



Faculty of Computer Science and Information Technology

**X-TAM: A Technology Acceptance Model Framework to Engage Users
with Gamified COVID-19 Preventive Measures**

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X-TAM: A Technology Acceptance Model Framework to Engage Users with Gamified
COVID-19 Preventive Measures

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



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ABSTRACT

During the COVID-19 pandemic, various pandemic applications have emerged, including contact tracing, information dissemination, and patient monitoring, to mitigate the spread of the virus. While these initiatives have shown effectiveness in reducing transmission, their success during the endemic phase remains uncertain. Engagement with COVID-19 initiatives has started to wane among individuals, both during and post-pandemic. This study addresses this issue by exploring the potential of gamification to increase users' engagement with COVID-19 initiatives. The research utilizes the Technology Acceptance Model (TAM) as a framework to validate the influence of gamification on users' engagement. By combining TAM with gamification, the study examines the acceptance of a gamified COVID-19 mobile application and its impact on users' engagement with pandemic initiatives. The research specifically focuses on the constructs of gamification perceived usefulness (GPU), gamification perceived ease of use (GEOU), and attitude toward gamification (ATUG), and their relationships with users' engagement. The findings indicate that GPU had the strongest positive impact on users' engagement ($\beta = 0.424$, $p < 0.001$), followed by ATUG ($\beta = 0.358$, $p < 0.001$), while GEOU ($\beta = 0.096$, $p = 0.194$) showed a smaller but positive effect. These results suggest that gamification enhances user motivation and promotes behavioral changes in practicing COVID-19 preventive measures. These findings contribute to a better understanding of how gamification can be effectively employed in mobile applications to promote adherence to pandemic prevention measures, benefiting both current and future pandemic situations.

Keywords: Gamification, technology acceptance model, engagement, COVID-19, mobile app

X-TAM: Rangka Kerja Model Penerimaan Teknologi untuk Melibatkan Pengguna dengan Gamifikasi Langkah-Langkah Pencegahan COVID-19

ABSTRAK

Semasa pandemik COVID-19, pelbagai aplikasi pandemik telah muncul, termasuk pengesanan kenalan, penyebaran maklumat, dan pemantauan pesakit, untuk mengurangkan penyebaran virus. Walaupun inisiatif ini telah menunjukkan keberkesanan dalam mengurangkan penularan, kejayaan mereka semasa fasa endemik masih tidak menentu. Penglibatan dengan inisiatif COVID-19 telah mula berkurangan dalam kalangan individu, semasa dan selepas pandemik. Kajian ini menangani isu ini dengan meneroka potensi gamifikasi untuk meningkatkan penglibatan pengguna dengan inisiatif COVID-19. Penyelidikan menggunakan Model Penerimaan Teknologi (TAM) sebagai rangka kerja untuk mengesahkan pengaruh gamifikasi terhadap penglibatan pengguna. Dengan menggabungkan TAM dengan gamifikasi, kajian ini mengkaji penerimaan aplikasi mudah alih COVID-19 gamified dan kesannya terhadap penglibatan pengguna dengan inisiatif pandemik. Penyelidikan secara khusus memfokuskan pada konstruk gamification perceived usefulness (GPU), gamification perceived ease of use (GEOU), dan sikap terhadap gamification (ATUG), dan hubungannya dengan penglibatan pengguna. Dapatan menunjukkan bahawa GPU mempunyai kesan positif yang paling kuat terhadap penglibatan pengguna ($\beta = 0.424, p < 0.001$), diikuti oleh ATUG ($\beta = 0.358, p < 0.001$), manakala GEOU ($\beta = 0.096, p = 0.194$) menunjukkan lebih kecil tetapi kesan positif. Keputusan ini menunjukkan bahawa gamifikasi meningkatkan motivasi pengguna dan menggalakkan perubahan tingkah laku dalam mengamalkan langkah pencegahan COVID-19. Penemuan ini menyumbang kepada pemahaman yang lebih baik tentang cara gamifikasi boleh digunakan dengan berkesan dalam aplikasi mudah alih untuk menggalakkan pematuhan

kepada langkah pencegahan wabak, yang memanfaatkan kedua-dua situasi pandemik semasa dan masa hadapan.

Kata kunci: *Gamifikasi, model penerimaan teknologi, penglibatan, COVID-19, aplikasi mudah alih*

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LIST OF ABBREVIATIONS

WHO	World Health Organisation
COVID-19	Coronavirus Disease 2019
TAM	Technology Acceptance Model
PU	Perceived Usefulness
PEOU	Perceived Ease of Use
ATT	Attitude Towards Using
BI	Behavioral Intention to Use
TRA	Theory of Reasoned Action
GAM	Gamification Acceptance Model
X-GAM	X-Tended Gamification Acceptance Model
GPU	Gamification Perceived Usefulness
GEOU	Gamification Perceived Ease of Use
ATUG	Attitude towards Using Gamification
UE	Users' engagement
HMSAM	Hedonic – Motivation System Adoption Model
UTAUT	Unified Theory of Acceptance and Use of Technology
ERPsim	Enterprise Resource Planning simulation
TTF	Task Technology Fit
SI	Social Influence
SEM	Structural Equation Modeling
SR	Social Recognition
SPSS	Statistical Package for Social Sciences
AMOS	Analysis of Moment Structures

CFA

Confirmatory Factor Analysis

CHAPTER 1

INTRODUCTION

1.1 Introduction

The COVID-19 pandemic has posed unprecedented challenges to societies worldwide, demanding swift and collective action to mitigate its impact (Tisdell, 2020). Governments, organizations, and communities have rallied to implement various initiatives aimed at combating the virus, such as vaccination campaigns, public health guidelines, and community-driven efforts (Barkia et al., 2021; Raoofi et al., 2020). However, one critical aspect that determines the success of these initiatives is users' engagement which is the active participation and sustained involvement of individuals in the fight against COVID-19.

As the world continues to navigate the ongoing pandemic, many countries are following a "middle path" strategy, balancing the gradual restoration of social, economic, and travel activities with measures to prevent the spread of the virus (Nicola et al., 2020). With an increasing number of people being vaccinated, most cases have been mild or asymptomatic (Dinleyici et al., 2021). As the pandemic transitions into an endemic state, where the virus remains present but managed through ongoing measures, the need for effective strategies to increase users' engagement becomes even more pronounced. It will be crucial to sustain social distancing and mask use in places such as hospitals, nursing homes, day care centers, and home care (Matuschek et al., 2020). To achieve this, governments must continue to innovate and expand upon strategies implemented throughout the pandemic, including the adoption of digital health technology such as teleconsultations and home monitoring through mobile applications and gadgets.

In this context, the integration of a gamification model offers a promising avenue to address the challenge of users' engagement in COVID-19 initiatives. The COVID-19 pandemic should not slow down the digital transformation of healthcare, but rather accelerate it (Lee & Lee, 2021). Gamification refers to the application of game design elements and mechanics in non-game contexts to motivate and engage users. By incorporating elements such as rewards, challenges, leaderboards, and progress tracking, gamification seeks to tap into users' intrinsic motivations, making participation in COVID-19 initiatives more enjoyable and meaningful. Even as the world transitions into the endemic phase of COVID-19, it remains important to continue taking precautions to reduce transmission while balancing the need to maintain a normal lifestyle (Chen et al., 2020; Fakhruddin et al., 2020). Community engagement in health campaigns is crucial, and one way to increase engagement is through the use of gamification in mobile apps. Thus, more researchers have started to adopt gamification into the mobile app to boost awareness of the danger of the disease (De Souza Gaspar et al., 2020).

This thesis aims to explore the integration of a gamification model to increase users' engagement towards COVID-19 initiatives. By leveraging the principles of gamification, it seeks to design and implement an innovative approach that fosters sustained users' engagement and encourages continued participation in these critical efforts. While there are many gamified mobile apps for COVID-19, little research has been done on the effectiveness of gamification in improving engagement (Alfaqiri et al., 2020). Most of the studies discuss the development of the application and converting the information into gamified content (De Souza Gaspar et al., 2020). This is a missed opportunity for a better understanding of the effect of gamification implementation in mobile apps to curtail COVID-19.

Throughout this research, various factors will be considered, including the design and implementation of the gamification model, the assessment of its effectiveness in increasing users' engagement, and the examination of its impact on user behavior change and participation in COVID-19 initiatives. The findings of this study have the potential to inform the development of more effective strategies to engage users, promote behavior change, and ultimately contribute to the collective effort in combating the COVID-19 pandemic in both crisis and endemic situations.

1.2 Background of Study

As the world sees a decline in new COVID-19 cases, many experts believe that the end of the pandemic is in sight (Lawton, 2021). However, it's worth noting that in nations with high vaccination rates, there seems to be less of a correlation between cases and deaths (Khorram-Manesh et al., 2022). The COVID-19 virus is becoming an endemic illness that will always be present. After taking account of patient age and underlying diseases, there are indications that COVID-19's severity is approaching that of seasonal influenza with high levels of population immunity. Even with widespread vaccination, it will be important to take other steps to prevent the spread of the virus.

The COVID-19 pandemic has led to an unprecedented increase in research on the disease. Since the start of the pandemic, it has been well-established that COVID-19 has had a disastrous effect on healthcare services (Kaye et al., 2021). This is particularly true in countries with underdeveloped and overworked health systems (Ma et al., 2020). To address this, mobile app solutions have been developed to reduce the risk of cross-contamination caused by close contact (Salehinejad et al., 2021). These apps are accessible, acceptable, and easily adopted, and can support social distancing efforts (Noronha et al., 2020). Among

different strategies, gamification has attracted the interest of researchers, who the last time have been exploring its potential to improve users' motivation and engagement. Studies on the effectiveness of gamification are promising and have yielded variable to positive results.

While gamification has been extensively studied in fields such as education, marketing, and customer engagement, its potential application in the context of COVID-19 initiatives is underexplored. The unique challenges posed by the pandemic, including rapidly changing information, fear, and the need for sustained behavior change, require innovative approaches to increase users' engagement. In addition, there is a lack of comprehensive analysis of quantitative evidence documenting its effectiveness in promoting well-being and engagement towards pandemic interventions (Floryan et al., 2020). Although studies about gamification for health are still scarce, there is an emerging body of literature on gamification to treat this pandemic (Laato et al., 2020). The use of game-design concepts such as competition and game elements such as challenges, points, and levels in non-game contexts has become a powerful approach to changing human behavior (Mora et al., 2017). In fact, gamification emerges as a viable strategy for addressing motivation and engagement issues (Alsawaier, 2018). Thus, adopting a suitable gamification design will make the user experience more engaging to increase users' motivation.

Besides, studies that explore the effectiveness of gamification have commonly focused on game-based learning and serious games (Rivera et al., 2021). Research on the impact of gamification especially out of education fields is limited to date. Without more studies and evaluation of the effect of gamification on users' engagement towards COVID-19 interventions or future pandemics, the purpose of gamification in this context remains scarce. There is a need to empirically evaluate gamification integration that will enable the

practitioners to apply and benefit users' experience and outcomes. As technology-enhanced pandemic initiatives become more prominent in the post-pandemic era, gamification may be considered as a viable option to increase users' engagement in following these initiatives and can be incorporated in future outbreak mobile apps to boost users' engagement in following preventive measures.

In this study, the Technology Acceptance Model (TAM) will serve as a theoretical framework to understand and evaluate the integration of a gamification model in the context of COVID-19 initiatives. TAM focuses on users' perceptions and attitudes towards technology adoption and usage, encompassing factors such as perceived usefulness and ease of use. By applying the TAM model, the study aims to assess users' acceptance and adoption of the gamification model, examining its impact on users' engagement, behavior change, and sustained participation. Therefore, the findings of this research contribute to the understanding of how gamification can effectively increase users' engagement in COVID-19 initiatives during both the pandemic and endemic phases.

1.3 Problem Statement

During the pandemic phase of COVID-19, numerous initiatives were launched globally to address the immediate crisis, including public health campaigns, testing centers, and vaccination drives. While these efforts were crucial, sustaining users' engagement and participation remained a significant challenge. Users often experienced fatigue or disinterest over time, leading to a decline in adherence to preventive measures, decreased vaccination rates, and a waning sense of urgency (Elnaem et al., 2021). Traditional approaches, relying on informational campaigns and static communication channels, struggled to maintain users' attention and motivation as the crisis persisted.

Transitioning into an endemic phase, where COVID-19 remains present but managed through ongoing measures, the need for sustained users' engagement in COVID-19 initiatives remains critical. Although the sense of urgency may be different compared to the early stages of the pandemic, ongoing efforts are necessary to ensure the effective management of the virus and prevent further outbreaks (Güner et al., 2020). In an endemic situation, the challenge lies in capturing users' attention, sustaining their motivation, and encouraging continued participation in initiatives such as vaccination drives, adherence to public health guidelines, and community-driven actions.

As the initial shock and fear of the pandemic subsides and cases decline, people may begin to relax their adherence to preventative measures such as mask-wearing and social distancing. Additionally, with the implementation of vaccines and the gradual return to normalcy, people may feel a sense of complacency and believe that the threat of the virus is diminished (Mohamed et al., 2021). This is particularly concerning as the COVID-19 virus continues to evolve and it is unknown how effective vaccinations will be in preventing future transmission (Anderson et al., 2020). Due to these factors, COVID-19 will remain a concern long after vaccinations become available (Goodman et al., 2020). Thus, it is essential to monitor public compliance with COVID-19 preventative measures (Thomas et al., 2021).

Integrating a gamification model offers a promising solution to these challenges. By incorporating game design elements and mechanics, a gamified approach can create an interactive and enjoyable experience for users, motivating them to actively engage in COVID-19 initiatives. The use of rewards, badges, levels, and challenges can tap into users' intrinsic motivations and foster a sense of achievement and progress (Hightow-Weidman et al., 2021; Jessen et al., 2018; Nurmi et al., 2020). This dynamic and interactive framework

can create a sense of excitement and competitiveness, encouraging users to stay engaged and actively participate over an extended period (Johnson et al., 2016).

In the endemic phase, the gamification model becomes equally crucial in sustaining users' engagement and motivation. As the immediate crisis fades, there is a risk of complacency and decreased participation. The gamified approach provides ongoing incentives and challenges, ensuring users remain motivated and committed to the cause (Chans & Portuguese Castro, 2021). The integration of a gamification model can serve as a catalyst for users' engagement, providing a fresh and innovative approach to captivate users' attention (Smiderle et al., 2020). It can address user fatigue by introducing novel and interactive elements that make the initiatives more appealing and enjoyable. By incorporating leaderboards, social sharing features, and community collaboration, the model fosters a sense of community and collective effort, reinforcing users' commitment to COVID-19 initiatives.

In summary, both during the pandemic and endemic phase, the integration of a gamification model addresses the challenge of users' engagement in COVID-19 initiatives. By creating an interactive and enjoyable experience, it captures users' attention, sustains their motivation, and encourages continued participation. The gamified approach offers a dynamic framework that taps into users' intrinsic motivations, promotes behavior change, and enhances the impact of COVID-19 initiatives, contributing to the collective effort of managing and mitigating the effects of the virus.

1.4 Research Questions

Below is the list of research question in this study:

- RQ1: How the gamification TAM framework could be developed to increase users' engagement to follow the preventive measures for COVID-19?
- RQ2: To what extent is the relationships between gamification of perceived ease of use, gamification of perceived usefulness, and attitude towards gamification towards users' engagement to follow the preventive measures of COVID-19?

1.5 Objectives

Below is the list of objectives for the study:

- OB1: To propose a framework of gamification and TAM theory to increase users' engagement to follow the preventive measures of COVID-19.
- OB2: To explore the relationships between gamification of perceived ease of use, gamification of perceived usefulness, and attitude towards gamification towards users' engagement to follow the preventive measures of COVID-19.

1.6 Linking Objectives to Research Questions and Problem Statement

To address the problem statement and resolve the outlined challenges, the study proposes two research questions (RQ1 and RQ2) and two corresponding objectives (OB1 and OB2). Below is a detailed explanation of how these objectives directly address the research questions and contribute to solving the identified problems.

1.6.1 Developing a Gamification-TAM Framework to Enhance Users' Engagement

The problem lies in declining users' engagement due to factors such as complacency, fatigue, and a sense of normalcy during the endemic phase (Anderson et al., 2020). To address this, Objective 1 (OB1) seeks to develop a gamification-based TAM framework that will combine the motivational elements of gamification (such as challenges, rewards,

leaderboards) with TAM's theoretical constructs, which focus on perceived usefulness (PU) and perceived ease of use (PEOU).

Gamification offers a dynamic, engaging, and interactive approach to sustaining user participation in preventive measures (Hightow-Weidman et al., 2021). By integrating gaming elements into COVID-19 mobile apps and initiatives, users can experience ongoing motivation to engage in these preventive behaviors, addressing the issues of complacency and fatigue.

The TAM model complements this by providing a theoretical foundation for how users accept and adopt new technologies. TAM explains how perceived usefulness (how beneficial the gamified app is in managing COVID-19) and perceived ease of use (how simple the app is to navigate) can influence users' intentions to engage with the system. By combining gamification with TAM, this framework ensures that not only is the app engaging, but users also find it easy and valuable enough to integrate into their daily routines.

Thus, Objective 1 aims to develop a theoretical framework that addresses RQ1 by illustrating how the integration of gamification with TAM can sustain users' engagement in following COVID-19 preventive measures. This framework serves as the primary solution to the problem of declining participation during both pandemic and endemic phases.

1.6.2 Exploring the Impact of Gamification Perceptions on Users' Engagement

Objective 2 (OB2) directly targets the underlying mechanisms of how users' engagement can be enhanced. The problem statement highlights reduced adherence due to diminished urgency, fatigue, and changing perceptions of risk during the endemic phase (Anderson et al., 2020). Objective 2 (OB2) aims to uncover how perceived ease of use

(PEOU), perceived usefulness (PU), and attitude towards gamification (ATUG) impact users' engagement (UE).

Perceived ease of use refers to the degree to which a user believes that using the gamified app is free of effort. This is particularly important in preventing frustration and ensuring that the app remains user-friendly, especially during extended periods of use when fatigue may set in (Davis et al., 1989). If users find the app intuitive and simple, they are more likely to engage with it over time, addressing the problem of declining participation.

Perceived usefulness refers to the belief that using the app will improve adherence to COVID-19 preventive measures and protect their health. By exploring this construct, Objective 2 seeks to understand whether users perceive the app as a valuable tool in managing their health during the pandemic. If users believe the app has significant benefits, they will be more motivated to adhere to preventive measures, thus counteracting complacency (Güner et al., 2020).

Attitude towards gamification (ATUG) reflects how users feel about the integration of gamification into a health app. Positive attitude can increase engagement by making the experience enjoyable and meaningful, thereby helping users overcome fatigue and sustaining their motivation in the long term (Rahman & Ahmad, 2018).

By exploring these relationships, Objective 2 provides empirical evidence to resolve RQ2 and illustrates how the identified constructs (PEOU, PU, and ATUG) influence engagement. This knowledge directly supports the solution of addressing the issue of decreased participation in COVID-19 preventive measures, as outlined in the problem statement.

1.7 Scope and Limitations

The research on the development of gamification framework for pandemic involves various areas including user, gamification elements, and gamification-engagement design frameworks. This research focuses on the engagement of users to follow the pandemic preventive measures and uses a gamified mobile app as a medium to execute the research.

The gamification framework proposed in this research only supports the design of gamification aimed to increase the engagement of users to follow preventive measures of the pandemic. The scope of the study is limited to secondary school teenagers as a research sample with ages ranging between 16 and 18 for the experimental evaluation of a prototype developed based on the game design through the proposed framework. These users are from the area of Kuching, Sarawak. The proposed framework concentrates on the four components such as gamification usefulness, ease of use, attitude towards gamification, and their engagement to follow the preventive measures.

1.8 Brief Methodology

In this study, the research method is a quantitative method that study the effectiveness of gamification towards users' engagement to become aware and practice the preventive measure of COVID-19. The research also sought to determine whether gamification can drive behavioral change in users toward practicing preventive measures against COVID-19. The quantitative approach is adopted because it can produce reliable and replicable data. The focus population for this study is teenagers that live in Kuching, Sarawak because younger people are more likely to develop asymptomatic cases, and they are socially active.

Besides, the researcher has adopted an explanatory research design to explain the relationship between two variables in a model. The purpose of the explanatory research design is to identify the existence of relationships between variables in GAM and how gamification affects users' engagement. X-GAM will be used in this study which is adopted from GAM. The model will be used in this study to test the relationship between gamification and user participation in following the preventive measure for COVID-19.

1.8.1 Research Design

The present study aims to extend the adopt the Gamification Acceptance Model (GAM) from the study conducted by Rahman and Ahmad (2018). GAM originated from TAM theory, which is further extended to include several new variables to measure the student's participation in the classroom. The proposed model aims to study the effectiveness of gamification in affecting users' engagement to follow the preventive measure for COVID-19. Therefore, the student participation is changed to users' engagement to fit the context of this study. The perceived usefulness, perceived ease of use, and attitude from the TAM are extended to include gamification. Figure 1.1 shows the proposed conceptual model.

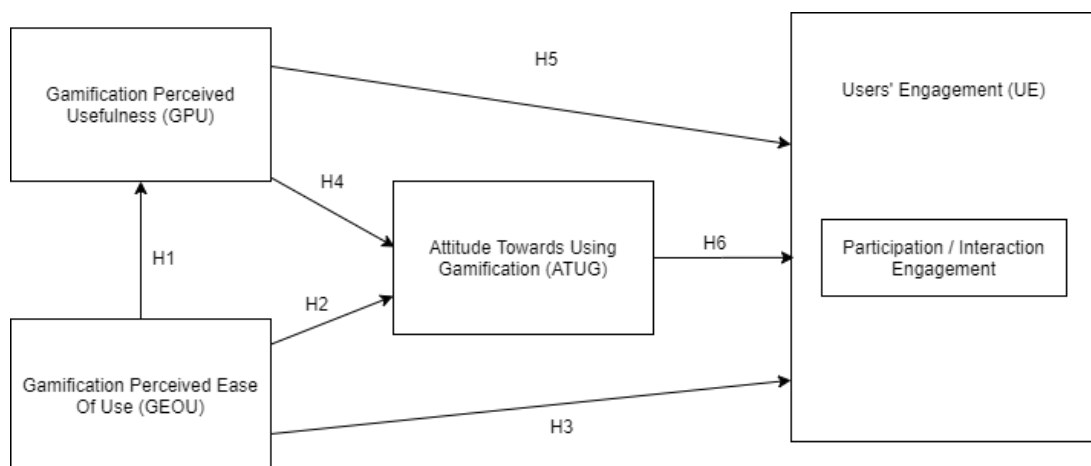


Figure 1.1: X-GAM, proposed conceptual model (H: Hypothesis)

1.8.2 Research Approach

The participants are secondary school teenagers between the age of 16 to 18 that live in Kuching, Sarawak. They use the gamified app about COVID-19 preventive measures for 3 weeks. At the end of the experiment, an online questionnaire is deployed to the participants to evaluate the gamified app. The questionnaire is constructed based on previous studies that have investigated gamification and TAM used the identical data collection approach (Çera et al., 2020). The structure of questionnaire is divided into two parts. One part asks about the demographics of users, and the other part measures the factors in the proposed model. The questionnaire has 15 questions that address five constructs to validate: four items on gamification perceived usefulness (GPU), four items on gamification perceived ease of use (GEOU), four items on attitude towards using gamification (ATUG) and three items on users' engagement (UE). Each item will be assessed with a 5-point Likert scale range from 1 = 'strongly disagree' to 5 = 'strongly agree'.

The hypothesized effects are tested using a two-step approach of SEM using AMOS. In the first step, confirmatory factor analysis (CFA) is employed to examine the reliability and validity of the scales used in this study. The second step comprised of an evaluation of the proposed model. The model is assessed by a range of commonly used indicators to ensure the data is fit with the proposed model. Convergent and discriminant validity will be assessed for the final multi-item constructs. Lastly, the factor loading estimates are assessed to ensure all indicators effectively measure their corresponding construct and support convergent validity. Figure 1.2 below summarizes the SEM process in this study.

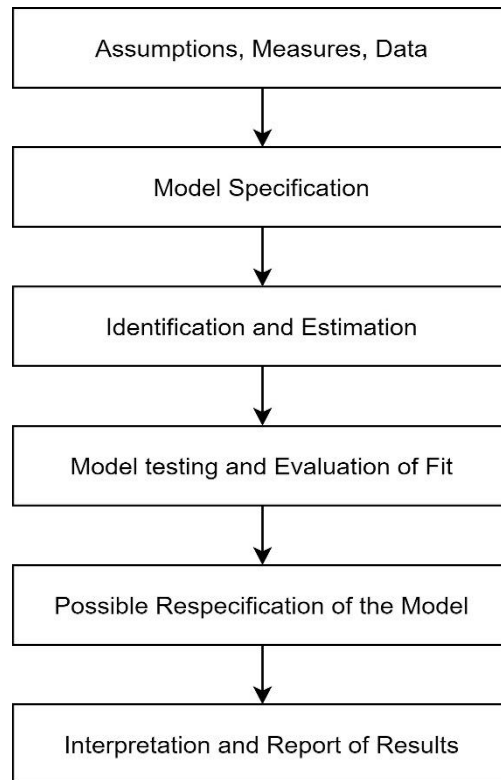


Figure 1.2: Summary of SEM processes

1.9 Significance of Study

The proposed research on integrating a gamification model to increase users' engagement towards COVID-19 initiatives holds significant importance in several ways:

- **Enhancing Users' engagement:** The research aims to address the persistent challenge of sustaining users' engagement in COVID-19 initiatives, both during the pandemic and endemic phases. By leveraging the principles of gamification, the study seeks to design and implement an innovative approach that can capture users' attention, motivate their active participation, and foster sustained engagement. This research has the potential to significantly enhance users' engagement, leading to increased

adherence to preventive measures, higher vaccination rates, and more effective community-driven actions.

- **Promoting Behavior Change:** The gamification model offers a dynamic framework that can effectively promote behavior change among users. By incorporating game design elements such as rewards, challenges, and progress tracking, the model can influence users' attitudes and actions towards COVID-19 initiatives. This research can shed light on the effectiveness of gamification in motivating behavior change, encouraging users to adopt and maintain healthy practices, and contributing to the overall success of the initiatives.
- **Informing Strategy Development:** The findings of this research can provide valuable insights and guidelines for the development and implementation of future engagement strategies in the context of COVID-19 or similar public health crises. By examining the effectiveness of different gamification elements, the study can contribute to the knowledge base on designing engaging experiences that resonate with users and drive their active participation. The research outcomes can inform policymakers, public health agencies, and organizations involved in COVID-19 initiatives, helping them design more effective and impactful strategies to engage users and combat the virus effectively.
- **Long-Term Impact on Public Health:** The significance of this research extends beyond the immediate context of COVID-19. The knowledge gained from exploring the integration of gamification in users' engagement strategies can be applied to future public health initiatives and crisis management efforts. By understanding the mechanisms that drive sustained engagement and behavior change, public health practitioners can leverage gamification principles to tackle various health challenges,

encouraging healthy behaviors, promoting preventive measures, and mobilizing communities towards collective action.

In conclusion, the proposed research on integrating a gamification model to increase users' engagement towards COVID-19 initiatives holds significant significance in enhancing users' engagement, promoting behavior change, informing strategy development, and contributing to long-term public health outcomes. The findings and insights gained from this research have the potential to shape future engagement strategies, empower individuals to actively participate in health initiatives, and strengthen collective efforts in managing and mitigating the effects of COVID-19 and similar crises.

1.10 Organization of Thesis

Chapter one delves into the general introduction of the study, highlighting the problem statements, research objectives, the scope of the study, and the thesis organization. In chapter two, the focus shifts to previous studies of gamification, the concept of the technology acceptance model (TAM), related works of gamification and TAM, challenges and research opportunity, open research issues, gamified COVID-19 mobile apps and its challenges, and future directions of mHealth and COVID-19 apps. Chapter three is about building the proposed conceptual model, research methods, and summary of gamified app development. This chapter also provides valuable insights on the analysis methods, sampling, and statistical techniques that will aid in achieving the research objectives. Chapter four covers the results, data analysis, and hypotheses. In chapter five, a comprehensive discussion is provided based on the findings, highlighting several key lessons learned, theoretical implications, practical implications, limitations, and future works for the research. Finally, chapter six concludes the study by summarizing the achievements, a list of completed objectives, and a conclusion.

1.11 Conclusion

In conclusion, the introduction section has discussed the overview of COVID-19 as a world pandemic and how it has greatly affected the world population. This chapter also presented the background of the study, discussing the current problem statements and research questions regarding the study. The objectives and scope are defined to guide and define the boundary of the study. The methodology is brief to give an overview of how the project will be conducted. Moreover, the significance of the study is also listed to better understanding the output of the research. The organization of the thesis is provided to give an overview of the structure of the thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

The objectives of this chapter are to discuss the existing literature on COVID-19 mobile applications, gamification and factors that allow gamification to affect human behavior. Moreover, this chapter examines the Technology Acceptance Model (TAM and its modifications, as well as its applications in various domains. The chapter identifies several challenges and research opportunities for gamification research in increasing users' engagement. The chapter also presents the current gamified COVID-19 mobile applications and the challenges in implementing them. The chapter concludes by laying out the future directions of mHealth and pandemic applications.

2.2 Mobile Application During the COVID-19 Pandemic

The COVID-19 pandemic has caused massive disruption to global trade, employment, and travel around the globe (Shah et al., 2020). Many countries must adopt strict measures to prevent the spread of the virus. Several preventive measures are being taken to avoid the spread of COVID-19. The citizens are advised to stay at home and maintain social distancing for as long as feasible.

To this date, mobile apps have proven to be effective in managing chronic diseases and their importance has only been amplified by the ongoing COVID-19 pandemic. With the need for quick and effective information sharing, mobile apps have been able to assist with social distancing efforts (Noronha et al., 2020). The surge in COVID-19 cases has led to a proliferation of mobile apps designed to help flatten the curve, including those for

information sharing (De Souza Gaspar et al., 2020), risk assessment (Gilmore et al., 2020), self-management of symptoms (Sorkin et al., 2021), and digital contact tracing (Zirbes et al., 2021).

Many studies focus on gamified mobile health applications in various health disciplines, such as depression (Salomao et al., 2019), cancer (Gil-Cosano et al., 2020), and physical monitoring. Unfortunately, the study to evaluate the effectiveness of gamified apps for the COVID-19 pandemic has been scarce. This is likely due to the pandemic being a relatively recent occurrence, and thus, the development of applications for this field is still in its infancy. Therefore, further research is needed to evaluate existing applications and guide the development of future COVID-19 apps.

2.3 Gamification

Over the past few years, the gamification buzzword has grown in popularity. The popularity of gamification has skyrocketed and its associated literature has grown rapidly, as seen by the rising number of fields in which gamification is used (Wunderlich et al., 2020). It focuses on adapting gaming mechanics into non-game environments. It introduces the element of excitement into dull tasks, besides providing motivational and cognitive benefits (Turan et al., 2016). Gamification is the process of transforming practices, programs, services, goods, or organizational structures to include game-like experiences (Klock et al., 2020). The concept of gamification has been around for decades, but it was not until recently that it gained widespread acceptance (Sardi et al., 2017). The word gamification has been long associated with the video game industries. Johnson et al. (2016) define gamification as “the application of game design elements to non-game contexts.” Therefore, rather than producing full-fledged games in a serious context, gamification intends to influence users’ actions and motivation through game-like interactions (Nasirzadeh & Fathian, 2020).

Gamification is a concept that has gained considerable attention across various industries and fields. Its effectiveness lies in leveraging elements and mechanics from games to engage and motivate individuals in non-game contexts. By incorporating game design principles, such as rewards, challenges, leaderboards, progress tracking, and narrative elements, gamification transforms tasks or activities into interactive and compelling experiences (Bitrián et al., 2021a). One of the key benefits of gamification is its ability to tap into users' intrinsic motivations (Hosseini et al., 2021). Games often trigger feelings of achievement, mastery, and autonomy, which can be harnessed to motivate individuals in different domains. By offering clear goals, challenges, and feedback, gamification provides users with a sense of purpose and progress, enhancing their motivation to participate and excel.

Another aspect of gamification is the use of rewards and recognition. Through the implementation of points, badges, virtual goods, or other forms of incentives, gamification acknowledges and reinforces desired behaviors (Rincon-Flores & Santos-Guevara, 2021). This rewards system not only provides immediate feedback but also creates a sense of accomplishment and status among users. The prospect of earning rewards or achieving higher levels can drive individuals to invest time and effort into tasks they might otherwise find mundane or tedious. Gamification also fosters a sense of competition and social interaction (Sailer & Homner, 2020). By incorporating leaderboards or allowing users to connect with friends and peers, it introduces a social dynamic that encourages users to compare their progress, engage in friendly competition, and collaborate towards common goals. This social element creates a sense of community and enhances the overall experience, as users feel connected and motivated by the shared journey.

Additionally, gamification can facilitate learning and skill development (Mee Mee et al., 2021). By providing immediate feedback and creating an environment that promotes experimentation and risk-taking, gamification supports the acquisition of new knowledge and the improvement of skills (Schultz et al., 2022). The interactive nature of gamified experiences encourages users to actively engage, practice, and refine their abilities in a safe and engaging setting. Overall, gamification offers a powerful approach to engage and motivate individuals in various contexts. Whether it's in education, fitness, employee training, or customer engagement, the integration of game elements can transform experiences, making them more enjoyable, meaningful, and rewarding. Gamification has the potential to enhance users' engagement, drive behavior change, and foster a sense of achievement and progress in diverse areas of application.

2.3.1 Games and Gamification

The concept of gamification should not be confused with playing traditional games. All the characteristics of games are elements such as fun, aesthetic appeal, adherence to rules, and involvement in the short term. Games contain well-defined rules, levels, and the possibility of loss. Gamification, on the other hand, inherently recognizes and compensates players for their participation (Duggal et al., 2021). In addition, games are utilized as a component of the gamification process to boost users' engagement and productivity in order to accomplish the goals that have been set. The term "gamification" can be broken down into its structural and content components (Filatro et al., 2016). Structural gamification introduces game-like elements into non-game content to increase engagement. There is no modification made to the content. Only the framework that surrounds the content has been given a gaming twist. In a general sense, it encourages sorts of behaviors by providing feedback on how those behaviors are being performed. Gamification on the other side

incorporates game aspects, mechanics, and thinking into the content to make it more like a game. It incorporates narrative, intrigue, and characters into gamification content. This type of gamification assigns specific responsibilities to users, making the experience more interactive and hands-on. The comprehensive gamification categorization is displayed in Figure 2.1.

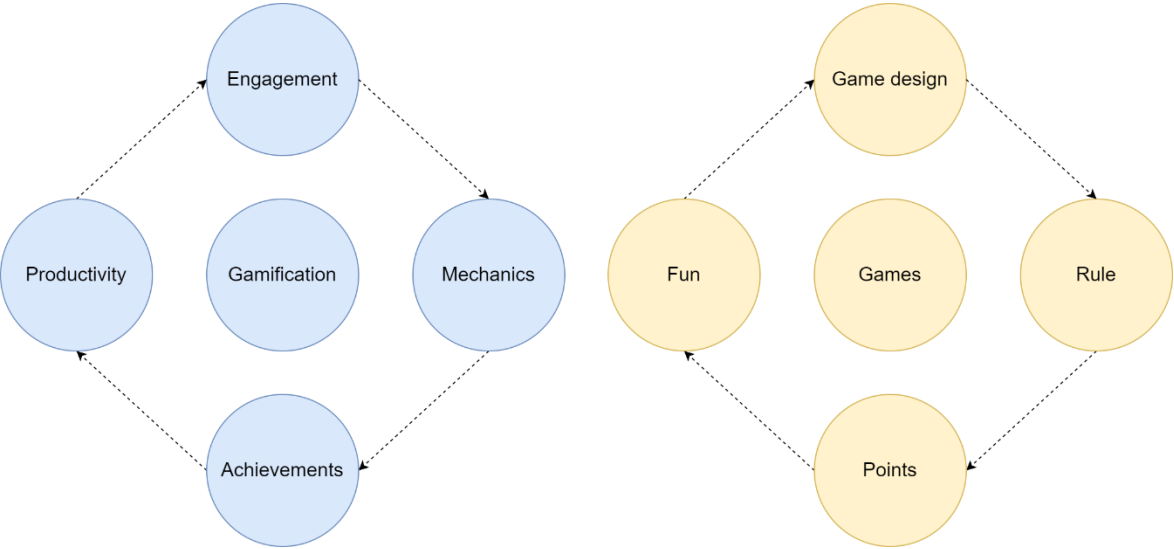


Figure 2.1: Games and gamification differences

Meanwhile, contrary to gamification, serious games are not intended for entertainment purposes (Cheng, 2020). Serious games are described as “games which do not have entertainment, amusement, or fun as their central motive” or “games designed to entertain players while learning, training, or change in behavior” (Sardi et al., 2017). Unlike serious games, gamification aims to create game-like experiences by blending gamification elements and game interface design. Game elements, such as scores, achievement badges, and leaderboards, are considered key gamification strategies (Johnson et al., 2016).

However, while the benefits of gamification on behavior are well-established (Çera et al., 2020), challenges in technology acceptance still exist. To address this, researchers

often turn to the Technology Acceptance Model (TAM), which is one of the most widely-used models for predicting usage, intention, and acceptance of technology (Al-Emran et al., 2021; Granić & Marangunić, 2019). Factors such as intrinsic and extrinsic motivation, as outlined by self-determination theory (SDT), also play a crucial role in understanding users' engagement in gamification (Aguiar-Castillo et al., 2020). Overall, it is important to consider user preferences and perceptions when designing gamification interventions in order to maximize their effectiveness.

2.4 Factors That Allow Gamification to Affect Human Behavior

As the COVID-19 pandemic has gripped the world, governments have implemented various measures to slow the spread of the virus, such as cancelling social gatherings and encouraging individuals to stay at home. However, the effectiveness of these measures relies heavily on the willingness of citizens to comply. Enter gamification - the process of incorporating game elements and mechanics into non-game contexts in order to increase engagement and motivation. Studies have shown that gamification can be a powerful tool for influencing human behavior, and therefore it is crucial to examine its potential role in the ongoing COVID-19 pandemic. The use of gamification in mobile apps, for example, has the potential to increase community engagement in health campaigns and encourage individuals to comply with preventive measures. As the pandemic continues to evolve, understanding the relationship between gamification and users' engagement in following interventions can lead to improved design and implementation of COVID-19-related mobile apps, ultimately playing a crucial role in protecting and managing the post-COVID-19 world.

2.4.1 Intrinsic vs Extrinsic Value

The use of gamification in mobile applications has been shown to affect user behavior and increase engagement. One key factor that influences a user's response to a

gamified application is the benefits they anticipate gaining from using it. A study by Akdim et al. (2022) found that a user's level of participation in technology depends on the functional and hedonic benefits they anticipate. Hedonic motivation, which includes elements such as learning, enjoyment, and emotional fulfillment (Ramirez et al., 2022), plays a crucial role in the acceptance of gamification among users.

According to self-determination theory (SDT), there are two types of motivation: intrinsic and extrinsic (Aguiar-Castillo et al., 2020). The term "intrinsic motivation" refers to motivation that is inherent in action, such as enjoyment, task engagement, or the task's ability to foster social and cognitive growth (Mitchell et al., 2020). On the other side, extrinsic motivation refers to motivation that is separate from the behavior and is done for a future benefit (Locke & Schattke, 2019). Extrinsic motivation, like awards and badges, may demotivate users who are primarily intrinsically motivated. Additionally, benefits that are not perceived as desirable or realistic may not serve as an external motivator (Mitchell et al., 2020).

When designing a gamification intervention, it is important to understand the user's motivations and preferences. Giving out too many awards might take away from users' feelings of accomplishment and pride, thus they should be used carefully. When employing gamified mobile health applications, Goodwin and Ramjaun (2017) found that users enjoy intrinsic rewards. However, these rewards are only worthwhile if users understand their purpose (Xi & Hamari, 2019). This highlights the importance of considering how gamification can fulfill intrinsic needs in users, as it is frequently believed to have a special impact on this aspect (Y. Yang et al., 2017).

2.4.2 Goal-Setting Theory

Goal-setting is key to the design of gamification (Groening & Binnewies, 2019). Gamification, according to several researchers, is the science of turning people's everyday activities into video games to aid in goal-achieving (Landers & Armstrong, 2017). According to goal-setting theory, the desire to accomplish a goal is what drives users to utilize gamified apps. Gamification offers several benefits as a tool for behavior change, as goal-setting can assist individuals in turning their needs into incentives and modifying their behavior (Yang & Li, 2021). Once a goal is determined, people can decide whether to work toward it (Landers & Armstrong, 2017). Human decision-making and emotions will be impacted by gamification. This has been shown to be effective in a variety of health-related areas, such as better diet (Suleiman-Martos et al., 2021), diabetes control (Alsalman et al., 2020), smoking cessation (Rajani et al., 2019), and alcohol consumption (Manning et al., 2021). It was claimed that gamification would increase various engagement factors, including enjoyment and fun, as well as a sense of mastery (Salemin et al., 2022). This would promote early and ongoing interactions with the app or technology, which are related to engagement and retention.

Previous studies have discovered that gamification-based success can act as a stand-in for external goal-setting and improve people's motivation and performance (Groening & Binnewies, 2019). Mechanisms such as scores, badges, and leaderboards are commonly used in the gamified environment to express achievement (Aljraiwi, 2019; Uz Bilgin & Gul, 2020). Achievement rewards typically have two effects on how people behave. First and foremost, they serve as a system of rewards. Users are shown their progress and performance levels after completing a task. By receiving rewards for their achievements, they may increase their executive motivation. Incentives for achievement can also serve as a type of

feedback (Friedrich et al., 2020). It is possible for people to complete tasks to gain feedback on subgoals, which is a common motivational strategy and tool for changing behavior. Gamification can therefore be an effective method for inspiring behavior change and performance if applied properly.

2.5 Users' Engagement (UE)

Despite the widespread use of the term "users' engagement," there is no single, universally accepted definition. Different fields have presented various definitions, with computer and information science research often viewing engagement as the factor that drives individuals to use and continue to use a technical system (Xiao et al., 2022). In the service context, engagement is seen as a multi-dimensional construct that includes behavioral, emotional, and cognitive elements and contributes to developing customer-based outcomes, brand trust, attachment, and loyalty (Islam et al., 2019). In the educational field, engagement is often recognized as a three-dimensional model that consists of emotional engagement, behavioral engagement, and cognitive engagement (Chaka & Nkhobo, 2019).

In the gamification field, literature has established various definitions of engagement from different perspectives. For example, Gupta and Gomathi (2017) depicted engagement as motivating and increasing participation, while Looyestyn et al. (2017) defined it as "one use only" and "sustained period." Bitrián et al. (2021) considered users' engagement as the quality of user experience characterized by cognitive, temporal, affective, and behavioral investment when interacting with a digital system. In this study, it is argued that users' engagement refers to motivating the user to perform desired behavior with more enthusiasm and encouraging their participation in an activity, as suggested by Gupta and Gomathi (2017). As a result, a conceptual gamification and users' engagement framework that consists of three constructs from TAM was proposed and used in this study.

2.5.1 Users' Engagement and Its Importance in COVID-19 Initiatives

Users' engagement plays a critical role in the success of COVID-19 initiatives. These initiatives encompass a wide range of activities aimed at preventing the spread of the virus, ensuring public safety, and promoting behaviors that contribute to community health. Without active and sustained users' engagement, the effectiveness and impact of these initiatives may be compromised.

In the context of COVID-19, users' engagement refers to the active participation, commitment, and adherence of individuals to recommended guidelines, interventions, and preventive measures (Hyland-Wood et al., 2021). This includes practices such as mask-wearing, social distancing, hand hygiene, and vaccination, as well as participation in testing, contact tracing, and public health campaigns. Users' engagement is not limited to individual actions but also encompasses collective efforts that contribute to community health and well-being.

Users' engagement is of paramount importance in COVID-19 initiatives due to several key reasons. First, the contagious nature of the virus requires a collective response. Individual actions have a direct impact on the health and safety of others, making it crucial for individuals to actively engage in preventive measures (Hu et al., 2021). Users' engagement facilitates a sense of shared responsibility, fostering a collective effort to combat the virus and protect vulnerable populations.

Second, sustained users' engagement is essential for long-term behavior change (Porat et al., 2020). The COVID-19 pandemic has necessitated a shift in behaviors and routines, and these changes need to be sustained over an extended period. Without consistent users' engagement, there is a risk of fatigue, complacency, or relapse into previous

behaviors, which can hinder efforts to control the spread of the virus and manage its impact (Rowan & Moral, 2021).

Third, users' engagement is closely tied to the effectiveness of public health messaging and interventions (Perski & Short, 2021). Clear and consistent communication is vital in conveying accurate information, dispelling myths, and promoting recommended behaviors (Roberts & David, 2021). Users' engagement ensures that individuals receive, understand, and act upon these messages, increasing the likelihood of behavior adoption and adherence.

Furthermore, users' engagement contributes to the success of COVID-19 initiatives by fostering a sense of community and social norms (Vanhamel et al., 2021). When individuals observe others actively engaging in preventive measures, it normalizes and reinforces those behaviors, creating a social environment that supports health-conscious actions (Raffali & Mohd Asraf, 2023). Users' engagement can also enhance trust in public health agencies, authorities, and the scientific community, facilitating the acceptance and uptake of recommended interventions.

Understanding the factors that influence users' engagement is crucial for designing effective strategies to increase participation and sustained involvement. Motivational factors, such as perceived benefits, self-efficacy, and social norms, play a significant role in driving users' engagement (Al-kumaim et al., 2021). Tailoring interventions to address barriers and facilitators of engagement, such as access to resources, trust in institutions, and cultural considerations, is essential for promoting widespread participation (Al-kumaim et al., 2021; Groot Kormelinck et al., 2021).

By recognizing the importance of users' engagement in COVID-19 initiatives and exploring the factors that influence it, targeted strategies can be developed to enhance engagement levels. Integrating gamification into these initiatives offers a promising approach to increase users' engagement by tapping into intrinsic motivations, fostering a sense of community, and providing enjoyable and rewarding experiences. Through effective gamification strategies, sustained user engagement can be encouraged, behavior change promoted, and the impact of COVID-19 initiatives maximized in safeguarding public health.

2.5.2 Gamification and Users' engagement: Evidence and Insights

Research and evidence have demonstrated the potential of gamification in increasing users' engagement across various domains. By incorporating game design elements and mechanics, gamification has proven effective in capturing users' attention, motivating their participation, and sustaining their engagement.

Numerous studies have explored the impact of gamification on users' engagement and behavior change. For example, in the field of education, research has shown that gamified learning environments can lead to higher levels of student engagement, increased knowledge retention, and improved academic performance (Bouchrika et al., 2021). Gamification elements such as progress tracking, achievements, and rewards have been found to enhance intrinsic motivation and foster a sense of accomplishment and competence (Kian et al., 2022).

In the context of health behavior changes, gamification has demonstrated promising results. Studies have found that gamified interventions can increase users' engagement, improve adherence to treatment regimens, and promote healthier behaviors (Mustafa et al., 2022). By providing immediate feedback, setting goals, and incorporating social elements,

gamification has the potential to tap into users' intrinsic motivations, boost self-efficacy, and reinforce positive behaviors.

Furthermore, gamification has been successfully employed in the business and marketing realm. Companies have utilized gamified experiences to engage customers, increase brand loyalty, and drive desired consumer behaviors (Torres et al., 2022). By integrating game-like mechanics, such as challenges, leaderboards, and rewards, organizations have been able to capture users' attention, stimulate competition, and foster a sense of achievement (Bauer et al., 2020; Grünewald et al., 2019). This, in turn, has led to increased customer engagement, improved brand perception, and higher conversion rates.

Insights from these studies highlight the key elements and design principles that contribute to the effectiveness of gamification in driving users' engagement. Some of these include:

- **Clear goals and feedback:** Gamification should provide users with clear objectives and feedback on their progress and performance. Setting specific goals and providing immediate feedback on users' actions can enhance their sense of achievement and motivation.
- **Rewards and incentives:** The strategic use of rewards, such as points, badges, or virtual goods, can incentivize users' engagement. Rewards should be meaningful, aligned with users' goals, and offer a sense of progression and status.
- **Challenge and progression:** Gamification should incorporate a sense of challenge and progression by gradually increasing the difficulty level and offering users opportunities to overcome obstacles. This helps to maintain users' interest, flow state, and motivation.

- Social interaction and collaboration: Integrating social elements, such as leaderboards, social sharing, or collaborative activities, can foster a sense of community and social interaction. Social features encourage competition, cooperation, and a sense of belonging, further enhancing users' engagement.

By leveraging the evidence and insights gained from previous studies on gamification, these principles can be applied to the design and implementation of gamified experiences in COVID-19 initiatives. Therefore, by incorporating gamification elements that align with users' intrinsic motivations, creating a sense of progression and achievement, and fostering social interaction, users' engagement towards COVID-19 initiatives can be effectively enhanced. These insights will guide the development of a gamification model tailored to the specific challenges and goals of increasing users' engagement and driving behavior change in the context of COVID-19.

2.6 Technology Acceptance Model (TAM)

Technology Acceptance Model (TAM) is a widely used theoretical model that aims to explain the adoption of new technology by users. It was developed in 1989 by Davis when the employees were not using the Information Technologies created for them (Malatji et al., 2020). TAM originated from the psychological Theory of Reasoned Action (TRA) that has been used to recognize determinants of human behavior regarding the probable adoption or rejection of technology (Granić & Marangunić, 2019). The model is composed of five key variables; perceived usefulness (PU), perceived ease of use (PEOU), attitude towards using (ATT), behavioral intention to use (BI), and actual system use. Below are definitions of variables provided by Rodrigues et al. (2016) in TAM:

- Perceived usefulness is defined as an individual's belief that using a particular technology will improve their job performance.
- Perceived ease of use, on the other hand, refers to an individual's perception of how effortless it is to use a system and how easy it is to learn to use it.
- Attitude towards using is an individual's evaluation of the target behavior based on certain dimensions, such as good/bad, and pleasant/unpleasant.
- Behavioral intention to use is an individual's willingness to exert effort to carry out the target behavior.
- Actual system use refers to the current or past use of the technology.

Out of all the variables, perceived usefulness and perceived ease of use are considered the most crucial factors in determining technology acceptance. These two variables have a significant impact on an individual's attitude towards using a technology. Additionally, perceived ease of use also affects perceived usefulness, while behavioral intention to use is constructed from attitude and perceived usefulness. Finally, actual system use is determined by behavioral intention. Figure 2.2 illustrates the relationships between the variables in the TAM model.

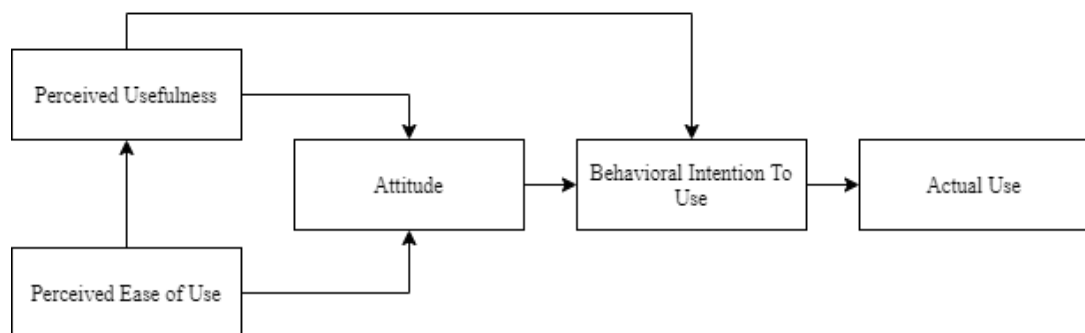


Figure 2.2: Technology Acceptance Model (TAM) (Davis et al., 1989)

Therefore, by utilizing the Technology Acceptance Model (TAM), researchers can gain insight into the intention and actual usage rates of technology, as the model effectively measures user behavior (Granić & Marangunić, 2019). Due to its potential benefits, TAM has been applied to a variety of domains, including healthcare (Salomao et al., 2019), education (Shah et al., 2020), internet banking (Rodrigues et al., 2016), and e-commerce (García-jurado et al., 2018). Its simplicity makes it a popular choice among researchers studying human behavior and intentions towards technology usage (Al-Qaysi et al., 2020).

2.7 Weaknesses of TAM

However, despite its popularity, the Technology Acceptance Model (TAM) has several limitations when evaluating technology adoption. One limitation is that it does not provide sufficient explanation for users' behavior, particularly in the context of mobile use or social influence (Malatji et al., 2020). The further argument stated that the model is unable to adequately predict technology acceptance specifically in the context of e-government. Additionally, some studies have found that TAM is not always accurate in predicting perceived usefulness, particularly in the context of gamification which focuses on entertainment rather than problem-solving (Weng et al., 2018). This is because for users who play games to enjoy and pass the time, the perceived usefulness of the technology is not a relevant factor.

Another limitation of TAM is that it relies on subjective measures, such as interpersonal influence, to represent users' behavior (Shroff & Keyes, 2020). Interpersonal influence is a way to influence a person via word of mouth either from a colleague or a friend (Kowalczyk-Anioł & Nowacki, 2020). This can be problematic as it is highly susceptible to falsification and unreliable in empirical research. Moreover, it is difficult to rely on friend's arguments as a social influence to influence a person to adopt new technology (Graf-Vlachy

et al., 2018). Users' behavior is often affected by several subjective factors such as societal norms and values, personal attributes, and personality traits (Granić & Marangunić, 2019). While this may be applicable for individual use, it is not credible to adopt in a working environment (Malatji et al., 2020). Furthermore, the original TAM does not consider additional factors that may influence behavior such as age and education. The exclusion of these external factors may affect the prediction of behavior, as this hidden personality often motivates users' behavior.

As a result, many researchers have proposed extending the TAM to improve its adaptability to the continuously changing information in gamification technology (Alghazi et al., 2020). Indeed, it may improve the capability of the model to predict the users' behavior. However, adding variables haphazardly can lead to a less coherent theory (Malatji et al., 2020). Besides, when considering review studies done in different languages, it can lead to the adoption and acceptance of terms being used interchangeably and incorrectly. Therefore, standardization in adding external variables is crucial to prevent further conflicts with the addition of new variables and relationships in the future.

2.8 Modification to TAM

Researchers have extended the original TAM with different external factors to improve prediction capability and adaptability to new contexts (Alghazi et al., 2020). In the context of gamification, researchers have added new variables to the model to study the factors that affect the adoption of gamified systems across various domains and users (Granić & Marangunić, 2019).

For example, Yoo et al. (2017) included variables such as utilitarian motivations, hedonic motivations, flow, distributive justice, network effect, privacy concern, and information quality in the TAM model to study the adoption of gamified tourism

applications. García-jurado et al. (2018) added the variables of gamification and flow to study the influence of gamification on the behavioral intention to use e-commerce platforms. Rodrigues et al. (2016) added two new variables, gamification, and socialness, to the TAM to determine the impact of the gamified application on users' intention to use the application. Vanduhe et al. (2020) expanded the TAM with Task Technology Fit (TTF), Social Influence (SI), and Social Recognition (SR) which help to determine the acceptance of gamified training among instructors. Aydin (2018) added SI, gender, and age to understand the factors that affected the intention to use gamified systems in the e-commerce domain.

In addition, other researchers have modified the TAM by adding new constructs and performing structural changes to the model. Oluwajana et al. (2019) proposed the Hedonic-Motivation System Adoption Model (HMSAM). Dick and Akbulut (2020) and Rahi and Ghani (2019) proposed the Unified Theory of Acceptance and Use of Technology (UTAUT).

Therefore, for the purpose of this study, the original TAM will be extended to include users' engagement, in addition to perceived usefulness, perceived ease of use, and attitude, which come from the original TAM. The extended TAM will examine how the users' attitude regarding gamification will affect their engagement, particularly in terms of participation/interaction while using the COVID-19 app. Besides, gamification is more likely to be accepted by users if they believe it is simple to use and beneficial to their learning (Alfaqiri et al., 2020). Likewise, the users will become more engaged while using a gamified app.

2.9 Usage of TAM

Researchers have established the predictive capability of Technology Acceptance Model (TAM) in the context of gamification. The reason people accept gamification is to increase adherence and motivation and subsequently, improve their work performance or

life quality. For example, most of the conducted studies can prove users' intent to use gamification because they believed the gamification is applicable and beneficial to their job (Obaid et al., 2020).

In line with TAM, research has found that users tend to favor and adopt gamification technology due to its ease of use (Alghazi et al., 2020; Dick & Akbulut, 2020; Rodrigues et al., 2016). These studies have established that perceived usefulness and perceived ease of use are the strongest determinants of adoption and enjoyment of gamified applications.

Moreover, perceived usefulness has been found to be a strong predictor of user motivation and satisfaction (Granić & Marangunić, 2019). This can be attributed to the fact that perceived usefulness can affect other important factors such as ease of use, enjoyment, and intention (Kulikajevs & Blažauskas, 2020).

In addition, playfulness and enjoyment are crucial factors in the adoption of gamification in various domains. It is not surprising that users are more likely to intend to use a gamified app as it creates an enjoyable experience while performing their tasks. For instance, Rodrigues et al. (2016) found that the inclusion of game elements such as points, leaderboards, and badges made the process of internet banking more enjoyable and easier to understand.

Similarly, Rahman and Ahmad (2018) discovered that students were more inclined to use a gamified application regardless of its usefulness, as the enjoyment of using the system enhanced their engagement in the classroom. In this sense, gamification has a positive impact on users' engagement and intention to use gamified apps.

2.10 Related Works of Gamification and TAM

Recently, the implementation of gamification in TAM has caught the attention of many researchers. Several publications have emerged discussing the integration of gamification and TAM. As a result, gamification with TAM has brought various effects to various domains. Thus, more studies have started to focus on this emergent topic. For instance, Klock et al. (2020) reviewed gamification literature to answer, “What are the methods to make tailored gamification?”, “What is the context of the user’s profile to be considered in tailored gamification?”, “What are characteristics of users’ profile?” and “What are the suitable game elements for tailored gamification?”. Their review aimed at extending the body of knowledge in gamification. They reported that most of the studies focused on user modeling for personalization, adaptation, and recommendation of game elements. Also, most tailored gamification is applied in educational settings. However, research about suitable game elements for each user’s profile and understanding of user modeling remains undiscussed. Thus, this study contributes to standardizing the game elements’ terminology, understanding users’ characteristics in users’ profiles, and studying the effect of different aspects of interaction on user experience.

Another review conducted by Sardi et al. (2017) aimed to answer the, “What are the trends of gamification in e-Health domains?”, “What are the game mechanics used in gamifying e-Health?”, “What are the challenges during gamification?” and “What are the benefits of gamified e-Health to users?”. Their review of 46 papers aimed at tackling chronic disease using serious games, proposed real-world gamifying applications, recommendations, and studying suitable gamification techniques.

Additionally, a systematic review by Johnson et al. (2016) focused on health domains. It aimed to evaluate the advantages and effectiveness of applying gamification to

health and well-being. However, the findings are lacking in comparing the effect of using gamification interventions to non-gamified interventions. Apart from that, the study majorly contributes to provide evidence of the effectiveness of gamification, addressing the effect of audiences on gamification and the purpose of gamification in health and well-being domains.

2.10.1 Main Research Purpose

There are four main objectives from the recent research about gamification and TAM which are the motivational level, the effectiveness of application, acceptance of technology, and development of new technology or model. Table 2.1 summarizes the main research purpose of their studies.

Table 2.1: Main research purpose

Aim	Authors	Domain*					
		HE	IB	EC	TR	HT	ET
To study the influence of gamification on users' motivation	Rusli & Prasetyowati (2018)	●					
	Rodrigues et al. (2016)		●				
	Aydin (2018)			●			
	Oluwajana et al. (2019)	●					
	Dick & Akbulut (2020)	●					
	García-jurado et al. (2018)			●			
To study the effectiveness of gamification	Rahman & Ahmad (2018)	●					
	Catal et al. (2020)						●
To study the acceptance of a gamified application	Yoo et al. (2017)				●		
	Rahi & Ghani (2019)		●				
	Vanduhe et al. (2020)	●					

To develop a new gamified application or model	Kulikajevs & Blažauskas (2020)	●					
	Salomao et al. (2019)					●	

** Legend: HE = Higher education, IB = Internet banking, EC = E-commerce, TR = Tourism, HT = Healthcare, ET = Evacuation training*

Most of the research focused on improving the motivation of users based on Table 2.1. Rusli and Prasetyowati (2018) tried to improve students' motivation and participation in campus routines. Rodrigues et al. (2016) used TAM to study the impact of the gamified application on users' intentions. Meanwhile, Rahi and Ghani (2019) studied the relationship between gamification and users' motivation and recommended gamified internet banking. Aydin (2018) focused on understanding the factors that affected the intention to use gamified systems in the e-commerce domain. Oluwajana et al. (2019) addressed the perception of users in the gamified learning environment by incorporating the Hedonic-Motivation System Adoption Model (HMSAM). One study investigated the extent of Enterprise Resource Planning simulation (ERPsims) as a learning tool to enhance the learning experience (Dick & Akbulut, 2020). The other researcher studied the influence of gamification on behavioral intention to use e-commerce (García-jurado et al., 2018).

Meanwhile, the effectiveness of the gamified application was studied by Rahman and Ahmad (2018). Their research has focused on the effectiveness of gamification techniques in improving students' engagement. Another study by Catal et al. (2020) investigated the effectiveness of the evacuation training system using augmented reality. Regarding acceptance of technology, Yoo et al. (2017) studied the factors that affect the adoption of gamified tourism applications. Another research determined the acceptance of gamified training among instructors (Vanduhe et al., 2020). Kulikajevs and Blažauskas (2020) developed a mobile application to visualize the course of action of an algorithm and reflect

changes made in source code. Salomao et al. (2019) proposed a model for ubiquitous care of anxiety and depression patients via gamification.

However, most of the studies adopted users' motivational level improvement as their primary focus for the research objective. Users' motivation predominantly affects other factors such as the adoption of gamification, users' intention, and users' enjoyment. Another beneficial aspect of gamification is in improving user communication and participation (Al-Qaysi et al., 2020). Other relevant gamification strategies, such as interactive narratives, character self-representation, and onboarding tutorials, have increased the acceptance of gamification (Klock et al., 2020). Therefore, gamification makes the routine activity more enjoyable while also retaining users' involvement.

2.10.2 Extent of Usage Using TAM for Evaluation

Recent studies have used TAM in predicting the usage of gamification among users.

Table 2.2 shows the summary of TAM evaluation usage in the studies.

Table 2.2: The extent of TAM in predicting the usage of gamification

Factor	Authors
Perceived of usefulness	Rusli & Prasetyowati (2018), Rodrigues et al. (2016), Yoo et al. (2017), Rahman & Ahmad (2018), Rahi & Ghani (2019), Kulikajevs & Blažauskas (2020), Aydin (2018), Vanduhe (2020), Salomao et al. (2019), Catal et al. (2020), Oluwajana et al. (2019), Dick & Akbulut (2020), García-jurado et al. (2018)
Perceived ease of use	Rusli & Prasetyowati (2018), Rodrigues et al. (2016), Yoo et al. (2017), Rahman & Ahmad (2018), Kulikajevs & Blažauskas (2020), Aydin (2018), Vanduhe (2020), Salomao et al. (2019), Catal et al. (2020), Oluwajana et al. (2019), Dick & Akbulut (2020), García-jurado et al. (2018)
Enjoyment	Rodrigues et al. (2016), Yoo et al. (2017), Rahman & Ahmad (2018), Kulikajevs & Blažauskas (2020), Aydin (2018), Catal et al. (2020), Oluwajana et al. (2019), Dick & Akbulut (2020), García-jurado et al. (2018)
Intention to use	Rodrigues et al. (2016), Yoo et al. (2017), Rahman & Ahmad (2018), Rahi & Ghani (2019), Kulikajevs & Blažauskas (2020), Aydin (2018), Vanduhe (2020), Catal et al. (2020), Oluwajana et al. (2019), Dick & Akbulut (2020), García-jurado et al. (2018)

Most of the studies conducted the test on perceived usefulness and ease of use in their application. Overall, the results showed that perceived usefulness and perceived ease of use were the strongest determinants of the adoption and enjoyment of using gamified applications. Moreover, perceived usefulness has emerged as a strong determinant of users' motivation and satisfaction (Granić & Marangunić, 2019). Besides, playfulness and enjoyment are also important factors in adopting gamification in various domains.

2.10.3 Domain

Concerning the research domain, it determines which domains are unexplored by the researcher. Table 2.3 shows the summary of domains for the studies.

Table 2.3: Description of domains of studies

Domain	Authors	Description
Education	Rusli & Prasetyowati (2018)	Support students' campus activities and routines.
	Rahman & Ahmad (2018)	Lessons accompanied with two gamification platforms such as Kahoot! And Quizizz.
	Kulikajevas & Blažauskas (2020)	A serious game for teaching algorithmic problems.
	Vanduhe (2020)	Integration of online gamification platform, Moodle for training the instructors in university.
	Catal et al. (2020)	Augmented reality in training evacuation education.
	Oluwajana et al. (2019)	Gametize the platform to create a gamified learning environment.
	Dick & Akbulut (2020)	ERPsim game provides information for decision-making among the students.
Internet banking	Rodrigues et al. (2016)	Integration of business application, FutuBank for e-banking process.
	Rahi & Ghani (2019)	Improve users' intention to adopt internet banking through gamification.
E-commerce	Aydin (2018)	Factors that affect intention to adopt gamified systems.

	García-jurado et al. (2018)	The extent of gamification in affecting behavioral intention among millennials and generation X to use e-commerce platforms.
Tourism	Yoo et al. (2017)	Focused on creating smart tourism applications with game elements.
Healthcare	Salomao et al. (2019)	Ubiquitous care for patients with depression and stress disorders using gamification.

Most gamification with TAM studies was primarily focused on education. For instance, Rusli and Prasetyowati (2018) focused on supporting students' activities and campus routines through their gamified application. Additionally, four studies attempted to improve the learning environment for the students via gamification (Dick & Akbulut, 2020; Kulikajevs & Blažauskas, 2020; Oluwajana et al., 2019; Rahman & Ahmad, 2018). One study tried to improve the training evacuation system using augmented reality (Catal et al., 2020).

The next domain is internet banking (Rahi & Ghani, 2019; Rodrigues et al., 2016). The studies focused on improving the users' experience with e-banking. The study by Aydin (2018) and García-jurado et al. (2018) on e-commerce analyzed the factors for the users to adopt gamified e-commerce. Other disciplines such as tourism and healthcare have only one study respectively. For the tourism discipline, Yoo et al. (2017) developed a smart tourism application. Salomao et al. (2019) studied the health domain and developed a gamified health system for depression and stress disorder patients.

In addition, the findings also revealed that most of the studies were primarily focused on education. These results support the review conducted by Trocky and Buckley (2016), which found that most reviewed studies about gamification focused on education as

it is easier to implement gamification into the learning experience. The other disciplines, however, are still in the infancy stage.

2.10.4 Gamification Elements

Regardless of the application context, gamification utilizes various game features to elicit a positive response from users (Hamari et al., 2018). However, different terminologies were used to describe a typical game element. For example, points and scores could have the same meanings. Although this is a well-known problem for the gamification topic in general (Klock et al., 2020), the following game elements from the studies were standardized based on the authors' definitions:

- **Avatar:** A user's representation in virtual worlds. It is also defined as a fictitious character in games within the game story context (Sailer et al., 2017).
- **Badges:** A graphical illustration of the user's accomplishments (Sailer et al., 2017).
- **Feedback:** Users are provided with relevant information. Some authors refer to it as feedback (Zaric et al., 2020).
- **Leaderboard:** Orders players based on specific parameters (e.g., points, levels, badges), interpreting the other game elements to compare the other users. This term is also referred to as ranking (Zaric et al., 2020).
- **Level:** Monitor the player's progress through the system over time, aided by visualization such as a progress bar (Zaric et al., 2020).
- **Narrative:** Plots that bind other game elements. Aside from a sequential or unfolding series of events or stories, it covers various themes and contexts (Klock et al., 2020).

- **Points:** Feedback in the form of a number when the user performs a particular action.

It is also known as experience points because it is gained as the knowledge and progress of users are constantly growing (Carrión-Toro et al., 2020).

- **Strategy:** Requires the user to devise a strategy for minimizing opportunities or minimizing losses and damages (Klock et al., 2020).

The studies by García-jurado et al. (2018), Salomao et al. (2019), Rusli and Prasetyowati (2018), Rodrigues et al. (2016), Oluwajana et al. (2019), Dick and Akbulut (2020), and Rahman and Ahmad (2018) adopted points as a game element. It acts as a prize or reward once the users perform certain actions. Points have been widely used in many gamified applications. Attaining several points motivates the users to complete the tasks with a better score. On the other hand, four studies by Vanduhe (2020), Rusli and Prasetyowati (2018), Rodrigues et al. (2016), Oluwajana et al. (2019), and Rahman and Ahmad (2018) used leaderboard as their gamified solution. Leaderboards encourage users to outperform their counterparts. It creates a competitive environment among users. As a result, they are compelled to play and win the game.

Moreover, Vanduhe (2020), Salomao et al. (2019), Rusli and Prasetyowati (2018), and Oluwajana et al. (2019) used badges for a representative of collectible prize for each completed task. Like points, badges encourage players to keep going to reach their next goal. Several studies implemented levels in their gamified applications (Dick & Akbulut, 2020; Oluwajana et al., 2019; Vanduhe et al., 2020). Game levels motivate the users to progress and achieve their objectives. They can also monitor their progress and how far they have attained and are motivated to unlock more achievements.

Meanwhile, points, leaderboards, and badges were among the most dominant gaming elements used. Other game elements such as avatars, feedback, narrative, and strategy also are integrated into the studies to encourage the involvement of users in gamification. However, these game elements were not as widely used as points, leaderboards, and badges.

Nevertheless, the researchers argue that the prevalence of these three gaming elements in gamified applications is merely used as pointification (Murillo-Zamorano et al., 2021). Despite that, the researcher prefers these three gaming elements because they are easy to incorporate (Sailer et al., 2017). However, Zaric et al. (2020) stated that these three gaming elements have little effect on users' motivation. Rather, these three game elements are merely measures of progress. Table 2.4 summarizes game elements used in the studies.

Table 2.4: Game elements in studies

Game elements	Authors
Avatar	Rodrigues et al. (2016)
Badges	Vanduhe (2020), Salomao et al. (2019), Rusli & Prasetyowati (2018), Oluwajana et al. (2019)
Feedback	Salomao et al. (2019), Catal et al. (2020)
Leaderboard	Vanduhe (2020), Rusli & Prasetyowati (2018), Rodrigues et al. (2016), Oluwajana et al. (2019), Rahman & Ahmad (2018)
Level	Vanduhe (2020), Oluwajana et al. (2019), Dick & Akbulut (2020)
Narrative	Oluwajana et al. (2019)
Points	García-jurado et al. (2018), Salomao et al. (2019), Rusli & Prasetyowati (2018), Rodrigues et al. (2016), Oluwajana et al. (2019), Dick & Akbulut (2020), Rahman & Ahmad (2018)
Strategy	Kulikajevs & Blažauskas (2020), Dick & Akbulut (2020)

2.10.5 Benefits of Gamification

Several studies discussed the benefits of gamification implementation. Gamification aims to restructure the playful elements of game activities. It turns a usual dull task into a more exciting, competitive, and interactive experience. In turn, this motivates the users to

engage in serious activities (Díez-Pascual & Díaz, 2020). The fun gameplay and continuous feedback may positively affect users' emotional feelings and increase their satisfaction and self-esteem (Dick & Akbulut, 2020). It also encourages and motivates the users (Dick & Akbulut, 2020; Oluwajana et al., 2019; Rahman & Ahmad, 2018; Rusli & Prasetyowati, 2018). These factors lead to positive behavioral change while they stay engaged in serious settings.

Besides, many studies reported that the presence of game elements could be of great assistance in maintaining the usage of the application (Catal et al., 2020; García-jurado et al., 2018; Rahi & Ghani, 2019; Rahman & Ahmad, 2018; Rodrigues et al., 2016; Vanduhe et al., 2020; Yoo et al., 2017). Furthermore, gamification keeps a high participation level from users (Rahman & Ahmad, 2018). Similarly, graphic aesthetics and game mechanics encourage simulation and player participation while providing a fun experience and entertainment (Yoo et al., 2017). Not only that, but gamification also helps players to experience satisfaction and extrinsic motivation via points and rewards.

Moreover, gamification helps to encourage users' intention to continually use the gamified application (Aydin, 2018; García-jurado et al., 2018; Kulikajevs & Blažauskas, 2020; Rahi & Ghani, 2019; Rodrigues et al., 2016; Vanduhe et al., 2020). Promoting game mechanics and creating entertaining gameplay help to make the application easier to use and accessible. Another advantage of the gamified application is in health monitoring, where it helps to improve health conditions and lifestyle (Salomao et al., 2019). For example, gamification assists individuals with chronic illnesses by improving adherence to medicine and treatment programs (Gmez-Portes et al., 2020). Table 2.5 shows the summary of the benefits of gamification and TAM in the studies.

Table 2.5: List of benefits from gamification for users

Benefits	Authors
Encourage and motivate users	Rusli & Prasetyowati (2018), Oluwajana et al. (2019), Dick & Akbulut (2020), Rahman & Ahmad (2018)
Increase the users' intention to use the application	García-jurado et al. (2018), Vanduhe (2020), Kulikajevs & Blažauskas (2020), Rodrigues et al. (2016), Aydin (2018), Rahi & Ghani (2019)
Improve users' health condition	Salomao et al. (2019)
Increase users' satisfaction	Dick & Akbulut (2020)
Increase users' acceptance of gamified application	García-jurado et al. (2018), Vanduhe (2020), Rodrigues et al. (2016), Rahman & Ahmad (2018), Catal et al. (2020), Yoo et al. (2017), Rahi & Ghani (2019)

2.11 Challenges and Research Opportunity

The idea of adopting gamification to motivate users is not new. Gamification apps have been a successful intervention for motivating and increasing users' participation. Nonetheless, there are still possible research routes for future research. First, the ability of existing applications can be expanded to support users from diverse backgrounds. For instance, in an education setting, gamified applications focus on students and help teachers or parents create a gamified learning environment. In the end, focusing on these groups of users will support the intended users to achieve their objectives, encourage positive behavior, and improve the overall users' work outcomes.

Secondly, the gamification evaluation method may be improved when applied to a specific domain. To fully evaluate the gamified applications in terms of viability, usefulness, and practicality in a real-world setting, a large-scale assessment of larger groups of users is needed (Tuah et al., 2021). It is recommended to use longitudinal studies toward focus group participants. The extensive evaluation will create substantial validation of the effectiveness

of gamification in various domains. Vanduhe (2020) and Dick and Akbulut (2020) made this recommendation based on their analysis. Therefore, it is feasible to develop more robust gamified applications based on rigorously validated research.

Third, future research should concentrate on augmenting the gamification features. These gamification augmentations will expand the original application features and capabilities. Besides, one of the persistent ways of maintaining or improving individuals' motivation is to create a customized game tailored to the individual's condition (Klock et al., 2020). With customizable game content, it is easier for the users to adapt to the gaming environments. Integration of social features into gamified applications is a great addition because it can boost the users' motivation further (Tuah et al., 2021).

However, with emerging opportunities, there are several challenges exist. The adoption of gamification technology is one of the clear challenges that has been consistently discussed. Nowadays, gamification technology has undergone rapid changes hence gamification applications are no exception. With constant changes in gamification, developers face several challenges to implement gamification effectively. They need to choose the right gamification techniques with gaming elements to develop practical, cost-effective, and low maintenance cost applications. Thus, it is a requirement for experts' involvement to help to develop a more robust gamified application.

Other challenges come from target users. There are groups of users that are not familiar with technology, let alone the gamification concept. They are transitioning from conventional, low-tech interventions to advanced interactive, gamified applications. It is not easy for them to adapt to this new technology. There is a need to organize training sessions to counter such problems. Additionally, the gamified application's interface has to be simple

yet packed with useful information for the users to quickly learn and adapt to the applications (Darejeh & Salim, 2016).

2.12 Open Research Issues

Several studies such as De Souza Gaspar et al. (2020), Rajani et al. (2021), and Tuah et al. (2021) mentioned various issues regarding the implementation of gamification. The fact that a significant amount of work has been done to address the problem of adopting gamification in various disciplines. The emerging issues are discussed below.

2.12.1 Game Elements

A combination of various game elements can stimulate better interaction between the user and the game elements. The first step towards gamification is to incorporate game elements into the learning experience. Research that has studied gamified applications has used multiple game elements to motivate users in different contexts (Bovermann & Bastiaens, 2020). However, despite its potential benefits, there are well-known drawbacks in retaining users' participation and maintaining the newly adopted behavior over time.

This issue arises from two typical mistakes: basic game features that are overlooked during the design process and a one-size-fits-all approach to producing game content (Khoshkangini et al., 2021). The first issue is that most gamified applications only concentrate on the surface layer of gamification features, such as points, badges, and leaderboards. However, these features do not utilize the full extent of games in improving players' engagement and motivation. The latter issues contribute to a lack of personalization, as the game content offered to the players does not consider their unique abilities, skills, or interests (Klock et al., 2020). These problems, when combined, can cause players to become bored or eventually frustrated.

Challenging yet realistic objectives and rewarding achievements have empirically been proven successful in maintaining players' attention and interaction over time. Nonetheless, they do require a considerable amount of effort and creativity from game designers. To achieve this, game designers must create new challenges periodically and match the game objectives to the game campaign, balance in-game rewards with goals, and specify task criteria based on player demographics (Sardi et al., 2017).

2.12.2 Evaluation Period

The evaluation period is the duration to validate the gamified application in terms of usage and purpose towards the specified users (Tuah et al., 2021). It is a crucial period to determine whether the gamified application truly brings any benefits. However, the limited duration of the evaluation period often brings a threat to the study result's legitimacy. Often, during the short testing period that mainly lasted three weeks, the researchers can perceive the persistent commitment from users and understand the efficacy of their proposed application (Tuah et al., 2021). Nevertheless, it is not feasible to conclude the gamification effect in long-term usage and engagement from such a short period. Therefore, experiments need to be conducted thoroughly over a sufficient amount of time to obtain a more viable result.

2.12.3 Personalization

Gamified applications often take into account various factors such as players' skills, game status, and objectives to create customizable game content. However, the created playable content often lacks consideration for the player's characteristics and physiological signals. These two factors are commonly used in the digital games industry for personalization features and to increase users' engagement (Khoshkangini et al., 2021).

Player characteristics include classifying users based on game preferences and playing styles (Vahlo et al., 2017). The most commonly studied characteristics include behavior, gender, age, player topology, and personality traits. Physiological signals can be represented in a variety of ways to convey their meaning, such as the player's ability to handle challenges, make precise task choices, and improve their game-playing habits (Pasqualotto et al., 2022). Therefore, there is a need to implement a framework that can classify player types. Despite this, players' views towards game functionality are always different, leading to users frequently abandoning games due to complicated or uninteresting features. To overcome this issue, a model that can choose the right gaming features according to the user profile is favorable.

2.12.4 Reward system

The implementation of providing rewards in the game design has a positive impact on the engagement and behavior of users (Cheng, 2020). Many studies have implemented badges, points, and leaderboards as a solution for their gamified applications (Obaid et al., 2020). These game elements, such as challenges, can provide players with rewards and increase their in-game status (for example, rising levels or earning achievements). However, some critics argue that these game elements are simply a means of scoring and do not necessarily motivate the user to continue playing and learning or demotivate the user (Obaid et al., 2020).

Despite these criticisms, many studies have adopted these game elements into their game designs due to their simplicity of implementation (Govender & Arnedo-Moreno, 2021). Therefore, a new framework is needed to analyze player modeling and individual play style to recommend a better reward system. For example, using a new framework can

enable the game to generate better reward challenges, improve the tailoring of administered challenges, and reward users based on their motivation and completed objectives. Furthermore, game design should also cater to users who are not intrinsically motivated. A motivated user's reaction to a gaming approach will often vary from those who are not motivated to play games. This gamified solution can help both types of users, inherently motivated and non-motivated users, to engage in gamification.

2.12.5 Evaluation Using TAM

The TAM has been widely used by researchers due to its simplicity (Al-Qaysi et al., 2020). However, TAM has several limitations when evaluating technology adoption. One limitation is its insufficient explanation of users' behavior, particularly for mobile use or social influence (Malatji et al., 2020). For example, the model is not able to adequately predict technology acceptance specifically in the context of e-government (Malatji et al., 2020). Besides, TAM is not accurate in predicting the perceived usefulness, especially in the context of gamification that focuses on entertainment rather than problem-solving (Weng et al., 2018). The users often use the gamified app for enjoyment and to pass time, making the perceived usefulness not applicable in this case.

Moreover, another limitation is concerning variables used to pertain to users' behavior. The example of a variable is represented via subjective means such as interpersonal influence. Interpersonal influence is a way to influence a person via word of mouth either from a colleague or a friend (Kowalczyk-Anioł & Nowacki, 2020). However, using subjective means is unreliable. It may be fabricated to rely on friend argument as a social influence to influence a person on adopting the new technology (Graf-Vlachy et al., 2018). Users' behavior is affected by a number of subjective factors such as norms and

values of societies, personal attributes, and personality traits (Granić & Marangunić, 2019). Even though it may apply to individual utilization, the theory is not credible to adopt in a serious environment (Malatji et al., 2020).

Furthermore, the original TAM does not consider additional factors that may influence the behavior such as age and education. The exclusion of these factors may affect behavior prediction, as these hidden personality traits such as personal motivations (Kim et al., 2016), psychological characteristics (Borghouts et al., 2021), or emotional states (Lu et al., 2019) often drive users' behavior. For instance, individual differences in openness to new experiences or risk aversion may determine how users engage with gamified applications (Triantoro et al., 2020). As a result, researchers have proposed extensions of TAM to include these external factors, improving the model's adaptability and accuracy in predicting technology adoption (Alghazi et al., 2020).

In conclusion, while TAM has been widely used in technology adoption research, it has several limitations that need to be considered when evaluating technology adoption, particularly in the context of gamification. Researchers have proposed extensions to the model to address these limitations and improve its accuracy in predicting technology adoption. As technology and the use of gamification continue to evolve, it is important to consider the limitations of the model and adapt it accordingly.

2.13 Gamified COVID-19 Mobile Apps

11 studies on gamified COVID-19 mobile applications are compared in terms of participants, aims, game elements used, and outcomes. Table 2.6 is a summary of relevant studies on gamification in COVID-19 applications.

Table 2.6: Comparison between the current study on gamified COVID-19 applications

Mobile app and authors	Participants	Objectives	Game elements	Outcomes
Plague Inc (Peng & Bai, 2021)	Residents of Taiwan	To investigate the effects of gameful experience on public knowledge, attitudes, and practices regarding COVID-19	Progress bar, score, leaderboards, points, feedback	Participants showed higher levels of knowledge and attitudes toward COVID-19
MeetDurian (Chen et al., 2022)	Students	To improve users' hygiene habits during the COVID-19 pandemic	Points, feedback	The results proved the acceptability and usability of the mobile app for preventing the infection of COVID-19
Escape of COVID-19 (Suppan et al., 2020)	Hospital staff within the Geneva University Hospital	To promote the dissemination of COVID-19 IPC practices among the hospital employees	Levels, points, feedback	The game successfully promotes safe behaviors among hospital employees during the COVID-19 pandemic
COVID-19 – Did You Know? (De Souza Gaspar et al., 2020)	Open community in Brazil	To provide information regarding the prevention of COVID-19 and personal care during the pandemic	Progress bar, leaderboard, feedback, badges, score	The mobile app successfully provides reliable information on topics related to the prevention of COVID-19
N/A (Yoon et al., 2021)	Frontline workers	To explore frontline workers' experience and their perceptions of the usefulness and features of	Badges, progress bar, scores, competition	The results showed that the frontline workers perceived the usefulness of mHealth apps

		mHealth apps for promoting well-being		for promoting well-being
Elena+ (Ollier et al., 2021)	Public users	To implement the best practices for the public during COVID-19	Badges, progress bar, feedback	N/A

All of the studies reviewed in this section aimed to promote COVID-19 interventions to the general public by increasing users' motivation and engagement through the use of gamification. Some researchers utilized existing mobile applications while others developed their own. In most cases, the gamified application was well-received by participants, deemed effective and engaging, and delivered a positive user experience.

Digital health solutions can be an effective method of combating COVID-19 by supporting institutions and promoting information dissemination (De Souza Gaspar et al., 2020). During a pandemic, it is crucial to provide clear and objective information to the intended population at the appropriate time. Efforts to offer COVID-19 interventions as a gamified activity have been successful in most research, with users viewing gamified mobile apps as beneficial for expanding their knowledge of COVID-19. The implemented gamification method has been shown to be an effective tool for disseminating pandemic information and engaging users.

One study, by Ollier et al. (2021), provided the theoretical foundations underlying the gamification method. The authors used several theory-driven and applied methods to promote engagement and enhance the delivery of pandemic lifestyle health outcomes during the COVID-19 pandemic. The most prevalent game components included competition, such as leaderboards and points, which resulted in increased user participation and enhanced

promotion of COVID-19 interventions. Most studies also used feedback and badges to recognize appropriate behavior.

While gamification has been shown to be an effective tool for promoting engagement and motivation, it is important to consider the potential drawbacks. Some studies have suggested that competition may affect extrinsic motivation more than intrinsic motivation, diminishing intrinsic motivation. However, most studies found that users still had favorable feelings associated with intrinsic motivation, even when competition was present. Yoon et al. (2021) discovered that some frontline employees were hesitant to use the gamification function, believing that competitiveness through scoring may be demoralizing and counterproductive when colleagues fell behind. Nevertheless, gamification can be used in combination with COVID-19-focused software to boost users' engagement. As the health sector continues to adapt to the challenges posed by COVID-19, technology-enhanced learning efforts will likely become more widespread and gamification may be viewed as a means of maintaining users' engagement.

2.14 Challenges of mHealth and COVID-19 Apps

The COVID-19 pandemic illustrates the difficulties of finding a single technological solution to a global problem. To increase the acceptability of digital technology, it is essential to take into account the diverse cultural, moral, and religious backgrounds of users (Fagherazzi et al., 2020). Digital measures can be perceived as intrusive and may raise concerns about individual liberties, particularly when collective public health benefits and maintaining local social order are prioritized during a crisis (Pan, 2020). It is important to consider these ethical implications when implementing digital solutions and ensure that they respect individuals' rights and cultural sensitivity.

2.14.1 Universal Solution

The COVID-19 crisis has highlighted the complexities of establishing a single, universal technological solution for a specific circumstance. To increase the acceptability of digital technology, it is necessary to take into account the diverse cultural, moral, and religious backgrounds of users (Fagherazzi et al., 2020). Despite this, there are still significant digital barriers in many countries, and vulnerable populations may be overlooked during the implementation of digital solutions (Mackert et al., 2016; Gamble et al., 2020). Individuals with limited health literacy, the elderly, and those living in rural or low-income areas may find it more challenging to understand and use digital solutions (Nguyen et al., 2017). The perception and effectiveness of digital efforts can also vary depending on whether they are implemented in high-income, middle-income, or low-income communities (Ferretti et al., 2020).

In developing countries, there are significant obstacles to implementing digital health solutions, particularly in rural and remote regions. These regions often lack digital infrastructure and long-term funding for the creation, operation, and maintenance of digital platforms (Mahmood et al., 2020; Muinga et al., 2020). These challenges must be taken into consideration when developing and implementing digital health solutions, to ensure that they are inclusive and accessible to all. Ultimately, creating a universal technological solution for a specific circumstance requires a comprehensive understanding of the diverse cultural, moral, and religious backgrounds of users, as well as the digital barriers and infrastructure in different regions.

2.14.2 Misused of Game Elements

In a recent study, participants expressed limited enthusiasm for the utilization of gamification as a nudge technique for boosting self-efficacy. Virtual rewards, such as

badges, which were intended to stimulate people's competitive natures, were generally perceived unfavorably (Galen et al., 2021). On the other hand, app-based resources, such as mindfulness-based activities and brief wellness articles, were scored highly as a well-liked and effective method of promoting a healthy lifestyle (Xu et al., 2022).

The adoption and sustained engagement of mHealth apps pose several key issues that must be considered (Baretta et al., 2019; Canhoto & Arp, 2017). According to Kayyali et al. (2017), users often stop using mHealth apps after a single use, despite their usefulness. This finding is consistent with past research and highlights the importance of a simple user interface in mHealth applications (Vaghefi & Tulu, 2019). To successfully adopt a mHealth app, it is essential to not only emphasize the benefits and relevance of the digital health app but also the transparency of data management.

Previous studies have also suggested that external incentives can increase the likelihood of users utilizing a wellness app (Mitchell et al., 2017). To maintain engagement, it may be beneficial to investigate elements of the app that can be modified to improve incentive efficacy, such as the type of incentive and reward timing. In order to increase the adoption and sustained engagement of mHealth apps, it is important to consider both the user experience and the incentives provided.

2.14.3 Users' Privacy and Data

As the COVID-19 epidemic persists, digital health technologies have increasingly been recognized for their advantages in the healthcare sector. However, with the scale at which these technologies are being implemented, there are also notable ethical concerns regarding privacy and data protection (Martinez-Martin & Kreitmair, 2018). A growing amount of sensitive health information is now being shared and maintained through technology, particularly through the use of telehealth and health apps (Martinez-Martin et

al., 2020). Unfortunately, these technologies do not always provide adequate protection for this information, leading to significant problems such as the exchange of personal information through digital health solutions (Singh et al., 2020). Additionally, there are concerns about potential government data abuse and spying. Research has shown that developers of health apps engage in misleading privacy and data practices, such as sharing users' personal information with third parties without their knowledge (Huckvale et al., 2019). Behavioral health information is a valuable commodity, and businesses may exploit the current security and privacy environment (Attaran, 2022). By utilizing behavioral inferences drawn from individuals' personal information, marketing campaigns could potentially be crafted to capitalize on people's anxieties about COVID-19. As trust in telehealth and mental health apps increases, it is essential to establish accountability and mechanisms to minimize illegal or unanticipated use of health data. Figure 2.3 illustrates the obstacles that arise while implementing mHealth and COVID-19 apps.

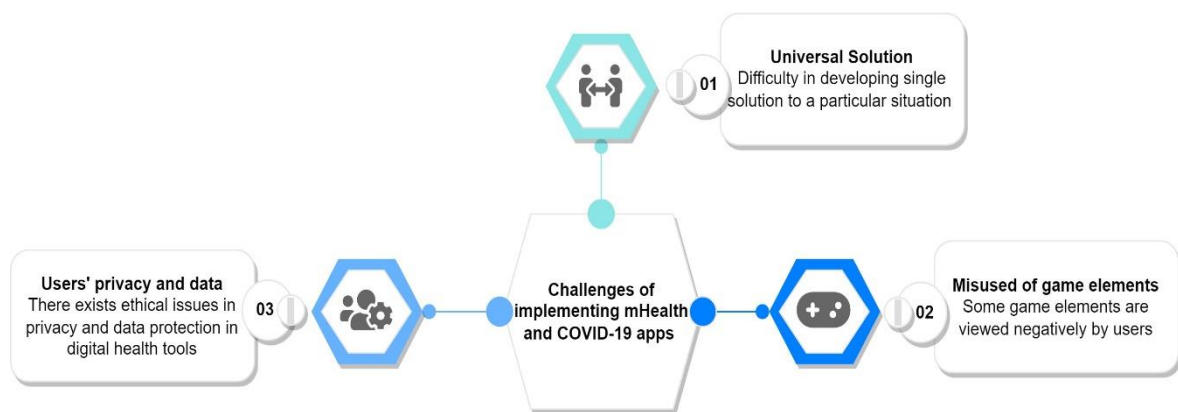


Figure 2.3: Summary of challenges in implementing mHealth and COVID-19 apps

2.15 Future Directions of mHealth and COVID-19 Apps

The rapid spread of COVID-19 has highlighted the need for effective health technology solutions. In response, telemedicine and telemonitoring platforms have been

widely adopted in hospitals and general offices. However, in light of the rapidly evolving information related to COVID-19, it is crucial to explore ways to uniformly update these solutions through open communication and comparability. This is necessary to ensure that all populations have access to and can use this information for research or evaluation (Fagherazzi et al., 2020).

While digital health technologies are being investigated to help with health and pandemic monitoring, it is essential to ensure their long-term integration into national healthcare systems, with the exception of emergencies. COVID-19 digital efforts must be relevant to both hospital and public health systems, population-adapted, readily deployable, and able to evolve alongside the COVID-19 body of knowledge.

As the COVID-19 pandemic entered its endemic phase, governments should have adopted mobile apps to facilitate a middle-ground vaccination and reopening of economies plan (B. Lee et al., 2021). While existing research is uncertain about the impact of contact-tracing apps in the event of a future outbreak (Akinbi et al., 2021), it is clear that these technologies have helped to limit the spread of the virus since the beginning of the epidemic (Hernandez-Orallo et al., 2020). Therefore, it is likely that similar applications may be used again in the event of future disease outbreaks.

In the fight against COVID-19 and future pandemic outbreaks, it is crucial to explore and utilize innovative technologies to help manage and contain the spread of the virus. Researchers have proposed the use of less invasive and privacy-preserving technologies such as Artificial Intelligence (AI) and Machine Learning (ML) to aid in related efforts (Lalmuanawma et al., 2020; Pham et al., 2020; Vaishya et al., 2020). In addition, Yang et al. (2020) suggested the Internet of Medical Things (IoMT) as a means to track positive cases and control the COVID-19 infection or future infectious illness epidemics. Other than that,

Zhang et al. (2021) proposed the usage of blockchain-based medical applications to protect the confidentiality of contact tracking data.

However, before incorporating these technologies into the general population, it is crucial to understand human behavior and attitudes towards their use. Researchers should investigate a variety of theories and models, such as the technology acceptance model, innovation diffusion theory, theory of reasoned action, health belief models and theory of planned behavior, social cognitive theory, and motivation theory, that can be used to examine the adoption and application of future contact tracing devices (He et al., 2021).

In addition to technical considerations, it is also important to address ethical and legal concerns related to the use of these technologies. The government, developers, decision-makers, and public health authorities must ensure that effective protections are in place to prevent harm and reduce risks in the battle against future pandemics (Gasser et al., 2020). Moreover data collected by these apps should only be used to support public health initiatives and the source code should be made publicly accessible for review (Lucivero et al., 2020). Additionally, the data should only be collected with the permission of individuals and systems should be designed to allow for data deletion when the pandemic is over (Abbas & Michael, 2020; Ahmed et al., 2020). Overall, Figure 2.4 provides a summary of the future directions of mHealth and COVID-19 applications.

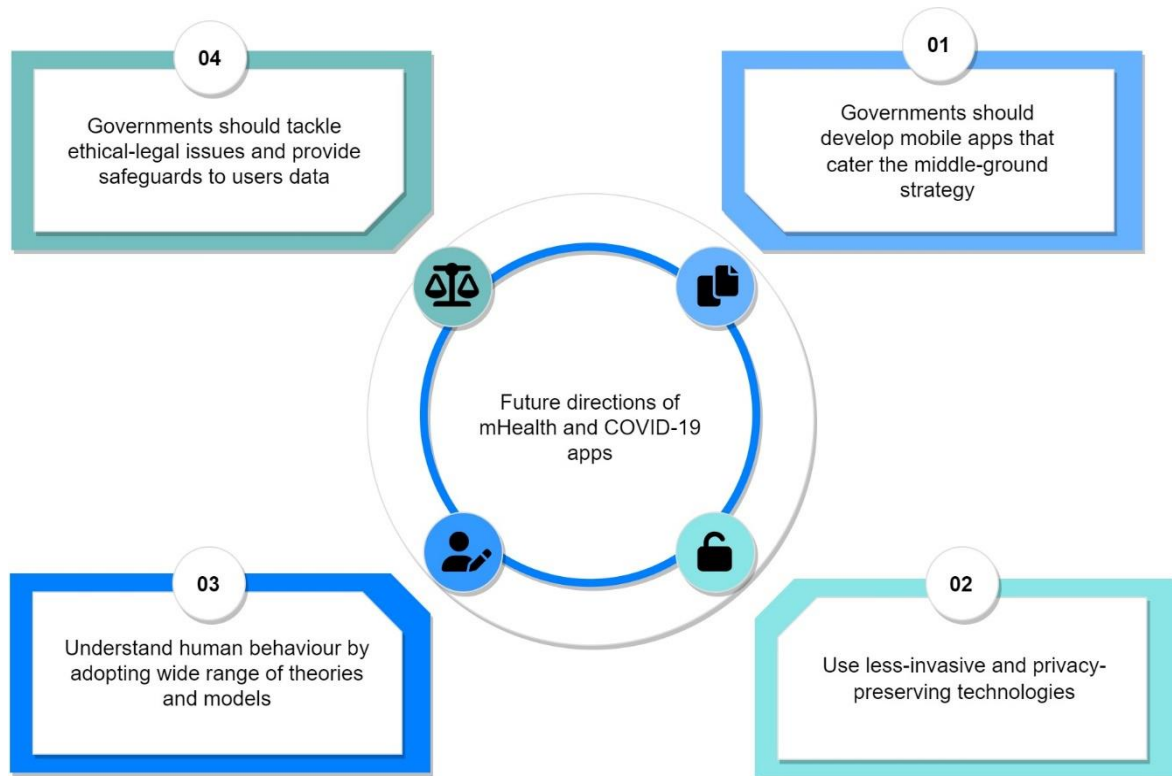


Figure 2.4: Summary of future directions

2.16 Conclusion

In conclusion, this chapter discusses the previous study on gamification and TAM research. Gamification has brought various forms of positive effects to the studied domains. The literature review has provided valuable insights into the potential of gamification and users' engagement in the context of COVID-19 initiatives. This chapter also discussed a general overview of TAM, its weaknesses, and the modification of TAM. Moreover, details on gamification and gamification TAM-based research also have been discussed thoroughly. The TAM has proved to be capable of measuring the usefulness, ease of use, enjoyment, and intention of users. Therefore, incorporating TAM with gamification may give an overview of how far the effectiveness of the gamified solution is towards the users' engagement.

CHAPTER 3

METHODOLOGY

3.1 Overview

The main goals of this chapter are to explain the rationale of using a quantitative approach, the strategy behind the selection of constructs to build conceptual models and compare the previous framework and current framework of engagement. This chapter will provide an in-depth explanation of the methodology, detailing the research design, participant recruitment process, data collection methods, and analysis procedures used to address the study's research questions and objectives. This chapter also presents several designs of user interfaces and flowcharts of the gamified COVID-19 mobile applications. The chapter concludes by laying out planned data analysis such as using Statistical Package for Social Sciences (SPSS) and Analysis of Moment Structures (AMOS) to test hypotheses and validate the proposed conceptual model.

3.2 Research Methods

A quantitative approach using a questionnaire will be used for this study. The quantitative technique was most suited for this study as it attempts to determine whether or not there are any measurable relationships between variables. This research will focus on determining if gamification can increase the user's engagement towards practicing the preventive measure of COVID-19 via extended TAM.

The process of research method consists of several processes: identification of the problem, studying existing literature to support the statement, construction of a proposed model, preparation of research instruments, testing phase, data collection, data processing,

and analysis, and conclude the study. The testing phase consists of participants using the gamified application for 3 weeks. The selection of participants will be based on the inclusion criteria. The gamified application will display the daily tasks about the preventive measure for COVID-19 for the participants to follow. The user obtains rewards such as points if they complete a task listed in the application.

3.3 Conceptual Model

Based on the previous research, several factors will affect the effectiveness of gamification on users' behavior. The main factors are gamification, perceived usefulness, perceived ease of use, attitude, participation, and engagement. These factors are determined based on the study that focuses on gamification and uses TAM as its conceptual model. This research aims to extend the original TAM theory to determine the effectiveness of gamification in influencing the user's behavior in following the preventive measure for COVID-19.

3.4 Building the Conceptual Model

The conceptual model is developed by adopting and adapting the previously proposed model in previous research. The approach taken in this study is to adopt other research TAM models and change the context to fit into the current study, rather than inventing a new model. The TAM was selected as the base model for this research because it is the most appropriate theory. The TAM theory mainly focuses on the acceptance of the system and is able to measure the attitude of users towards the system (Yang et al., 2021). One of the outcomes of this study is the creation of an extended TAM model that can predict the effectiveness of gamification in increasing the users' engagement to follow the preventive measure for COVID-19.

3.4.1 Choosing Already Validated Constructs

The TAM theory by Davis et al. (1989) have offered a theoretical framework for effectively predicting the intents and determining technological acceptance. Due to the flexibility in TAM theory, it can be adapted into research and introduced with a new construct. As such, it is one of the most influential research models. To adapt TAM to suit the context of this study, the model has been extended with additional validated constructs such as gamification perceived ease of use (GEOU), gamification perceived usefulness (GPU), and attitude towards using gamification (ATUG). These constructs are crucial for evaluating how users interact with and perceive the gamified COVID-19 application. By incorporating these validated constructs, the extended TAM model improves its ability to predict users' engagement by assessing not only the technical usability of the app but also how users perceive its usefulness in managing COVID-19 preventive measures. This extension allows for a more comprehensive understanding of how gamification drives user behavior, providing deeper insights into the factors that influence their participation in preventive measures. Utilizing the flexibility of TAM and extending it with these constructs ensures a more accurate conceptual model, providing a reliable measure of both technology acceptance and behavioral intention.

Many previous researches have verified the validity of TAM constructs to measure users' engagement (García-jurado et al., 2018; Mee Mee et al., 2021; Y. Yang et al., 2017). Three TAM constructs and users' engagement as extended construct were adopted from the previous studies done by Oluwajana et al. (2019) and Rahman and Ahmad (2018). These measures have a well-established theoretical basis and have demonstrated strong construct validity and reliability.

3.4.2 Gamification Perceived Ease of Use

Perceived ease of use was one of the two initial constructs investigated in Davis's (1989) TAM theory, and it has been one of the main constructs in all subsequent TAM research. The definition of the construct defines that technology is effortless in terms of physical and mental effort. Davis et al. (1989) originally defined the constructs as "the degree to which a person believes that using a particular system would be free of effort". Perceived ease of use plays important role in TAM-related studies as it has been tested to positively affect perceived usefulness. The gamification perceived ease of use is adopted from the GAM by Rahman and Ahmad (2018) denoted as the degree to which the students expect the gamification to be free of effort. As such, the context of this study focuses on the user's belief that the usage of gamification should be free of effort.

Gamification Perceived Ease of Use is defined as 'the degree to which the users expect the gamification to be free of effort. Therefore, integrating gamification in mobile will lead to the users' belief the gamification is easy to use and does not hinder their experience to follow the preventive measure for COVID-19. Thus, the proposed hypotheses are:

H1: Perceived ease of use has a positive influence on the user's perceived usefulness of gamification to practice preventive measures against COVID-19.

H2: Perceived ease of use has a positive influence on the user's attitude towards using gamification to practice preventive measures against COVID-19.

H3: Perceived ease of use has a positive influence on the users' engagement.

3.4.3 Gamification Perceived Usefulness

Perceived usefulness is the second main construct found in the original TAM theory proposed by Davis et al. (1989). The construct is used to express the reality that technology enhances job function. Davis et al. (1989) has defined perceived usefulness as “the degree to which a person believes that using a particular system would enhance his or her job performance”. The inclusion of gamification in this construct is defined as the degree to which the students’ belief in using gamification will enhance their performance in learning based on the GAM theory. Thus, this study focuses on the effect of gamification in enhancing their performance in following the preventive measure of COVID-19 in the app.

Gamification Perceived Usefulness is defined as ‘the degree to which the users’ belief in using gamification will enhance their performance in learning’. The definition is adopted according to the context of this study which defines the GPU as the degree to which the users’ belief in using gamification will increase their ability to follow the preventive measure for COVID-19. Therefore, it infers that:

H4: Perceived usefulness has a positive influence on the user’s attitude towards using gamification technology in becoming aware of practicing preventive measures for COVID-19.

H5: Perceived usefulness has a positive influence on the users’ engagement.

3.4.4 Attitude Towards using Gamification

Attitude is a construct that does not present in the original TAM study but appears in TAM-2. The TAM-2 was influenced by the TRA model that predicted and explained the acceptance of information technology in corporate environments. Based on the model, the

reason for the acceptance of technology is determined by the person's intention to use it, which is also influenced by the person's attitude towards the technology.

Thus, this construct is mainly used in predicting the actual usage of a technology influenced by the attitude of an individual. The GAM theory denoted that gamification would have a positive effect on the student attitude in using the online gamification system. Attitude Towards Using Gamification found in GAM has defined it as 'the degree to which users perceived desirable or undesirable feelings related to the use of gamification for learning. The positive effect mainly focuses on continuous intention to use the system and feels the gamification system gives benefits to the student.

Therefore, to fit into the context of this study, the variable is redefined to the degree to which users perceived the desirable feelings related to the gamification for following the preventive measure of COVID-19. The gamification will positively affect the users' attitude when using the gamified app. The integration of gamification will improve the overall experiences of users using the gamification app when following the preventive measure for COVID-19. Therefore, the following hypothesis is proposed:

H6: User's attitude toward using gamification technology has a positive influence on the users' engagement.

3.4.5 Users' Engagement

The users' engagement construct is adopted from the GAM theory proposed by Rahman & Ahmad (2018). In the GAM theory, the construct is named student engagement which is purposely to study student participation in the classroom. The construct is made up of two variables, skill engagement and participation or interaction engagement. Skill engagement focuses on the acquired skill the student obtained from using the gamified

platform in the classroom. The interaction engagement measures how the online gamification system affects the overall experiences in learning. Through the study by Rahman and Ahmad (2018), it is determined that the student's engagement is affected by the attitude of the student when using the online gamification system for learning. The attitude is comprised of the motivation of students to learn using the gamification system. It showed that if the student shows a positive attitude, it has a positive effect on the student engagement construct.

Therefore, to apply the theory to the context of this study, the research is focusing on understanding if the users' attitude will affect their participation in following the preventive measure of COVID-19 via gamification. The users' engagement can be referred to individual's emotional and intellectual commitment to attain a goal by measuring their hard work and dedication (Alsawaier, 2018). It involves the users' commitment, satisfaction, loyalty, and willingness to do an activity to achieve a specific objective. For this study, only interaction engagement is adopted because the study does not focus on developing or acquiring new skills.

3.4.6 Indicators of X-tended Gamification Acceptance Model (X-GAM)

In this study, a questionnaire survey was employed to investigate the effectiveness of gamification in mobile application to influence users' behavior in following COVID-19 preventive measures. The survey instrument was based on Rahman and Ahmad (2018) , which were adapted to meet the specific needs of this study. The survey items consisted of the following: gamification perceived usefulness (GPU), gamification perceived ease of use (GEOU), attitude towards using gamification (ATUG), and users' engagement (UE). Table 3.1 shows the list of indicators of X-GAM, the proposed conceptual model, and survey questions.

Table 3.1: Indicators of X-Tended Gamification Acceptance Model (X-GAM)

Variables (Definition)	Code	Survey question	Indicators	References
Gamification Perceived Usefulness Definition: the degree to which the students' belief in using gamification will enhance their performance in learning.	GPU	Using the gamification app improves my desire to follow the preventive measures for COVID-19	Improve task completion	(Oluwajana et al., 2019)
		Using the gamification app increases my performance to follow the preventive measure for COVID-19	Frequency/ Efficiency	(Rodrigues et al., 2016)
		Using the gamification app increase my productivity to follow the preventive measure for COVID-19	Enhance work performance	(Sukendro et al., 2020)
		Using the gamification app is useful in following the preventive measure for COVID-19	Useful	(Rahman & Ahmad, 2018)
Gamification Perceived Ease of Use Definition: the degree to which the users expect the gamification to be free of effort	GEOU	I find the gamification app to be flexible to be used	Flexible	(Rahman & Ahmad, 2018)
		The gamification app functionality and interface are clear and understandable	User friendly	(Rahman & Ahmad, 2018)
		Interacting with the gamification app does not require a lot of my mental effort	Effortless	(Rahman & Ahmad, 2018)
		Overall, I believe that the gamification app is easy to use	Easy to use	(Rahman & Ahmad, 2018)
Attitude towards Using Gamification Definition: the degree to which the user perceived desirable or undesirable feelings related	ATUG	I think that using gamification app is a good idea	Feelings	(Rahman & Ahmad, 2018)
		The gamified app made practicing the preventive measures for COVID-19 more interesting	Affectionate	(Rahman & Ahmad, 2018)
		Playing the gamified app COVID-19 was fun	Desire	(Rahman & Ahmad, 2018)
		I like following the preventive measure using	Instill positivity	(Rahman & Ahmad, 2018)

to the use of gamification		the gamified app COVID-19		
Users' engagement Definition: individual's emotional and intellectual commitment to attain a goal by measuring their hard work and dedication	UE	Having fun in the following the preventive measure	Interaction	(Rahman & Ahmad, 2018)
		Able to follow the preventive measures willingly	Voluntarily	(Rahman & Ahmad, 2018)
		Show positive progress in following preventive measures for COVID-19	Desirable outcomes	(Rahman & Ahmad, 2018)

3.4.7 Proposed Conceptual Model

The proposed conceptual model was adopted from the study by Rahman and Ahmad (2018) which was extended from the original TAM. It has introduced new variables into the TAM model which are gamification and student engagement. For the current study, rather than focusing on the effectiveness of gamification on student performance, the current study adopted the model, also known as GAM, and shifted the focus to the general users, following the preventive measure for COVID-19. A quantitative approach will be used to gather the required data to test the conceptual model via the questionnaire method. The result will show the established causal relationships between the constructs in the conceptual model. Structural equation modeling will be used to test the conceptual model.

To study the effectiveness of gamification, a selection of variables will be chosen to test the theory. The variables will need to be examined and adjusted according to the COVID-19 context. The existing model in which GAM is used as the main reference. One of the variables, namely, users' engagement is modified from the GAM, originally known as students' engagement. In addition, the context of variables also is changed from focusing

on students and classroom participation to users' engagement and participating in following the COVID-19 preventive measures. Specifically, the model proposes one new variable which is users' engagement. Figure 3.1 is the proposed model constructed from the variables mentioned above.

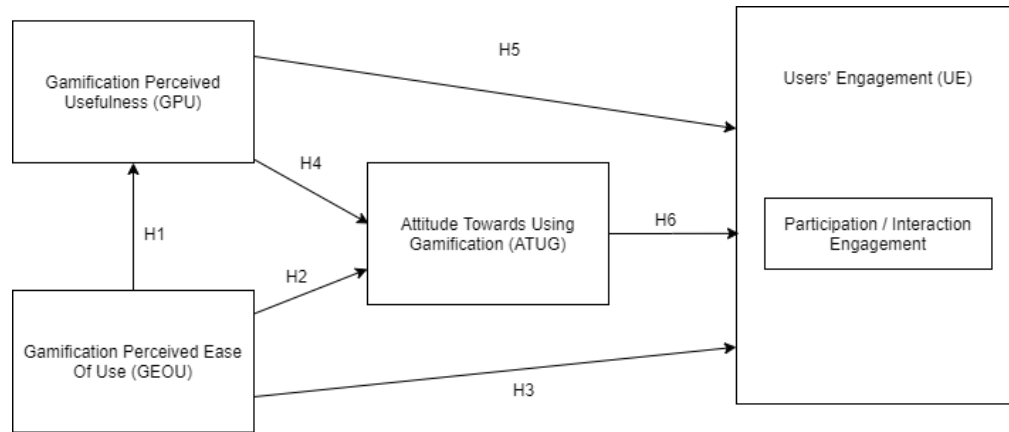


Figure 3.1: X-Tended Gamification Acceptance Model (X-GAM)

3.5 Proposed Framework

The gamification design outlines the most common elements of gaming that will be implemented in order to guarantee that users will be engaged in the process of adhering to COVID-19 preventive measures. The framework indicated that a user's attitude toward gamification, as well as their perceptions of its usefulness and ease of use, will influence the level of engagement they have with the system. Engagement is a behavioral term that refers to the participation and involvement of users in adhering to COVID-19 preventive measures. This type of engagement is known as behavioral engagement. In addition, people are more inclined to adopt gamification if they believe it is easy to use and would benefit them in their day-to-day lives. As a result, they will have a higher level of engagement during the play session that makes use of the gamified application. Figure 3.2 illustrates the entire

gamification architecture that will be utilized to encourage users to implement COVID-19 preventive measures.

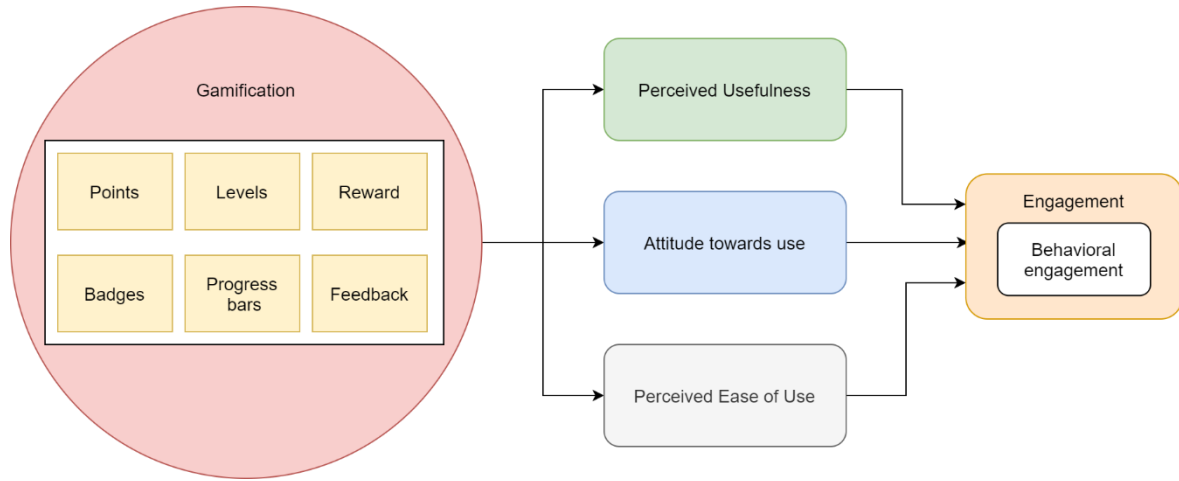


Figure 3.2: Gamification and users' engagement framework

3.5.1 Framework Comparison

An analysis of previous research has been carried out to investigate and explore a comparative analysis of the application of gamification in a variety of settings. The research that was conducted by Yang et al. (2017) looked into the factors that led people to have the intention to participate in gamification behaviors. Their study centered on determining the extent to which one's attitude about a brand is correlated with their level of behavioral engagement with that brand. Therefore, they suggested a research model consisting of six constructs: Perceived Usefulness, Perceived Ease of Use, Perceived Social Influence, Perceived Enjoyment, Engagement Intention, and Brand Attitude. According to the findings of their study, perceived usefulness and perceived enjoyment are major contributors to the intention of engaging in the activity and attitude toward the brand.

On the other hand, Mee Mee et al. (2021) proposed a new conceptual model that focuses on the use of analogue gamification with the goal of improving the motivation and

attitude of primary school pupils. Their conceptual model includes four constructs: analogue gamification, motivation, attitude, and engagement. They hypothesized that the introduction of gamified analogue games would have a major impact on the learners' desire to learn as well as their mentality about the subject matter. A better learning environment will be created through the use of analogue gamification, which will also increase the level of engagement shown by learners.

García-Jurado et al. (2021) found that gamification has a direct impact on users' engagement in e-commerce. The reputation system that the users have access to is where their gamification application may be seen most clearly. The success of the system is largely predicated on the relevance of the consumers' feedback regarding the products. Gamification and engagement are the two concepts that are utilized in their conceptual model. In conclusion, they have demonstrated that the incorporation of gamification into the e-commerce reputation points system produces direct effects on the level of engagement exhibited by users. They also proposed using components from the TAM or UTAUT models in order to explore the long-term effects of gamification and engagement on the behavior and usage of e-commerce websites. In this study, a conceptual model was proposed to investigate users' acceptance of gamification and its effects on their engagement rate in following COVID-19 preventive measures. Specifically, the study focused on examining users' engagement rates in adhering to these preventive measures. This model's fundamental concept is based on the idea that game 'building blocks' can be used in real-world occurrences in order to motivate particular actions inside a gamified setting (Landers et al., 2017). It is anticipated, within this framework of the study, that the use of gamification can encourage participants to remain engaged in the process of adhering to preventive measures. The model contends that the degree to which GEOU influences GPU is also significant. GPU

and GEOU are the two components that will influence users' engagement regarding gamification. GPU also works in conjunction with GEOU.

In addition, the model that was proposed suggested that the views of the users regarding gamification will affect their engagement regarding their participation or involvement in following the preventive measures. Gamification is also more likely to be embraced by users if they feel it to be easy to use and helpful to attain the objective, they have set for themselves. During their time spent utilizing the gamified application, the users will develop a greater sense of engagement. In addition to this, incorporating game mechanics into non-game content can engage users and influence their behavior in a way that encourages sustained participation in the activity. Therefore, they will continue to adhere to the preventative measures after the gamified application has developed an environment that encourages and engages users to sustain their high level of interest and commitment. This environment can be achieved by providing users with rewards and badges for completing certain tasks within the application.

A comparative analysis presented in Table 3.2 identifies the key distinctions between previous research and the current conceptual model for gamification implementation.

Table 3.2: Comparison between past research and present on gamification and engagement implementation

Factors	Yang et al. (2017)	Mee Mee et al. (2021)	García-Jurado et al. (2021)	Present conceptual model
Year of publication	2017	2021	2021	2021
Aim	To investigate the antecedents of the behavioral intention to engage with	To enhance primary school learners' motivation and attitude	To examine the influence of gamification on users' engagement in e-commerce	To investigate the users' acceptance of the gamification and its effects

	gamification and to examine the relationship between the behavioral intention of engagement and brand attitude			on the users' engagement rate to follow the COVID-19 preventive measures
Constructs	Perceived Usefulness, Perceived Ease of Use, Perceived Social Influence, Perceived Enjoyment, Intention of engagement, Brand Attitude	Analogue gamification, motivation, attitude, and engagement	Gamification and Engagement	Gamification Perceived Usefulness, Gamification Perceived Ease of Use, Attitude towards Using Gamification, Users' engagement
Domain	E-commerce	Education	E-commerce	Health

3.6 Target Population and Sample

In this study, secondary school students aged 16 to 18 were chosen as the target population from SMK Matang Jaya, SMK Petra Jaya, and Kolej DPAH Abdillah, all located in Kuching, Sarawak. The decision to select secondary students as participants was based on two primary factors: their role as potential active silent spreaders of COVID-19 and their familiarity with gamified applications. This specific age group has been identified as a significant vector in the transmission of COVID-19. Adolescents often show asymptomatic or mild symptoms when infected, making them less likely to realize they are carriers, and thus more likely to unintentionally spread the virus within their social circles (Davies et al., 2020). Given their high levels of social interaction, both within and outside school settings, and a tendency to be less adherent to preventive measures like mask-wearing, engaging this

group is critical for public health interventions aimed at breaking the chain of transmission (Panovska-Griffiths et al., 2020).

Moreover, this age group is particularly familiar with digital technologies and gamification, as they regularly use smartphones, gaming consoles, and other devices for communication, education, and entertainment. Known as "digital natives," adolescents have grown up surrounded by technology, making them well-suited to engage with gamified applications (Kalogiannakis et al., 2021). Their proficiency with technology means they are not only comfortable using mobile apps but also receptive to gamification features such as rewards, challenges, and progress tracking. This makes secondary students an ideal sample for testing the effectiveness of gamification strategies to encourage adherence to COVID-19 preventive measures.

By focusing on this demographic, the study effectively targets a group that is both critical in the transmission of COVID-19 and highly familiar with gamified applications. Therefore, to ensure that the selected participants were representative of this population and capable of engaging with the gamified mobile app, the following inclusion criteria were applied:

- be at least 16 to 18 years old
- own an Android smartphone
- must know English Language
- able to complete the survey on their own
- must be in Kuching, Sarawak during the duration of the experiments

There are also exclusion criteria such as

- are not owning a smartphone
- inability to answer the survey by themselves
- have mental health issues

In determining the appropriate sample size for this study, the sample-to-variable ratio guideline was taken into account. The guideline suggests a minimum observation-to-variable ratio of 5:1, which means that for each independent variable, there should be at least five observations. However, higher ratios of 15:1 or 20:1 are preferred for ensuring sufficient statistical power and analysis reliability (Ali Memon et al., 2020).

Based on the four variables in this study, the minimum requirement according to the 5:1 ratio would be 20 observations. However, to enhance statistical power and increase the chances of detecting meaningful effects, a larger sample size was deemed necessary. Hence, a total of 137 students who met the inclusion criteria were recruited.

By adhering to a higher ratio, the aim was to minimize the risk of underpowered analyses and strengthen the validity of the findings. It is important to consider these factors to ensure the study's ability to detect meaningful effects and provide credible evidence. The required amount of sample size needed for this study is determined using the a-priori sample size calculator for structural equation models (Aydin, 2018). The total recommended sample size is 137. Below are the parameters to calculate the sample size:

- Anticipated effect size = 0.3
- Desired statistical power level = 0.8

- Number of latent variables = 4
- Number of observed variables = 16
- Probability level = 0.05
- Output = 137

Therefore, the minimum number of participants to be recruited for this study is 137 students that fitted the description of inclusion criteria.

3.7 Instruments

For this study, the adapted survey instrument is designed to measure the effectiveness of gamification on users' engagement in following the preventive measures for COVID-19. Google Forms is chosen as the online survey platform to collect quantitative data for the evaluation of the gamified application. An online survey is utilized due to the convenience and flexibility it offers to both participants and researchers (Evans & Mathur, 2018). The questionnaire consists of 15 questions: four items on Gamification Perceived Usefulness (GPU), four items on Gamification Perceived Ease of Use (GEOU), four items on Attitude Towards Using Gamification (ATUG), and three items on Users' Engagement (UE). Participants are asked to respond to each of the questions on a 5-point Likert scale, ranging from 1 = 'strongly disagree' to 5 = 'strongly agree'. One open-ended question is included at the end of the questionnaire to gather feedback on their experience using the gamified application. Please refer to Appendix A for the questionnaire used in this study.

3.8 Procedures

This study engaged secondary school teenagers living in Kuching, Sarawak. The study was conducted over 3 weeks, during which the participants used the gamified COVID-

19 app. Participants were recruited through recommendations by teachers from their schools. Afterward, participants were screened to assess their eligibility to participate in the study. They were required to complete a basic questionnaire that asked about demographics, such as age, gender, smartphone ownership, and interest in gamification. Only complete questionnaires and participants who met the eligibility criteria were recruited for the study. An email was sent to eligible participants, informing them of their selection for the study. A download link to the app was sent via email to the participants. After the 3-week period, a second questionnaire was administered. This questionnaire was divided into two parts: one part asking about users' demographics (age and gender), and the other part containing questions related to the constructs in the proposed model. No personal information about the respondents was collected in the questionnaire, allowing respondents to answer without concerns about data exploitation. On average, it took approximately 5-10 minutes to complete the survey.

3.9 Development of Gamified Mobile Application

The development of the gamified application used the waterfall model. The model has five phases: requirements analysis and specification, design, implementation, unit testing and system testing, and maintenance (Naga Malleswari et al., 2018). The steps are always in order and do not overlap, which resembles a cascade of waterfalls. Each phase must be completed first before the next phase begins. Besides, the model is based on a predictive approach. This approach works well with a project with detailed planning, detailed features, and tasks to be delivered during the product life cycle (Dima & Maassen, 2018).

- I. Requirements analysis and specification: In this phase, the exact requirements are listed and documented to describe the needs of the project.

- II. Design phase: The requirements are analyzed and understood in order to prepare a system design. The system design is required to specify the hardware and system requirements to define the overall system architecture.
- III. Implementation and unit testing: The requirements in design are implemented into the system after testing each unit. There is also post-integration to detect any failures and faults present in the system.
- IV. Integration and system testing: After the functional and non-functional testing is completed, the system will be deployed to users.
- V. Maintenance: In this phase, a patch will be released to fix any issues during system usage. The system will also receive enhancements to make up for missed features.

The waterfall model is adopted because of the following reasons:

- The requirements are well-defined and understood.
- The duration of the project is short.
- The milestone of the project is well understood.
- The process and results are well documented.

3.9.1 Design of Gamified Application

The key design for the app is to reward the behavior that follows the preventive measure. It will implement several gamification elements from the literature review such as points, badges, levels, progress bar, and feedback. The gamification content will be focused on preventive measures to mitigate the spread of COVID-19. Below are the gamification themes content on preventive measures recommended by WHO that will be presented in the application (De Souza Gaspar et al., 2020):

- Coronavirus: General information about COVID-19, how it is transmitted, and the vulnerable groups.
- Usage of mask: The reason and how to wear it properly.
- Sanitization and cleaning: Take note to clean the home and equipment used for work.
- Social: How to socialize safely with people and what precaution measures when outside of the home.

3.9.2 Explanation of COVID-19 Preventive Measures Used in the Study

In this study, several key COVID-19 preventive measures were focused that are critical for controlling the spread of the virus. The specific measures examined were:

1. Mask-Wearing: Encouraging individuals to wear masks, especially in public spaces and situations where social distancing is challenging (Matuschek et al., 2020).
2. Social Distancing: Promoting the practice of maintaining physical distance from others to reduce virus transmission (Nicola et al., 2020).
3. Hand Hygiene: Emphasizing the importance of regular hand washing and the use of hand sanitizers to eliminate pathogens (Shi et al., 2024).
4. Vaccination Participation: Encouraging individuals to get vaccinated to build community immunity and reduce the severity of the disease (Latif et al., 2022).
5. Adherence to Public Health Guidelines: Following recommendations such as avoiding large gatherings, staying home when feeling unwell, and complying with travel advisories (Güner et al., 2020).

3.9.3 Reasons for Choosing These Preventive Measures

The selection of these COVID-19 preventive measures is based on their critical role in controlling the spread of the virus and their suitability for enhancing users' engagement

through gamification strategies. Below are the key reasons for focusing on these particular interventions:

1. **High Impact on Public Health Outcomes:** These preventive measures, including mask-wearing, social distancing, and vaccination, are widely recognized by global health authorities such as the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) as highly effective strategies for reducing COVID-19 transmission (Güner et al., 2020). By focusing on these measures, the study targets the most impactful behaviors necessary for controlling the pandemic and protecting public health.
2. **Behavioral Dependence:** The success of these preventive measures relies heavily on individual and collective behavior change. This makes them ideal targets for interventions aimed at enhancing users' engagement (Caceres et al., 2022). The effectiveness of these actions, such as consistent mask-wearing and maintaining social distance, is directly linked to how well the public adheres to them.
3. **Relevance to Gamification Strategies:** These behaviors are well-suited to integration within a gamified framework. For instance, users can be rewarded for consistently reporting their adherence to mask-wearing or social distancing practices (Johnson et al., 2016). Gamification elements such as challenges, rewards, and progress tracking can be structured around these specific behaviors to increase motivation and public participation.
4. **Addressing Complacency and Fatigue:** As the pandemic transitions into an endemic phase, adherence to preventive measures has declined due to complacency and pandemic fatigue (Mohamed et al., 2021). Targeting these key measures allows the study to re-engage the public by reinvigorating commitment to COVID-19

prevention, helping counter the diminishing urgency and commitment seen in many populations.

5. **Measurable and Trackable Behaviors:** These preventive actions, such as vaccination or mask usage, are easily observable and can be self-reported or monitored through app interactions. This allows the collection of data necessary to assess users' engagement and the effectiveness of the gamification elements applied in encouraging adherence to these measures.
6. **Alignment with Public Health Campaigns:** The selected measures are consistent with ongoing public health initiatives, which ensures that the interventions developed in this study will complement and reinforce existing efforts (Verelst et al., 2016). By aligning with broader public health goals, the study's gamified strategies are positioned to support and amplify the impact of national and global campaigns.

3.9.4 User Interface (UI) of Gamified COVID-19 Mobile Application

The user interface of the app adopts a minimalist concept to ensure the user experience is smooth and the app is easily navigated. The game has a dedicated logo, icons, and color themes to define the visual identity of the app. After the splash screen, the app displays a page for the user to enter their username. Figure 3.3 shows the design of the splash screen interface while Figure 3.4 shows the form interface to enter the username.



Figure 3.3: Splash screen

Figure 3.4: Form to enter the username

When the user completes the form, the main interface is displayed. The main interface shows the user's information, overall score, quizzes about COVID-19 initiatives, and a button for the online questionnaire. The score represents the accumulation of points from tasks completed by the user. The quiz tests the user's knowledge of COVID-19 initiatives and can only be answered once. Figure 3.5 shows the design of the main interface of the app whereas Figure 3.6 shows the quiz screen.

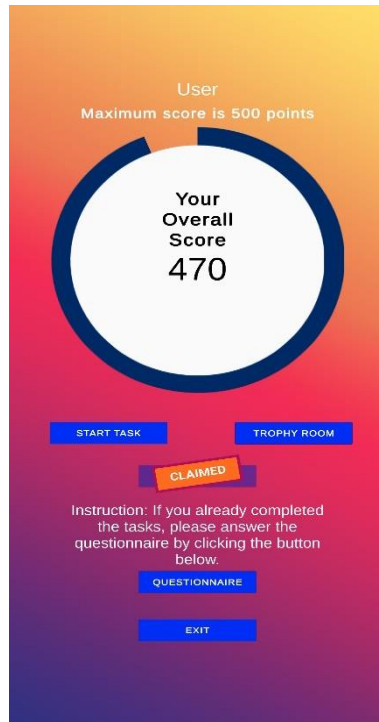


Figure 3.5: Main menu

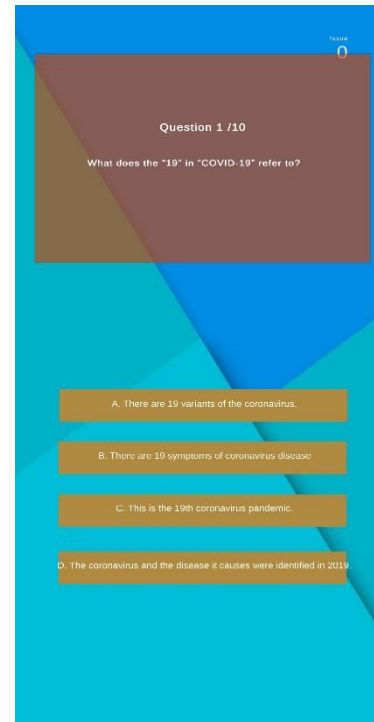


Figure 3.6: Quiz screen

By tapping the start task button on the main interface, the user is redirected to a new page displaying a list of tasks related to COVID-19 initiatives. Each completed task rewards the user with a certain number of points and contributes to overall progress. Upon task completion, the app stores the points and updates the progress accordingly.

To complete a task, the user must follow the instructions provided for each one. Points are awarded once the user performs the required action, and the app accumulates these points while displaying progress for each task. A progress bar on the main menu also tracks the user's overall progress.

After a task is completed, or certain conditions are met, the app displays a reward screen, awarding the user points and badges for each completed task. These badges can be viewed on the trophy screen by tapping the trophy button in the main menu. Figure 3.7 shows

the list of task screens, Figure 3.8 shows the reward screen and Figure 3.9 shows the trophy screen.

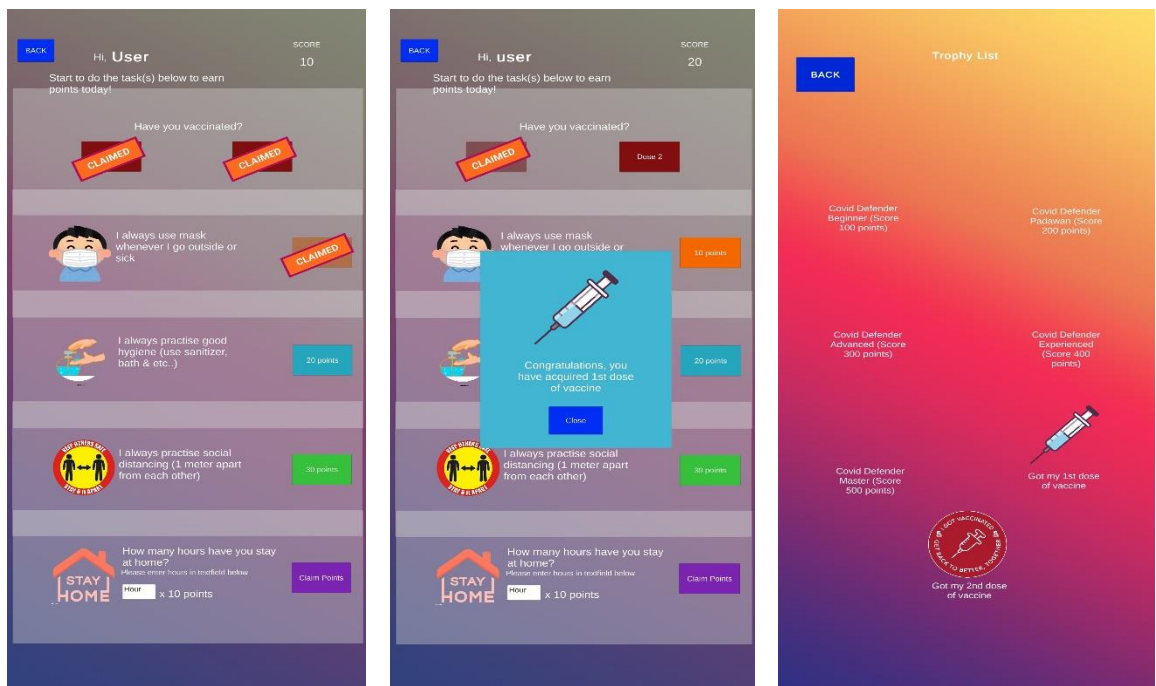


Figure 3.7: List of tasks **Figure 3.8:** Reward screen **Figure 3.9:** Trophy screen

All collected points are stored in the local storage of the user’s mobile phone. The app does not store or collect any sensitive user data. However, the use of cookies and access to the phone’s storage is required to save and maintain the score.

3.10 Flowchart

Figure 3.10 shows the flowchart of the application from the beginning to the end of the application.

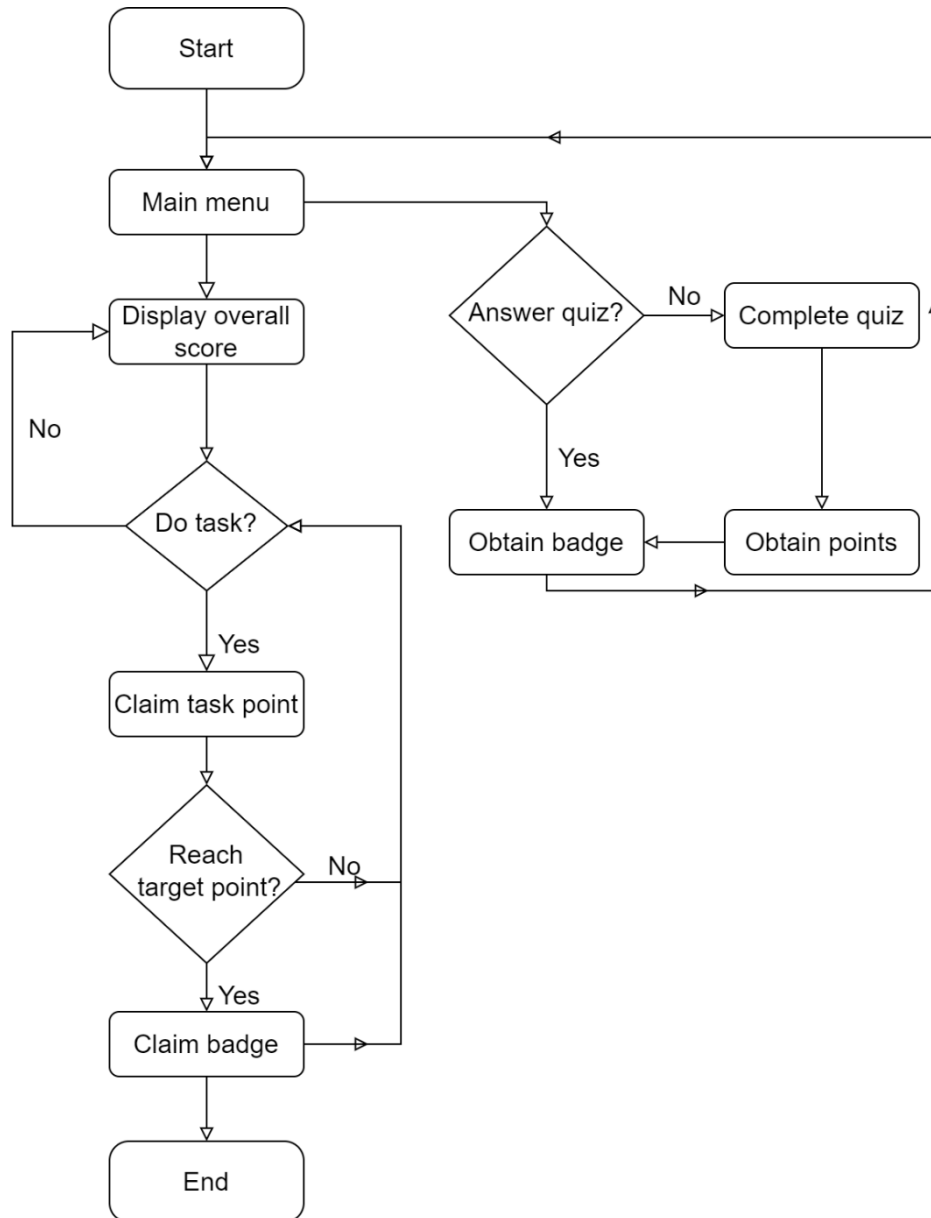


Figure 3.10: Main flowchart of the application

The application directs the user to a page where they can input their username after the splash screen. After entering their username, users are redirected to the main menu page, which displays their overall score as well as options for tasks and earned badges. In addition, users have the opportunity to answer a COVID-19-related quiz, which contributes to their overall score. Users initiate the task by using the "start task" button. Each accomplished task

earns the user a specified number of points and progress. Eventually, users receive a badge as a reward if the accumulated points meet a predetermined condition or threshold. Users can view all of their badges via the main menu. The assignments reset the following day, and users can continue to accumulate points.

3.11 Plan for Data Analysis

For this study, the collected data were analyzed using the Statistical Package for Social Sciences (SPSS) and Analysis of Moment Structures (AMOS). SPSS is software specifically for statistical data analysis, while AMOS is software for performing structural equation modeling. To measure the reliability of the data, reliability analysis was used. Reliability refers to the degree of consistency between the measured data. Cronbach's alpha quantified the survey instrument's internal consistency or average correlation of items (Cronbach, 1951), and it is one of the most frequently utilized reliability statistics by researchers. Correlational analysis and confirmatory factor analysis (CFA) were used to test the validity of the collected data. CFA was employed to verify whether the data fit into the proposed measurement model (Abraham et al., 2019).

Structural Equation Modeling (SEM) was employed as the primary statistical technique to analyze the relationships between the constructs in the proposed gamification-TAM framework and users' engagement in adhering to COVID-19 preventive measures. SEM is a comprehensive statistical approach that combines factor analysis and multiple regression, allowing for the examination of complex relationships among observed and latent variables simultaneously (Purwanto & Sudargini, 2021).

3.12 Justification for Using Structural Equation Modeling (SEM)

Structural equation model (SEM) was used to verify the hypotheses and the proposed model. It was used to examine the relationships between the constructs of the proposed model. Moreover, SEM is widely used in modeling multivariate relations (Tarka, 2018). Below are the justifications on why this study using SEM:

1. **Complex Model Examination:** The proposed model includes multiple constructs such as Gamification Perceived Ease of Use (GEOU), Gamification Perceived Usefulness (GPU), Attitude Toward Using Gamification (ATUG), and Users' Engagement (UE). SEM is adept at handling such complex models where multiple dependent and independent variables are interrelated (Hidayat & Patricia Wulandari, 2022). It allows for the assessment of direct and indirect effects among variables, providing a deeper understanding of the underlying relationships.
2. **Measurement of Latent Constructs:** The study involves latent variables that are not directly observable, such as perceived usefulness and attitude towards gamification. SEM enables the inclusion of these latent constructs by using multiple observed indicators for each latent variable, enhancing the accuracy and validity of the measurements (Vikrant et al., 2021).
3. **Simultaneous Analysis:** SEM allows for the simultaneous analysis of the entire model rather than examining individual relationships in isolation. This holistic approach ensures that the interdependencies among variables are accounted for, leading to more reliable and valid results (Grace, 2021).
4. **Assessment of Model Fit:** SEM provides various fit indices to assess how well the proposed model fits the observed data (Owolabi et al., 2020). This is crucial for

validating the theoretical framework and ensuring that the model accurately represents the data.

5. Handling Measurement Errors: Unlike traditional regression analysis, SEM accounts for measurement errors in the observed variables, leading to more accurate estimates of the relationships among latent constructs (Zhang et al., 2021).

3.13 Suitability for Using Structural Equation Modeling (SEM) in This Study

In this study, Structural Equation Modeling (SEM) was chosen as the primary analytical method because of its robust ability to test and validate complex theoretical frameworks. SEM is particularly well-suited for research that explores relationships between multiple constructs and investigates the causal pathways between them. Given the study's objectives, which involve examining the relationships between gamification constructs within the Technology Acceptance Model (TAM) and their impact on users' engagement, SEM provides the necessary tools for rigorous model testing and validation. Below are the key reasons why SEM is appropriate for this study:

1. Alignment with Research Objectives: The study aims to explore the relationships between gamification constructs within the TAM framework and Users' Engagement (UE). SEM is particularly suitable for testing theoretical models and hypotheses about relationships among variables, aligning with the study's objectives (Zhang et al., 2021).
2. Theory Testing and Development: SEM is often used in social sciences for theory testing and development. It allows researchers to test theoretical propositions against empirical data, making it ideal for validating the extended TAM framework proposed in this study (Purwanto & Sudargini, 2021).

3. Use in Technology Acceptance Studies: SEM has been widely used in studies involving the Technology Acceptance Model and gamification to analyze user acceptance and behavior (Al-Gahtani, 2016). Its application in this study is consistent with established methodologies in the field.

3.14 Conclusion

In conclusion, this chapter has discussed the methodology used to study the relationship between gamification and users' engagement in following the preventive measure for COVID-19. The research design is classified as quantitative research using an online questionnaire survey. Also, this chapter describes the type of sample and size. The process of building the conceptual model is explained in detail. The designing process of gamified applications to test the users' engagement also has been explained briefly. Lastly, the plan details for data analysis have been discussed in order to answer research questions and objective.

CHAPTER 4

RESULTS

4.1 Overview

This chapter aims to discuss the results obtained from data collection, as well as the analysis for measurement fit, convergent validity, and discriminant validity, to test both the reliability and validity of the data and the proposed model. The chapter also presents a measurement model constructed using AMOS from the collected data. In the final section, the chapter summarizes the results by inserting the hypothesis estimates into the proposed model and validates both the model and each hypothesis.

4.2 Data Collection

4.2.1 Sampling and Procedures

As stated in the previous chapter, the online questionnaire was divided into two sections. In the first section, the respondents' basic demographic information was gathered. The variables' measurement items were the subject of the second section. This questionnaire was carried out from the 31st of January to the 14th of February 2022. An online questionnaire was used because it is able to collect a large number of participants. Participation was voluntary, as proven by a signed consent form (digital consent).

170 secondary students responded to the questionnaire. There were 20 incomplete questionnaires among them. After these surveys were removed, the data was analyzed using the remaining 150 valid response. Table 4.1 contains the complete demographic information for these 150 respondents.

Table 4.1: Demographic characteristics of respondents.

Demographic characteristic		Frequency	Percentage (%)
Gender	Male	71	47
	Female	79	53
Age	16	43	29
	17	57	38
	18	50	33

As seen in Table 4.1, most respondents were aged 16 to 18. The sample's characteristics were generally similar to those of young and active mobile phone users. The sample was therefore statistically valid.

150 valid samples were collected for the research. Males made up 47% of the sample, while females made up 53%. Students ranged in age from 16 to 18, with 29% being 16 years of age, 38% being 17 years of age, and 33% being 18 years of age.

4.3 Data Analysis

For hypotheses testing and data analysis, SEM was performed using the Analysis of Moment Structures (AMOS) 26 software. This method allowed for the simultaneous demonstration of both the direct and indirect effects of independent factors on dependent variables.

4.3.1 Analysis and Results

A factor analysis with varimax rotation was used to determine gamification perceived usefulness, gamification perceived ease of use, attitude toward using gamification, and users' engagement. The Kaiser-Meyer-Olkin (KMO) value for this analysis was 0.949, which demonstrates that the sample is highly suitable for factor analysis. The KMO value is derived using the Statistical Package for the Social Sciences (SPSS) tool because the

calculation because the calculation involves comparing correlations and partial correlations between variables, a process that is complex and typically performed using specialized statistical software (Shrestha, 2021). A high KMO value, such as 0.949, indicates that a large proportion of the variance is shared among the variables, making factor analysis appropriate. According to Chan & Idris (2017), a KMO value greater than 0.6 signifies adequate factorability of the correlation matrix. In this case, the KMO value of 0.949 suggests superb sampling adequacy, further confirming that the data is suitable for identifying underlying constructs. In other words, the Kaiser-Meyer-Olkin (KMO) test verifies whether the sample data is appropriate for factor analysis.

4.3.2 Measurement Fit

Multiple goodness-of-fit criteria were utilized by AMOS to derive Maximum Likelihood Estimation (MLE) from a covariance matrix. Alamri et al. (2020) suggested a series of goodness-of-fit measures for testing the suitability of a given model, which were utilized throughout this analysis. Several variables, including absolute misfit and relative fit indices, were employed to evaluate the model's fit. Actual misfit indices were measured using the approximate square root mean error (RMSEA) as well as relative performance indices such as the Tucker Lewis index and the collective match index: Comparative Fit Index (CFI), Tucker Lewis Index (TLI), and Incremental Fit Index (IFI).

The model is considered to have a good fit if the indices reflect the following: i) the χ^2/df value is between 1 and 5, indicating an acceptable balance between model complexity and fit; ii) the CFI, IFI, and TLI indices are close to 1.00, suggesting that the model provides a good fit compared to a baseline model; and iii) the RMSEA value is 0.08 or below, which suggests a moderate level of error and is satisfactory for most SEM applications (S & Mohanasundaram, 2024).

The derived model values are as follows: the chi-square ratio is 1.232, Goodness of fit (GFI) =.916, Root-Mean Residual (RMR) =.042, IFI =.979, TLI =.974, CFI =.979, and Root mean square error of approximation (RMSEA) =.045. The tested values in Table 4.2 were derived from the model evaluation process using Structural Equation Modeling (SEM) through the AMOS software. AMOS performs calculations based on the model's covariance structure, producing several goodness-of-fit indices to assess how well the model fits the data. Below is an explanation of how some key values were derived:

1. Chi-square ratio (χ^2/df): This value was obtained by dividing the model's chi-square statistic by the degrees of freedom. A value of 1.232 indicates a good fit, suggesting that the model balances complexity and accuracy well, as values between 1 and 5 are considered acceptable.
2. Goodness of Fit Index (GFI): GFI was computed based on the variance and covariance explained by the model. A value of 0.916, which exceeds the recommended threshold of 0.90, shows that the model explains a large proportion of the observed variance.
3. Root-Mean Residual (RMR): RMR represents the average residual variance between the observed and predicted covariance matrices. A value of 0.042, close to 0, indicates a good fit with minimal residual error.
4. Incremental Fit Index (IFI), Tucker Lewis Index (TLI), and Comparative Fit Index (CFI): These indices compare the tested model to a null or baseline model (with no relationships among variables). Values of 0.979 (IFI and CFI) and 0.974 (TLI) demonstrate a high degree of fit relative to the baseline model, all exceeding the recommended 0.90 threshold.

5. Root Mean Square Error of Approximation (RMSEA): RMSEA was derived from the residual variance and degrees of freedom, with a value of 0.045 indicating a very good fit. RMSEA values below 0.05 reflect an excellent fit, while values below 0.08 indicate a reasonable fit.

Based on the values that were found, the model did meet the conforming fit goodness criterion. Metrics of how well the model fits are listed in Table 4.2.

Table 4.2: Summary of goodness fit indices.

Types of measures	Recommended values	Tested model
$X^2 / d.f$	< 5.0	1.232
Goodness of fit (GFI)	> 0.90	0.916
Root-Mean Residual (RMR)	Close to 0 (perfect fit)	0.042
Incremental Fit Index (IFI)	The value should be equal to or greater than 0.90	0.979
Tucker Lewis Index (TLI)	The value should be equal to or greater than 0.90	0.974
Comparative Fit Index (CFI)	The value should be equal to or greater than 0.90	0.979
Root mean square error of approximation (RMSEA)	A value below 0.10 indicates a good fit and below 0.05 is deemed a very good fit	0.045

4.4 Convergent and Discriminant Validity

To carry out data analysis, SPSS 26.0 software packages were utilized. It is common knowledge that, prior to carrying out the reliability and validity study, one must first acquire the factor loading of each measurement item. This is supported by the findings of Knekta et al. (2019), which state that this step is required. It is recommended that the factor loading of each measurement item be greater than 0.40. If this is not the case, the measurement item in

question should be excluded from the subsequent data analysis. Table 4.3 shows the results of Cronbach's alpha and confirmatory factor analysis.

Table 4.3: Cronbach's alpha of Measuring and Confirmatory Factor Analysis

Construct	Items	Cronbach's a	Factor Loading	CR	AVE
GPU1	Q1	0.816	.769	0.8993	0.6901
GPU2	Q2		.720		
GPU3	Q3		.775		
GPU4	Q4		.752		
GEOU1	Q5	0.789	.651	0.9203	0.7433
GEOU2	Q6		.740		
GEOU3	Q7		.567		
GEOU4	Q8		.768		
ATUG1	Q9	0.809	.830	0.8926	0.6765
ATUG2	Q10		.621		
ATUG3	Q11		.772		
ATUG4	Q12		.744		
UE1	Q13	0.780	.691	0.8645	0.6810
UE2	Q14		.729		
UE3	Q15		.805		

According to Table 4.3, each one of the factor loadings associated with the measurement items was greater than 0.40. As a result, every measurement item was kept for use in the data analysis. Cronbach's alpha and composite reliability were two of the most common methods used to evaluate reliability. In order to attain construct dependability for an existing scale, Cronbach's alpha statistic, which is a standard option for a coefficient alpha, should be greater than 0.7 (Al-Rahmi et al., 2019; Oliva et al., 1992). It is considered to be a satisfactory fit for the composite reliability (CR) if the values are better than 0.70, and the average variance extracted (AVE) should be greater than 0.5 (Gu et al., 2019).

According to Gilbert A. Churchill (1979), when the values of Cronbach's alpha and composite reliability were greater than 0.70, the constructs' reliability was acceptable. Additionally, if the factor loading of each measurement item was greater than 0.40 and the value of AVE was greater than the benchmark of 0.50, then the validity of the constructs can be said to be well-referenced. This is because both factors indicate that the AVE value is higher than the benchmark. Figure 4.1 shows the findings of an analysis on the reliability and validity of the data.

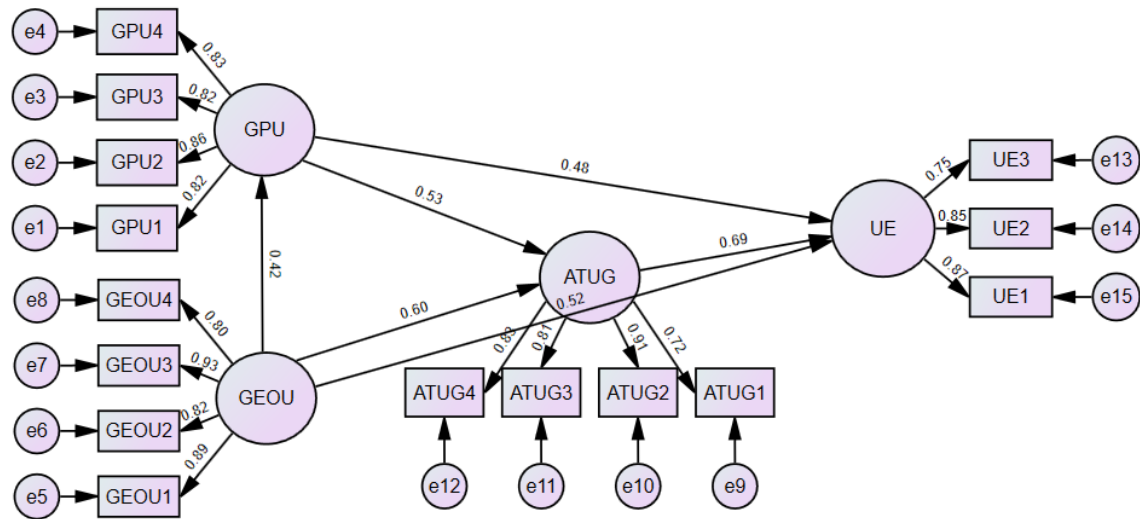


Figure 4.1: Measurement model

As can be seen in Table 4.3 and Figure 4.1, every one of the values for composite reliability was greater than 0.70, the factor loading of each measurement item was greater than 0.40, and the value of AVE was greater than 0.50. Thus, both the reliability and validity of the variables can be considered satisfactory.

To maintain discriminant validity, the indicators needed to correlate sufficiently with the construct. Table 4.4 shows that the square roots of the AVE for each construct were higher than their inter-factor correlations on all other constructs. Therefore, the

discriminating validity of the constructs was demonstrated to be sufficient. The convergent validity for the constructs was adequate.

Table 4.4: Discriminant validity

Factors	GPU	GEOU	ATUG	UE
Gamification Perceived Usefulness (GPU)	0.831			
Gamification Perceived Ease of Use (GEOU)	0.746	0.862		
Attitude Towards Using Gamification (ATUG)	0.827	0.743	0.822	
Users' engagement	0.792	0.678	0.78	0.825

4.5 Hypothesis and Testing Analysis

4.5.1 Hypothesis Testing Analysis

Figure 4.2 displays the findings obtained from conducting the analysis to test the hypotheses.

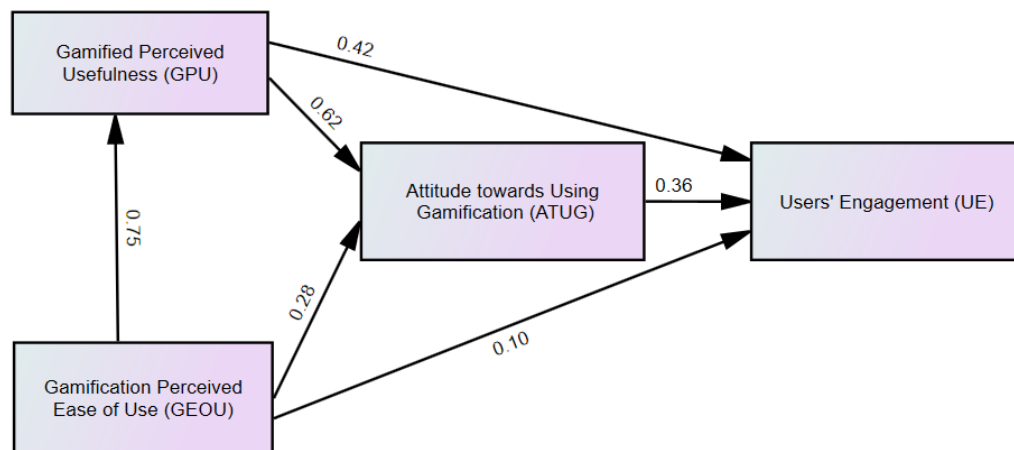


Figure 4.2: Results of the proposed model (hypotheses estimate)

Hypotheses testing was achieved by investigating standardized estimates, standard errors, and significance levels for each individual hypothesis in the model. The results are detailed in Table 4.5.

Table 4.5: Research model hypothesis testing results

	Hypothesis	Standardized Estimate (Std. Est)	Standard Error (S.E)	Critical Ratio (C.R.)	P	Result
H1	GEOU -> GPU	0.746	0.048	13.677	***	Supported
H2	GEOU -> ATUG	0.284	0.062	4.364	***	Supported
H3	GEOU -> UE	0.096	0.076	1.297	0.194	Not supported
H4	GPU -> ATUG	0.615	0.070	9.448	***	Supported
H5	GPU -> UE	0.424	0.102	4.812	***	Supported
H6	ATUG -> UE	0.358	0.095	4.094	***	Supported

Hypothesis H1 posited that Gamification Perceived Ease of Use (GEOU) positively influences Gamification Perceived Usefulness (GPU). The analysis revealed a standardized estimate (β) of 0.746, with a standard error (SE) of 0.048 and a critical ratio (CR) of 13.677. The p-value was less than 0.001, indicating that the result is statistically significant. Therefore, H1 is supported, demonstrating a strong positive relationship between GEOU and GPU. This implies that when users find the gamified application easy to use, they are more likely to perceive it as useful.

Hypothesis H2 suggested that Gamification Perceived Ease of Use (GEOU) positively affects Attitude Toward Using Gamification (ATUG). The findings showed a standardized estimate of 0.284, SE of 0.062, and CR of 4.364, with a p-value less than 0.001. This significant result supports H2, indicating that the ease of use of the gamified application

positively influences users' attitudes toward using gamification. Users who perceive the application as easy to navigate tend to have a more favorable attitude toward its use.

Hypothesis H3 proposed that Gamification Perceived Ease of Use (GEOU) positively influences Users' Engagement (UE). The results yielded a standardized estimate of 0.096, SE of 0.076, and CR of 1.297, with a p-value of 0.194. Since the p-value exceeds the standard significance level of 0.05, H3 is not supported. This indicates that, in this study, the perceived ease of use does not have a significant direct effect on users' engagement. It suggests that other factors may play a more critical role in driving engagement than ease of use alone.

Hypothesis H4 asserted that Gamification Perceived Usefulness (GPU) positively affects Attitude Toward Using Gamification (ATUG). The analysis produced a standardized estimate of 0.615, SE of 0.070, and CR of 9.448, with a p-value less than 0.001. These results support H4, confirming a significant positive relationship between GPU and ATUG. This finding implies that when users perceive the gamified application as useful, they develop a more positive attitude toward using it.

Hypothesis H5 stated that Gamification Perceived Usefulness (GPU) positively influences Users' Engagement (UE). The results showed a standardized estimate of 0.424, SE of 0.102, and CR of 4.812, with a p-value less than 0.001. This significant finding supports H5, indicating that the perceived usefulness of the application has a substantial positive effect on users' engagement. Users who find the application beneficial are more likely to engage with it actively.

Hypothesis H6 posited that Attitude Toward Using Gamification (ATUG) positively affects Users' Engagement (UE). The analysis revealed a standardized estimate of 0.358, SE

of 0.095, and CR of 4.094, with a p-value less than 0.001. This result supports H6, confirming that a positive attitude toward using gamification significantly enhances users' engagement. Users with favorable attitudes toward the gamified application are more likely to be engaged.

In a nutshell, out of the six hypotheses tested, five were supported by the data, indicating significant positive relationships as hypothesized. Specifically, H1, H2, H4, H5, and H6 were supported. Hypothesis H3 was not supported, as the relationship between Gamification Perceived Ease of Use and Users' Engagement was not statistically significant.

4.6 Conclusion

This chapter explained the results of the analysis after running with SEM and AMOS software. The collected data was obtained from the responses from the secondary student at secondary schools around Kuching, Sarawak. The collected data was first analyzed to ensure their reliability and validity. Among the reliability and validity tests were KMO, measurement fit, convergent, and discriminant validity. All of the required values met the specifications and are in accordance to proceed for SEM and AMOS. The chapter ended with hypotheses and testing analysis based on the measurement model made using AMOS. Findings showed that all of the hypotheses were positive and supported, further proving that the proposed model is validated.

CHAPTER 5

DISCUSSIONS

5.1 Overview

This chapter aims to discuss each of the hypotheses and explain the reason behind the relationships between the constructs and suggestions to improve the users' engagement to follow COVID-19 preventive measures. Furthermore, the chapter presents several key lessons learned from gamification implementation with COVID-19 preventive measures, theoretical and practical implications of gamified applications in increasing users' engagement to follow preventive measures during the pandemic. The chapter ends with discussions of current limitations and suggesting future works that can be done to improve and expand the scope of the study.

5.2 Discussions

The core objective of the present study is to investigate the influence of gamification in TAM constructs (gamification perceived ease of use, gamification perceived usefulness, and attitude toward adopting gamification) on users' engagement to adhere to COVID-19 preventive measures by extending the TAM with this factor. The findings from the SEM and AMOS triggered that gamification perceived ease of use, gamification perceived usefulness, and attitude toward adopting gamification had a favorable effect on the users' engagement to comply with COVID-19 preventive measures. This implies that the expectations for GEOU, GPU, and ATUG are significantly correlated with users' engagement.

In this study, the strong correlation between GPU and users' engagement was supported by the high standardized estimate ($\beta = 0.615$, $p < 0.001$), indicating that when

users perceived the gamified COVID-19 application as beneficial, they were more likely to engage with it. The positive relationship between GEOU and engagement ($\beta = 0.096$, $p = 0.194$), though not as significant, also suggests that users value ease of use, but they prioritize usefulness when it comes to engagement. This finding is particularly relevant given that the sample consisted largely of young, tech-savvy individuals who are more likely to engage with applications they perceive as useful in managing health-related behaviors.

These results support the findings of a recent preliminary study that revealed users' engagement is positively affected by gamification (Mee Mee et al., 2021). Furthermore, the study showed that attitude toward using gamification (ATUG) also plays a crucial role in driving engagement ($\beta = 0.358$, $p < 0.001$), which mirrors the findings of Rahman and Ahmad (2018), who found that gamification with TAM constructs positively influences users' engagement. The results align with these studies, further validating the role of TAM constructs in understanding and predicting users' engagement with gamified health applications. Additionally, the analysis revealed that perceived usefulness is the most significant predictor of engagement, which is consistent with the notion that users are more inclined to adopt and engage with applications they find beneficial, especially in health-related contexts such as COVID-19 preventive measures.

5.2.1 The Impact of Gamification Perceived Ease of Use on Perceived Usefulness

Gamification perceived ease of use was observed to have a significant positive effect on gamification perceived usefulness based on H1. The outcome of this is comparable to that of Varannai et al. (2017) and Panagiotarou et al. (2020). This suggests that perceived ease of use had a significant impact on perceived usefulness. It is known that perceived ease of use proved to be the most powerful predictor of perceived usefulness. As confirmed by

Salloum et al. (2019) and Kamal et al. (2020), the finding suggested that users are more likely to utilize the gamified application because it requires minimal effort.

5.2.2 The Influence of Gamification Perceived Ease of Use on Attitude Towards Using Gamification

According to H2, gamification perceived ease of use will have a favorable impact on individuals' attitudes regarding the usage of gamification. When utilizing the gamified COVID-19 application, the results demonstrate a significant and favorable relationship between the perceived ease of use and the attitude of the users. This finding is also consistent with the findings of previous studies conducted by Mukminin et al. (2020), which indicate that the level of users' attitude toward using the gamified app is supported by the ease of use of the application.

5.2.3 The Effect of Gamification Perceived Ease of Use on Users' Engagement

Moving on to H3, gamification perceived ease of use did not have a significant positive effect on users' engagement with the COVID-19 preventive measures app. This finding diverges from previous research where perceived ease of use often significantly influences users' engagement (Rahman & Ahmad, 2018). Two main factors are the prototype nature of the app and the prioritization of usefulness over ease of use among young users.

Firstly, regarding the prototype nature of the app, usability issues inherent in prototype applications may have negatively influenced users' perceptions of ease of use. Prototype apps often lack the refinement of fully developed applications; they may have incomplete features, design inconsistencies, or technical glitches that can hinder the user experience (Ahmad Faudzi et al., 2023). In the study, some user interface (UI) elements

required adjustments, such as button placements and text sizes that were not optimized for all screen sizes. This can lead to accessibility barriers, making interactions more difficult and negatively affecting perceived ease of use (Awan et al., 2021).

Usability problems can increase the cognitive load on users as they have to spend more effort figuring out how to use the app (Gunesekera et al., 2019). Difficulties in navigation and interaction can lead to frustration, reducing overall satisfaction and perceived ease of use (Sandesara et al., 2022). Casadei et al. (2017) highlighted that usability issues in prototypes can hinder user experiences and prevent users from achieving their goals when using a mobile app. Similarly, Buchner et al. (2022) discussed how poor usability increases cognitive load, which can negatively impact users' engagement.

Secondly, the prioritization of usefulness over ease of use among young users plays a significant role. Younger users, often referred to as digital natives, have grown up with technology and are generally more comfortable navigating new applications, even if they are not entirely user-friendly (Gumasing et al., 2023). Research suggests that younger users may prioritize the functionality and usefulness of an app over its ease of use (Kesharwani, 2020). If users perceive that the app provides significant benefits or meets their needs effectively, they are more likely to continue using it despite usability issues (Chan & Honey, 2022).

Younger users might focus on what the app allows them to accomplish, valuing its usefulness in achieving their goals over how easy it is to use (Magsamen-Conrad et al., 2015). Kesharwani (2020) found that digital natives are more influenced by perceived usefulness than by perceived ease of use when adopting new technology. Additionally, Alshurideh et al. (2019) indicate that perceived usefulness often has a more substantial impact on behavioral intention, especially among users with higher technical proficiency.

These factors explain why gamification perceived ease of use did not significantly affect users' engagement in the study. The significant positive impact of gamification perceived usefulness on both attitude and engagement suggests that ensuring the app provides valuable content and features is crucial, especially for younger users. Developers should focus on enhancing the app's usefulness and ensuring that it meets the users' needs effectively, even if some usability improvements are still underway.

The lack of a significant positive effect of perceived ease of use on users' engagement can thus be attributed to prototype limitations and user demographics. Usability issues inherent in a prototype may have negatively influenced users' perceptions of ease of use. Moreover, the young demographic of the participants likely placed greater importance on the app's usefulness, being willing to overlook usability shortcomings if the app provided valuable features.

5.2.4 The Effect of Gamification Perceived Usefulness on Attitude Towards Using Gamification

Additionally, based on H4, the result revealed that gamification perceived usefulness has a positive impact on users' attitudes toward gamification. Similarly, a research study conducted by Sukendro et al. (2020) also supports this relationship. This suggests that users are more likely to be excited about using the gamified app if they perceive it brings substantial benefits to them.

5.2.5 The Influence of Gamification Perceived Usefulness on Users' Engagement

Moreover, the result of H5 indicated that gamification perceived usefulness has a positive impact on users' engagement. This finding is in line with the findings of the earlier research by Rahman and Ahmad (2018) and Jung and Lee (2018) on the influence that

perceived usefulness has on engagement. This implies that users' engagement is influenced by the perceived usefulness, which indicated that the app's usefulness had increased the user's interest in using the gamified app.

5.2.6 The Impact of Attitude Towards Using Gamification on Users' Engagement

Lastly, in H6, users' engagement will improve as a result of their attitude toward using gamification. This result prompts that the positive attitude toward the usage of gamification has a strong correlation coefficient on the level of engagement shown by users. Therefore, the findings of the study showed that users' attitudes had a significant impact on the degree to which they engaged with the gamified COVID-19 application. This result supports previous engagement studies which pointed out that attitude has a positive influence on engagement (Florenthal, 2019; Rahman & Ahmad, 2018). Furthermore, the results showed that gamification with TAM constructs is positively associated with engagement which confirms the conclusions drawn in extant engagement studies (Mee Mee et al., 2021; Y. Yang et al., 2017).

5.2.7 Sample Size Determination and Justification for Structural Equation Modeling

The study adopted a sample size of 150 respondents after carefully filtering valid responses from an initial pool of 170 participants. This sample size was considered appropriate for conducting Structural Equation Modeling (SEM), given the relative simplicity of the model, which consisted of four constructs. The decision to use this sample size was supported by prior research from Ali Memon et al. (2020), which suggests that SEM studies typically recommend sample sizes ranging from 100 to 200 participants.

In the context of SEM, a sufficiently large sample size is essential to ensure the statistical power of the analysis. A sample size of 150, falling within the recommended

range, was chosen to generate robust findings and establish significant effects between the variables under investigation. This sample size also allows for a more comprehensive examination of the relationships between the constructs, providing greater confidence in the results (Kyriazos, 2018).

With a sample size of 150, the study was able to meet the requirements for achieving a satisfactory model fit in SEM analysis. According to established guidelines, SEM requires a minimum observation-to-variable ratio of 5:1, meaning that for each independent variable, there should be at least five observations (Ali Memon et al., 2020). However, for stronger statistical power and reliability, higher ratios of 15:1 or 20:1 are preferred. In this study, a higher ratio was adhered to, which significantly enhances the statistical power and increases the likelihood of detecting meaningful relationships between the constructs.

Additionally, the a-priori sample size calculator for SEM (Aydin, 2018) recommended a minimum sample size of 137 participants, based on key parameters such as anticipated effect size, desired statistical power, number of latent and observed variables, and probability level. The inclusion of 150 participants exceeded this minimum, providing added confidence in the reliability of the model fit assessment and reducing the risk of underpowered analysis.

Furthermore, the chosen sample size contributes to the assessment of model fit, a critical aspect of SEM. Including an appropriate number of participants helps evaluate how well the theoretical model aligns with the observed data. With 150 participants, the study had a higher likelihood of achieving a satisfactory model fit assessment, leading to a more accurate representation of the underlying relationships among the constructs.

In summary, selecting a sample size of 150, following the careful filtration of responses, was based on the requirements of the SEM model used in the research. This sample size aligns with established recommendations in SEM studies, enhancing the statistical power, reliability, and model fit assessment, thereby bolstering the credibility of the findings and strengthening the overall research outcomes.

5.2.8 Suggestion Measures to Improve Users' Engagement to Adhere COVID-19 Preventive Measures

In addition to incorporating game elements, there are several other strategies that can be employed to enhance users' engagement and promote adherence to COVID-19 preventive measures through gamification. These strategies focus on creating a comprehensive and immersive experience that motivates users to actively participate and comply with the recommended guidelines. Here are some suggestions:

- **Personalized Progress Tracking:** Implement a personalized progress tracking system that allows users to monitor their own progress in adhering to preventive measures. This can include visual representations, such as progress bars or milestone achievements, to provide users with a sense of accomplishment and motivate them to continue their efforts.
- **Social Interaction and Competition:** Foster a sense of community and social interaction by integrating features that allow users to connect with each other. This can include leaderboards, challenges, or shared goals, where users can compare their progress and compete in a friendly manner. Encouraging healthy competition can create a supportive and engaging environment.
- **Real-world Rewards and Incentives:** Offer tangible rewards or incentives for users who consistently follow the recommended preventive measures. These rewards can

range from discounts on essential goods or services to exclusive access to certain events or resources. Providing real-world benefits can significantly boost user motivation and reinforce positive behavior (Jayalath & Esichaikul, 2022).

- **Informative and Interactive Content:** Provide users with informative and interactive content related to COVID-19 prevention measures. This can include educational materials, quizzes, or interactive simulations that enhance users' knowledge and understanding of the importance of preventive actions. Engaging content not only increases user involvement but also empowers them to make informed decisions about their health and safety (Bitrián et al., 2021a).
- **Personalized Reminders and Notifications:** Utilize personalized reminders and notifications to prompt users to engage in preventive behaviors. These reminders can be tailored to individual preferences and delivered through various channels, such as push notifications, email, or SMS. By keeping COVID-19 prevention measures top of mind, users are more likely to incorporate them into their daily routines.
- **Gamified Challenges and Quests:** Design gamified challenges or quests that involve completing specific COVID-19 preventive tasks or activities. These challenges can be interactive, engaging, and aligned with real-world actions, making the overall experience more enjoyable and motivating for users (Rincon-Flores et al., 2022).
- **Continuous Feedback and Positive Reinforcement:** Provide users with continuous feedback on their progress and offer positive reinforcement for their efforts in following preventive measures. This can be in the form of encouraging messages, virtual rewards, or even virtual characters that acknowledge and celebrate users' achievements (Chans & Portuguese Castro, 2021).

By implementing these strategies alongside game elements, the gamified approach to COVID-19 prevention can effectively engage users and promote long-term adherence to preventive measures. However, these strategies were not incorporated into this study due to several practical limitations. The prototype nature of the gamified application limited the scope of the features that could be implemented. Additionally, time and resource constraints restricted the ability to fully develop and integrate these advanced features. Future iterations of the application could explore these strategies further, but the primary focus of this research was on evaluating the effectiveness of core gamification elements in promoting users' engagement. It is important to continually evaluate and refine these measures based on user feedback and emerging research to ensure their effectiveness in driving users' engagement and behavior change.

5.2.9 Expanding the Reach of Gamification: Applying the Model to Other Diseases

Reaching beyond the realm of COVID-19, the gamification model developed for promoting adherence to preventive measures can be effectively applied to a range of other diseases. To ensure successful implementation, it is crucial to follow specific guidelines and considerations. By adapting the gamification model, researchers and practitioners can harness the power of gamified interventions to engage users and foster adherence in disease prevention efforts. The following guidelines provide a roadmap for extending the gamification model beyond COVID-19 and into other disease contexts.

- **Identify Common Preventive Measures:** Analyze the preventive measures recommended for the target disease and identify commonalities with COVID-19 preventive measures (Ingram et al., 2022). Determine the behaviors or actions that users need to adopt to reduce the risk of infection or transmission. This forms the basis for designing gamified activities and tasks.

- **Adapt Gamified Activities:** Modify the gamified activities and tasks to align with the specific preventive measures of the target disease. Tailor the challenges, quests, or milestones to address the unique requirements and behaviors associated with the disease. For example, if the disease requires hand hygiene, create activities that encourage proper handwashing techniques (Crosby et al., 2020).
- **Customize Information and Content:** Develop informative and interactive content that educates users about the target disease (Peyravi et al., 2020). Provide disease-specific information, such as symptoms, transmission routes, and prevention strategies. Personalize the content to ensure its relevance to the specific disease context.
- **Integrate Disease-Specific Rewards:** Identify relevant rewards and incentives specific to the target disease. These can include virtual or real-world rewards that motivate users to engage in preventive behaviors. For instance, for diseases related to physical activity, rewards can be related to achieving certain fitness milestones or gaining access to fitness-related resources (Tuah et al., 2021).
- **Incorporate Disease-Specific Feedback:** Adapt the feedback system to provide users with continuous feedback on their progress in adhering to preventive measures for the target disease. Offer tailored suggestions and guidance based on the specific behaviors required. Feedback can be in the form of progress tracking, encouraging messages, or personalized recommendations.
- **Consider Disease-Specific Challenges:** Introduce disease-specific challenges and quests that are relevant to the target disease (Adlakha et al., 2020). These can involve completing tasks related to prevention, raising awareness, or supporting research

efforts. Encourage users to actively participate and contribute to disease prevention and control.

- **Evaluate and Refine:** Continuously evaluate the effectiveness of the gamified model in promoting adherence to preventive measures for the target disease (Mulchandani & Orji, 2022). Gather user feedback, conduct surveys, and measure behavioral outcomes to assess the impact of the gamification approach. Use these insights to refine and improve the gamification model accordingly.

By following these steps, the gamification model can be adapted and generalized to various diseases, ensuring that the engagement strategies effectively promote adherence to disease-specific preventive measures. It is crucial to consider the unique characteristics and requirements of each disease to tailor the gamified experience accordingly.

5.3 Key Lessons Learnt

This study aims to better comprehend and convey the effect of gamification in persuading users to comply with COVID-19 preventative measures. Due to the potential of gamification, its growing effect in a variety of sectors has become an important and recognized study issue. The conceptual GAM model was derived from the previous literature and made to adapt into the current study to study the users' engagement to adhere to COVID-19 preventative measures. To evaluate the GAM model with users' engagement, empirical research was carried out on 150 secondary school students. The findings validate the GAM model's expansion by proving gamification can effectively influence the users' engagement to follow COVID-19 preventive measures.

The study makes several important contributions, one of the most important of which is an investigation of the impact that gamification plays in influencing the users' intention

to utilize the app. According to the data, gamification perceived ease of use and gamification perceived usefulness are the most influential elements in people's decision to utilize a gamified application. The perceived ease of use and perceived usefulness of gamification, in particular, have a favorable influence on the users' views about the app as well as their intentions to use the app. Gamification's perceived usefulness is influenced by its perceived simplicity of usage.

To encourage users to follow the COVID-19 preventative measures, the primary focus should be on the perceived ease of use, the perceived usefulness, and attitudes towards gamification. This study brought to light the significance of factors such as perceived simplicity of use, perceived utility, and attitude toward gamification in encouraging users to utilize an app as a medium to comply with COVID-19 preventative measures. In general, these factors play an important role in influencing user behavior. Based on the data, the potential repercussions have been analyzed and determined.

5.4 Theoretical Implications

The present study has significant theoretical implications, contributing to the understanding of the impact of gamification and the Technology Acceptance Model (TAM) on users' engagement in complying with COVID-19 preventive measures (Hamari et al., 2014). This study represents the first attempt to integrate gamification and TAM in the context of adherence to COVID-19 preventive measures, yielding valuable insights.

Firstly, the developed conceptual model extends the TAM framework by incorporating users' engagement to examine adherence to COVID-19 preventive measures. TAM, known for its consideration of motivation factors and human attitudes (Varannai et al., 2017), provided a strong foundation for this study. The constructed model effectively

explains a substantial variance in predicting the actual use of gamification in the context of COVID-19 preventive measures in Malaysia. Notably, all the established paths in the model were statistically positive, with the exception of gamification perceived ease of use, which received partial support. This finding suggests a strong alignment between users' engagement and the gamification-TAM framework, making a significant contribution to the field.

The unprecedented combination of users' engagement and gamification-TAM in this study opens doors for future research exploring the impact of users' engagement in different settings. Researchers may find this model useful in investigating the role of users' engagement in various contexts. The outcomes of this study enhance the understanding of the crucial role played by users' engagement in fostering the acceptance of gamified COVID-19 mobile apps in Malaysia.

Furthermore, this study highlights the role of gamification as a key concept in increasing motivation and influencing users' behavior, particularly in the context of a pandemic. By integrating gamification elements and tailored content into daily practices, the pandemic mobile applications can effectively leverage gamification to increase user motivation and encourage desired behaviors (Nicolaidou et al., 2022). This empirical confirmation emphasizes the importance of the synergy between gamification and users' engagement in promoting adherence to COVID-19 preventive measures.

The findings also underscore the success of gamified COVID-19 mobile applications in promoting desired user behaviors during the pandemic. This approach enhances the app's attractiveness for daily usage and has the potential to build strong motivation among users to adhere to COVID-19 initiatives (Calik et al., 2022). While gamification is recognized as

a tool for increasing motivation and promoting desired behaviors (Welbers et al., 2019), its effects in the context of pandemic mobile apps are still underestimated.

By improving the understanding of the interplay between gamification, users' engagement, and the TAM framework, this study contributes valuable insights that can inform the development and implementation of gamified interventions in disease prevention efforts. It provides a foundation for future research endeavors aimed at exploring broader applications of gamification beyond COVID-19, ultimately advancing knowledge and strategies in promoting users' engagement and adherence to preventive measures across various disease contexts.

5.5 Practical Implications

This study reveals that gamification can effectively enhance users' engagement in adhering to COVID-19 preventive measures, highlighting its potential practical implications. To transform pandemic mobile apps into gamified experiences, governments and health practitioners should adopt an integrated approach by developing gamified content centered around pandemic preventive measures and incorporating appropriate gaming elements (Faghy et al., 2021). Despite the limited research on gamification for pandemics, the potential benefits of using gamification to increase users' engagement in following preventive measures are promising.

However, it is important to note that governments and health authorities may currently lack awareness of the use of gamification in COVID-19 mobile apps. To better integrate gamification into existing COVID-19 mobile apps, they should follow the guidelines outlined by researchers. These guidelines will assist governments in developing attractive and effective gamified COVID-19 mobile apps that can be utilized by the community during both the pandemic and endemic phases (Calik et al., 2022).

In times of crisis, such as a surge in subvariant COVID-19 cases or a transition to maintaining low-level cases, the gamification strategy may need to be revised. In such situations, the focus should shift from increasing engagement to raising awareness and maintaining the community's adherence to preventive measures (Seale et al., 2020).

The study's results offer new insights into pandemic situations and gamification design, suggesting several practical strategies for users and practitioners. Gamification designers should develop specific goal-setting functions tailored to pandemic mobile apps. Separating goal-setting from achievement incentives is crucial, as personal goal-setting reflects users' adherence to preventive measures and effectively influences their behaviors and performance levels (Beatriz Pereira, 2020; Deniz-Garcia et al., 2022).

Furthermore, the level of difficulty for each individual's goals should be balanced with their abilities. The relationship between a person's abilities and the difficulty of their goals can impact their flow experience, which in turn influences their behavior. It is important to align goal difficulty with individual capacities or skills to facilitate the best flow state and positive emotions. Users should establish reasonable objectives according to their capabilities and adjust their goals as they progress, starting with simpler goals to boost motivation and satisfaction and gradually increasing the challenge for long-term behavioral performance (Yang & Li, 2021).

Additionally, the usability and usefulness of gamified mobile apps are crucial factors to consider. The research indicates that an app that is easy to use and provides useful content positively influences the relationship between attitude and engagement. Designers should ensure clear and intuitive navigation within the app and carefully design gamified content with appropriate difficulty levels and rewards to avoid user frustration (An, 2020). Achievement incentives should be tailored to the difficulty of users' goals. Users with

challenging goals should receive specific accomplishment incentives, while those with easier goals can be offered more general incentives. The moderating effect of achievement incentives should be considered in this process. These practical strategies not only promote the adoption of gamified COVID-19 mobile apps but also enhance users' engagement in following preventive measures, contributing to sustained behavior change, improved public health outcomes, and greater adherence to government and health authority guidelines during both pandemic and endemic phases.

5.6 Limitations and Future Works

While this study contributes significantly to the understanding of gamification's influence on engagement in adhering to COVID-19 preventive measures, there are several limitations that should be addressed in future research. Additionally, there are potential avenues for further investigation to enhance the model's effectiveness. These limitations and future directions include:

- **Generalizability of the Conceptual Model:** The developed conceptual model has only been validated with a group of secondary students from secondary schools. Future studies should aim to examine the applicability and effectiveness of the model across different age groups and in various countries. This would provide valuable insights into the model's cross-cultural and cross-demographic effectiveness.
- **Health Practitioners' Acceptance:** This study primarily focused on examining students' acceptance of gamified COVID-19 mobile apps and neglected to explore the acceptance of such technology among health practitioners. Future research should address this gap by investigating health practitioners' acceptance of gamified COVID-19 mobile apps. Understanding their perspectives can provide valuable

insights into how effectively users carry out preventive measures under the guidance of healthcare professionals.

- **Expanding the Model's Constructs:** While this study focused on examining the effectiveness of the gamification-Technology Acceptance Model (TAM) in influencing users' engagement, future research should explore the influence of other relevant constructs. For example, investigating the role of social influence and lifestyle behaviors can enhance the model's comprehensiveness and provide a more holistic understanding of user acceptance and engagement (Wang & Qi, 2021). Integrating lifestyle behavior into the model may also contribute to increased acceptance of gamified COVID-19 mobile apps.
- **Increasing Sample Size:** The sample size of 150 participants used in this study was appropriate for conducting Structural Equation Modeling (SEM) analysis, as outlined in Section 5.2.7. SEM requires a sufficient sample size to estimate model parameters with accuracy and to achieve acceptable model fit (Fan et al., 2016). The sample size in this study aligns with the recommended sample-to-variable ratio for SEM (Ali Memon et al., 2020), ensuring the statistical power needed to detect meaningful relationships between variables. However, while the current sample size was sufficient for the context of this study, it is important to note that generalizability, which refers to the ability to apply the findings to a broader population, could be enhanced by increasing the sample size in future studies. Larger sample sizes provide greater statistical precision, reduce standard errors, and make the results more representative of the population (Smith et al., 2021). For example, Kyriazos (2018) argues that larger sample sizes in SEM not only improve model stability but also allow for better testing of model invariance across different subgroups, increasing

the external validity of the findings. Therefore, while this study was able to achieve satisfactory model fit with a sample of 150 participants, future research should consider increasing the sample size to ensure broader generalizability. A larger sample would allow for a more comprehensive examination of the effectiveness of gamified interventions across different populations, environments, or even cultural contexts. This would strengthen the study's external validity and provide a more statistically robust basis for drawing conclusions about the impact of gamification on users' engagement with COVID-19 preventive measures.

- **Exploration of Additional Gamification Elements:** This study incorporated a limited number of gaming elements into the gamified COVID-19 mobile app. To broaden the scope of the study and enhance users' engagement, future research should explore the integration of other gamification elements, such as a narrative story or additional game mechanics. Investigating the influence of these elements on users' engagement can provide valuable insights into designing more effective and engaging gamified interventions.

By addressing these limitations and pursuing the suggested future directions, researchers can advance the understanding and application of gamification in promoting adherence to preventive measures for various diseases. It is important to continuously refine and expand the research model to optimize its effectiveness and impact.

5.7 Conclusion

This chapter explained the results after running with SEM and AMOS software. The proposed model showed that gamification perceived ease of use, gamification perceived usefulness, and attitude towards using gamification have a positive impact on the users' engagement to adhere to the COVID-19 initiatives. The relationship between constructs is

also discussed thoroughly. The chapter also touched on key lessons learned, theoretical and practical implications and ended with limitations and future works.

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CHAPTER 6

CONCLUSION

6.1 Overview

The objectives of this chapter are to summarize the whole study in a more concise form. The chapter begins by laying out the objectives achieved after the end of the study. The chapter concludes by discussing the aim of the thesis, answering the research questions, summarizing the methodology used, discussing the results, study's contributions and ending with reflection of the whole study.

6.2 Study's Achievements

The results obtained from the study demonstrated that it managed to meet all of the stated objectives. The research's accomplishments are presented in Table 6.1 below.

Table 6.1: Summary of achievements

Item	Statement	Achievements
RQ1	How can the gamification TAM framework be developed to increase users' engagement in following COVID-19 preventive measures?	The study successfully developed a conceptual framework that combines gamification elements with TAM constructs: Perceived Ease of Use (PEOU), Perceived Usefulness (PU), and Attitude Toward Using Gamification (ATUG). This framework was validated through empirical research, demonstrating its effectiveness in enhancing users' engagement with COVID-19 preventive measures. This directly addresses RQ1.
OB1	To propose a framework combining gamification and the Technology Acceptance Model (TAM) to increase users' engagement in following	Achieved by developing and proposing the gamification-TAM framework as explained above. The framework provides a structured approach for enhancing users' engagement with

	COVID-19 preventive measures.	COVID-19 preventive measures, fulfilling OB1.
RQ2	What are the relationships between gamification's perceived ease of use, perceived usefulness, and attitudes towards gamification in influencing users' engagement with COVID-19 preventive measures?	The study explored the relationships among the TAM constructs with gamification (GEOU, GPU, ATUG) and users' engagement using Structural Equation Modeling (SEM). The findings revealed significant relationships: GPU and ATUG positively influenced users' engagement, while GEOU influenced GPU and ATUG. This exploration addresses RQ2 by demonstrating how these constructs interact to influence users' engagement.
OB2	To explore the relationships between gamification's perceived ease of use, perceived usefulness, and attitudes towards gamification in enhancing users' engagement with COVID-19 preventive measures.	Achieved through empirical analysis using SEM, which demonstrated significant relationships among the constructs. The study showed how GEOU, GPU, and ATUG influence users' engagement, thereby fulfilling OB2.
Result	Key Findings: • GEOU→GPU: Significant positive effect. • GEOU→ATUG: Significant positive effect. • GPU→ATUG: Significant positive effect. • GPU→UE: Significant positive effect. • ATUG→UE: Significant positive effect. • GEOU→UE: Insignificant effect.	The results indicated that while Gamification Perceived Ease of Use influenced Gamification Perceived Usefulness and Attitude Toward Using Gamification, it did not have a direct significant effect on Users' engagement. Gamification Perceived Usefulness and Attitude Toward Using Gamification were significant predictors of Users' engagement.
Discussion and Conclusion	Analyzed the implications of the results for theory and practice, and provided recommendations based on the findings.	Concluded that the gamification-TAM framework effectively enhances users' engagement with COVID-19 preventive measures. Emphasized the importance of Gamification Perceived Usefulness and Attitude Toward Using Gamification in

		influencing engagement. Recommended that app developers and health practitioners focus on improving the usefulness of the app and fostering positive attitudes toward gamification to increase users' engagement.
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6.3 Research Contributions

This research has made the following contributions while achieving its individual research objectives.

6.3.1 Systematic literature review (SLR) of gamification and Technology Acceptance Model (TAM)

An extensive SLR was conducted to summarize the current understanding of the relationship between gamification and the Technology Acceptance Model (TAM). The main research purpose, methods used, and the extent of TAM in predicting gamification usage were analyzed, as well as the use of gaming elements, identified benefits and challenges, and current issues faced in implementing gamification. The findings indicate that using gamification to increase user motivation is a common research goal, and that all studies have used TAM to predict perceived usefulness over other constructs (Aydinliyurt et al., 2021; Bitrián et al., 2021b; Salimon et al., 2021). This suggests that perceived usefulness has a strong correlation with other important factors. Furthermore, the review identified five major benefits of gamification: motivating users, increasing user intention, improving health management, increasing user satisfaction, and promoting acceptance of new technology. All of these benefits align with the primary goal of gamification, which is to trigger user motivational mechanisms and improve cognitive performance and social effects (Aydinliyurt et al., 2021; Martinho et al., 2020). Additionally, the review highlighted several

challenges faced in adopting gamification and provided recommendations for researchers to address open research issues.

6.3.2 Game Components

An extensive literature review was conducted to identify and compile a comprehensive list of game elements commonly used in gamification and serious game design. The identified game elements include points, badges, levels, rewards, progress bars, and feedback. Through further analysis, it was determined that each of these game elements plays a crucial role in the design of the game and can contribute to various aspects of users' engagement in following COVID-19 preventative measures. These game elements are found to be effective in increasing motivation, providing a sense of accomplishment, and promoting desired user behavior (Antonaci et al., 2019; Wee & Choong, 2019). The findings of this literature review provide valuable insights for game designers and researchers in the field of gamification and serious game design, particularly in the context of promoting adherence to COVID-19 preventative measures.

6.3.3 Prototype of Gamified COVID-19 Mobile Apps

A prototype of a gamified COVID-19 mobile application has been developed to demonstrate the practical implementation of the proposed framework. The prototype utilizes gamified content to engage users and encourage them to focus on completing the task of adhering to preventive measures. The results of the experimental evaluation indicate that the use of a gamified approach in a COVID-19 mobile application is effective in increasing users' engagement in following preventive measures, even in the context of declining COVID-19 cases.

6.3.4 Evaluation of X-GAM Framework

The proposed framework in this research is a specialized approach for game designers and researchers to effectively target behaviors associated with pandemic preventative measures and identify appropriate gamified content to increase users' engagement in following government-enforced initiatives. The framework can be further developed and refined for use in addressing future pandemics, by including specific identification of recommended preventive measures related to the pandemic and incorporating them into the design of the gamified pandemic mobile app. The proposed framework can thus serve as a valuable tool for addressing public health crises through the use of gamification.

6.4 Conclusion

6.4.1 Aim of Thesis

This thesis aimed to investigate the effect of gamification on users' engagement in following the COVID-19 preventive measures. The disengagement in the adherence to preventive measures and lack of framework was identified as the main problems. The literature begins with underlying the concept of gamification and its application across different domains were researched to understand how effective gamification is when applied in different situations. A study was conducted to understand the state of gamification in COVID-19 mobile applications to determine if it improves the adoption and engagement of users to follow preventive measures.

6.4.2 Answering the Research Questions

The thesis focuses on exploring the integration of gamification elements into the Technology Acceptance Model (TAM) framework to increase users' engagement in

following preventive measures for COVID-19. It addresses two main research questions (RQs) that aim to investigate the development of the gamification TAM framework and examine the relationships between gamification, perceived ease of use, perceived usefulness, attitude towards gamification, and users' engagement in COVID-19 preventive measures.

RQ1 focuses on the development of the gamification TAM framework. The study incorporates three constructs from TAM, namely perceived ease of use, perceived usefulness, and attitude along with users' engagement, to assess the effectiveness of the framework in promoting engagement with COVID-19 preventive measures. By integrating these constructs, the study aims to measure the usability of the gamified interventions, behavioral changes among users, and the overall level of users' engagement.

RQ2 delves into the relationships between gamification, perceived ease of use, perceived usefulness, attitude towards gamification, and users' engagement. To assess these relationships, the study employs a mobile app specifically designed for COVID-19 initiatives with gamification elements. Secondary school students participate in the study, and they are given a questionnaire to rate the effectiveness of the gamified COVID-19 app. The questionnaire primarily focuses on measuring the three constructs of TAM (perceived ease of use, perceived usefulness, attitude towards gamification) and users' engagement with the preventive measures.

In summary, this thesis explores the integration of gamification into the TAM framework to enhance users' engagement in following COVID-19 preventive measures. The research questions aim to develop the gamification TAM framework and examine the relationships between gamification, perceived ease of use, perceived usefulness, attitude towards gamification, and users' engagement. The study utilizes a mobile app and a questionnaire-based approach to collect data from secondary school students, ultimately

seeking to provide insights into the effectiveness of gamification in promoting engagement with COVID-19 initiatives.

6.4.3 Summary of Thesis Methodology

The TAM was used as a basis for measuring and determining the relationship between gamification and users' engagement in following COVID-19 preventive measures. The online questionnaire measured the TAM constructs GEOU, GPU, and ATUG as well as the added model extensions users' engagement. A framework consisting of individual TAM constructs, gamification, and users' engagement as the measured variables was constructed. The proposed framework was used to investigate the relationships between TAM constructs with gamification and users' engagement.

6.4.4 Result and Conclusion from Analysed Data

The collected data were statistically analyzed using SEM and AMOS, and the calculated correlations showed a positive relationship between gamification, the individual TAM constructs, and users' engagement to follow COVID-19 preventive measures. All relationships in the proposed framework yielded positive results, which indicate that the data fit well in the model and that gamification positively affects users' engagement. This answered the first research question.

As for the second research question, the analysis revealed that GEOU, GPU, and ATUG related to gamification in gamified COVID-19 mobile applications were found to have a positive relationship with UE to follow COVID-19 preventive measures. Notably, GPU was the most significant factor affecting users' engagement. This was expected, as the usefulness of gamified content strongly influences the adoption of a gamified mobile app. The users became more motivated to use the gamified mobile app because it was beneficial

to them, especially during the COVID-19 pandemic, when the perceived risk of infection was high (White et al., 2023). The experiment was conducted during the pandemic, when people were still concerned about COVID-19, and this fear likely contributed to their motivation to engage with the app.

It is important to note that users may be less inclined to engage with the app if they do not perceive a health threat (Walrave et al., 2020). This concern likely contributed to users' motivation to use the gamified mobile app, as they were actively seeking tools to help them adhere to preventive measures. The fear of contracting COVID-19, or any other health risk, plays a significant role in influencing users' willingness to adopt preventive measures and related technologies. Additionally, ATUG was statistically significant in affecting UE, consistent with prior research, which shows that a positive attitude toward gamification increases behavioral intention to use the app. However, GEOU did not significantly affect users' engagement, likely due to the prototype phase of the gamified COVID-19 mobile app, which may have negatively impacted the overall user experience.

6.4.5 Summary of Study's Contribution

Gamification motivates the adoption of gamified COVID-19 mobile app and increase the users' engagement to follow COVID-19 preventive measures. The users' engagement will increase when the three TAM constructs were adopted. The proposed model advocates that GPU, GEOU, and ATUG contributed towards maintaining the users' engagement. However, it is important to note that gamification alone may not be sufficient to overcome all the factors that may lead to decreased adherence in an endemic phase, such as fatigue, burnout, and complacency. Therefore, it is suggested to use gamification as a part of a holistic approach to encourage people to follow the preventive measures. Below are the summary of valuable insights and benefits for future unforeseen pandemics from this study:

- Understanding the effectiveness of gamification: The study explores how gamification elements impact users' engagement and behavior change in the context of COVID-19 initiatives. The findings can help establish a foundation for understanding the effectiveness of gamification in public health emergencies. This knowledge can be applied to future pandemics or health crises, enabling policymakers and health authorities to design and implement gamified interventions more effectively.
- Identification of key design principles: By examining the key design principles and features of gamification that contribute to its effectiveness in COVID-19 initiatives, the study provides valuable insights into the mechanics and strategies that drive users' engagement and behavior change. These principles can be extrapolated and adapted to future pandemic scenarios, enabling the development of targeted gamification interventions that align with specific public health objectives.
- Lessons learned for public health campaigns: The research findings and insights from this study can contribute to the broader field of public health campaigns beyond the context of COVID-19. Gamification has the potential to enhance users' engagement and behavior change in various health-related initiatives. Lessons learned from this study can inform the design and implementation of gamified interventions in future public health campaigns, fostering greater participation and adherence to recommended behaviors.
- Building a knowledge base for future research: This study significantly contributes to both academic research and practical applications in public health by developing a gamified COVID-19 mobile application and an accompanying model framework. The framework integrates gamification elements with Technology Acceptance

Model (TAM) constructs which are Perceived Ease of Use (PEOU), Perceived Usefulness (PU), and Attitude Towards Using (ATT) to enhance users' engagement (UE). This serves as a guiding reference for health practitioners and app developers in designing effective gamified health apps. By empirically validating the relationship between these constructs and users' engagement, the model provides evidence-based design principles that prioritize app features improving users' engagement, such as usefulness and user-friendliness. This approach ensures the framework can be adapted to address other public health crises and pandemics by tailoring gamification elements to specific preventive behaviors. Additionally, the study lays a foundation for future research by filling existing gaps on gamification and users' engagement, enabling a more informed, evidence-based approach for utilizing gamified interventions in future health crises.

In summary, the insights and findings from this study can be of immense benefit for future unforeseen pandemics. The understanding of gamification's effectiveness, identification of key design principles, cultural adaptation strategies, and lessons learned can inform the development of tailored gamified interventions, thereby enhancing users' engagement, behavior change, and overall response to future health crises.

6.5 Reflection on the Study

Throughout this research, I gained valuable insights into constructing a model framework, mastering Structural Equation Modeling (SEM), and developing well-founded discussions in an academic context. The process of integrating gamification concepts with the Technology Acceptance Model (TAM) taught me how to create a robust model aimed at increasing users' engagement in COVID-19 preventive measures. I learned to select relevant

constructs, such as Perceived Ease of Use and Perceived Usefulness, and to map out their relationships based on both theoretical and empirical evidence.

Mastering SEM was a pivotal aspect of the study, as it allowed me to test the proposed model rigorously. I became proficient in using AMOS for SEM analysis, validating the model through confirmatory factor analysis, and interpreting complex data results. This experience deepened my understanding of how theoretical constructs interact, ultimately strengthening the study's contribution to both the academic field and practical applications in public health.

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APPENDICES

Appendix A: Questionnaire Question for Sampling



UNIVERSITI MALAYSIA SARAWAK

Faculty of Computer Science and Information Technology

Questionnaire Question

X-GAM: A GAMIFICATION-BASED FRAMEWORK FOR INCREASING MOBILE APP ENGAGEMENT TO PREVENT THE SPREAD OF COVID-19

The purpose of this questionnaire is to gather the sample for the study above. This study is on examining how effective gamification in mobile apps increases the users' engagement to follow the preventive measure of COVID-19. Your feedback from this questionnaire is valuable and will help to further the research of this study. We will be grateful if you could spend some time answering all the questions below.

Section A: Personal Information

1. Please select your gender

- A. Male
- B. Female

2. Please select your age

- A. 16 years old
- B. 17 years old
- C. 18 years old

3. Do you have your own mobile phone?

- A. Yes
- B. No

Section B: Knowledge on Gamification

4. Do you know or familiar with the term 'Gamification'?

- A. Yes
- B. No

5. If yes, state where you have heard about the 'Gamification' term.

- A. Internet
- B. News
- C. Friend
- D. Other: _____

6. Gamification turns the non-game contexts to game contexts. It rewards the user with points or badges after completing a task. An example is KAHOOT!. Have you encountered or been involved with that kind of situation?

- A. Yes
- B. No

Appendix B: Questionnaire Question for Evaluation of Gamified Mobile App



UNIVERSITI MALAYSIA SARAWAK

Faculty of Computer Science and Information Technology

Questionnaire Question

X-GAM: A GAMIFICATION-BASED FRAMEWORK FOR INCREASING MOBILE APP ENGAGEMENT TO PREVENT THE SPREAD OF COVID-19

The purpose of this questionnaire is to gather your response on the gamified mobile app for the study above. This study is on examining how effective gamification in mobile apps is in increasing users' engagement to follow the preventive measure for COVID-19. Your feedback from this questionnaire is valuable and will help to further the research of this study. We will grateful if you could spend some time answering all the questions below.

Section A: Personal Information

1. Please select your gender

- A. Male
- B. Female

2. Please select your age

- A. 16 years old
- B. 17 years old
- C. 18 years old

Section B: Evaluation for the gamified mobile app

For each statement, please check whether you Strongly Disagree, Disagree, Neither agree nor disagree, Agree, or Strongly Agree.

No.	Questions	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
		1	2	3	4	5
1	Using the gamification app improves my desire to follow the preventive measures for COVID-19					
2	Using the gamification app increases my performance to follow the preventive measures for COVID-19					
3	Using the gamification app increases my productivity to follow the preventive measures for COVID-19					
4	Using the gamification app is useful in following the preventive measures for COVID-19					
5	I find the gamification app to be flexible to be used					
6	The gamification app functionality and interface are clear and understandable					
7	Interacting with the gamification app does not require a lot of my mental effort					
8	Overall, I believe that the gamification app is easy to use					
9	I think that using gamification app is a good idea					
10	The gamified app made practicing the preventive measures for COVID-19 more interesting					
11	Playing the gamified app was fun					
12	I like practicing the preventive measure using the gamified app					

This gamified app contributes to me in:						
13	Having fun following the preventive measures for COVID-19					
14	Following the preventive measures of COVID-19 willingly					
15	Showing positive progress in following the preventive measures for COVID-19					

16. How is your overall experience in using this gamified COVID-19 app?

Appendix C: Student Confirmation Letter - Application to Collect Information

Fakulti Sains Komputer dan Teknologi Maklumat
Faculty of Computer Science and Information Technology



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25 Januari 2022

Kepada Yang Berkenaan

Tuan/Puan,

Permohonan Mengumpul Maklumat Untuk Kajian Pascasiswazah – Mohammad Hazim Afiq bin Kalana

Dengan segala hormatnya perkara di atas adalah dirujuk.

Sukacita dimaklumkan bahawa pelajar berikut akan mengumpul maklumat untuk projek beliau. Berikut adalah butir-butir pelajar:

Nama Penuh	:	Mohammad Hazim Afiq bin Kalana
No. Matrik	:	21020007
No. Kad Pengenalan	:	950704135755
Program	:	Sarjana Sains
Tajuk Projek	:	<i>X-GAM : A Gamification- Based Framework For Increasing Mobile App Engagement To Prevent The Spread Of Covid-19</i>
Penyelia	:	Ts. Syahrul Nizam Junaini

Sehubungan itu, sukacita kiranya pihak tuan dapat memberikan kerjasama kepada pelajar berkenaan untuk menyalurkan maklumat yang diperlukan bagi memenuhi syarat kursus. Segala maklumat yang diperolehi akan hanya digunakan untuk tujuan akademik semata-mata dan akan dijamin kerahsiaannya.

Ini adalah sebagai makluman kepada pihak tuan/puan dan sekiranya ada sebarang pertanyaan, sila hubungi penyelia pelajar tersebut.

Sekian, terima kasih.

Annabelandak Katek
Penolong Pendaftar Kanan

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