter of Appreciation for Storyboard Review

www.uitm.edu.my

UNIVERSITI TEKNOLOGI MARA | Fakulti Sains Komputer Dan Matematik

[redacted]
Nutritionist
Klinik Kesihatan Telok Panglima Garang,
42500 Telok Panglima Garang, Selangor.
MALAYSIA

YBhg. Tan Sri/Dato'/Datin/Prof./Dr.,

APPRECIATION FOR YOUR TIME AND EXPERTISE AS AN EXPERT REVIEWER

We would like to thank you for agreeing to involve as an expert reviewer in a doctoral study of this following student. Below are the details:

Student Name:	**Noor Izdhora Binti Mohd Bazid**
Student ID:	**2017794475**
Faculty:	**Faculty of Computer Science & Mathematics, University Teknologi MARA, Malaysia (UiTM)**
Research Title:	**A Conceptual Framework Supporting Obesity Awareness in Serious Game**
Main Supervisor:	**Dr Suzana Ahmad**
Co-Supervisors:	**Dr Norizan Mat Diah & Dr Siti Sabariah Buhari**

2. It is herewith, we attached an emolument receipt as an expert reviewer for verifying content of a game storyboard for the above-mentioned student.

3. We are sending our heartfelt appreciation for the time and professional help you have provided. It is with your expertise that we were able to further improve the game storyboard for the research study. Thank you so much for generously sharing your time and expertise.

Thank you.

Yours sincerely,

SUZANA AHMAD, PhD
Senior Lecturer
Faculty of Computer & Mathematical Sciences
Universiti Teknologi MARA
40450, Shah Alam
Selangor

Dr Suzana Ahmad
Senior Lecturer
Faculty of Computer Science & Mathematics
Universiti Teknologi MARA Shah Alam
MALAYSIA

Fakulti Sains Komputer dan Matematik
Universiti Teknologi MARA
40450 Shah Alam, Selangor, MALAYSIA
Tel: (+603) 5543 5329/5324/5304/5497/5396
Faks: (+603) 5543 5501
E-mel: *dekan@fskm.uitm.edu.my*

ISO 9001:2015 No. Sijil: 10120156
UiTM di hatiku

AUTHOR'S PROFILE

Noor Izdhora Mohd Bazid has completed her PhD in Computer Science at the Faculty of Computer Science and Mathematics, Universiti Teknologi MARA. She has been conferred a Bachelor of Computer Science (Honours) (Multimedia Computing) from Universiti Teknologi MARA, Malaysia and Master of Instructional Multimedia from University Science of Malaysia (USM). Her research interest includes serious game, game design and development, and human-computer interaction (HCI).

LIST OF PUBLICATION:

Mohd Bazid, N. I., Ahmad, S., Mat Diah, N., & Buhari, S. S. (2024). Exploring Common Game Elements in Serious Game Interventions for Health and Obesity Awareness in Children: A Systematic Review. International Journal of Emerging Technologies in Learning (iJET), 19(4), 17–32. https://doi.org/10.3991/ijet.v19i04.48005

Mohd Bazid, N. I., Ahmad, S., & Mat Diah, N. (2022). A Conceptual Framework Supporting Obesity Awareness in Serious Game. The International Journal of Multimedia and Its Application (IJMA), 14(3). https://doi.org/10.5121/ijma.2022.14301

Mohd Bazid, N. I., Mohamed Shaari, N. A., Buhari, S. S., & Abd Rahman, H. (2018, December 11). Creating Awareness in Obesity through Augmented Reality Game for Children: Preliminary Study. International Conference on Creativity, Innovation, & Invention in Digital Technology (CIIDT) USM.