EFFECTS OF GAME-BASED PROBLEM-SOLVING FRAMEWORK ON SOFT SKILLS DEVELOPMENT FOR UNDERGRADUATE STUDENTS

TAN BEE SIAN

SULTAN IDRIS EDUCATION UNIVERSITY

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EFFECTS OF GAME-BASED PROBLEM-SOLVING FRAMEWORK
ON SOFT SKILLS DEVELOPMENT FOR
UNDERGRADUATE STUDENTS

TAN BEE SIAN

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ABSTRACT

This study aims to develop and validate the game-based problem-solving framework to develop innovation capability among undergraduate students. This study focuses in the use of digital game-based learning (DGBL) approach to learn soft skills required for developing product innovation capacity. This study consists of two phases. The first phase involves exploratory study to develop the conceptual framework. In the second phase, a quasi-experimental design was used in this study. A total of 106 undergraduate students were chosen from two universities as studied subjects to participate in a one-group pre and post-test study. There are three instruments developed in this study that were soft skills game *"Inventors of Future" (IoF)*, a game-based training module and an achievement test. Wilcoxon Signed Rank test showed significant difference between two groups on pre-test and post-test scores of overall soft skills ($p < .001$), problem solving ($p < .001$), creative thinking ($p < .001$) and critical thinking ($p < .001$). Further analysis from Kruskal Wallis H test and Mann Whitney U test revealed that students from the applied sciences background improved their soft skills score significantly after the exposure to the framework. The findings also showed that students from both universities developed critical thinking skills significantly through learning self-assessment technique from *IoF*. Both results implied that the adaption of soft skills in DGBL required open-ended learning environment with guided instructions. The results also implied that soft skills performance can be assessed from the alignment of Bloom's taxonomy with game-based content. A guiding principle is developed as a contribution of this study for students, instructors, and game designers in adapting the framework to develop soft skills among undergraduate students in future. In conclusion, this framework can be applied in learning critical thinking skill required for developing innovation capacity.

KESAN KERANGKA PENYELESAIAN MASALAH BERASASKAN PERMAINAN TERHADAP PEMBANGUNAN KEMAHIRAN INSANIAH UNTUK PELAJAR PRASISWAZAH

ABSTRAK

Kajian ini bertujuan untuk membina dan menentukan kesan kerangka penyelesaian masalah berasaskan permainan terhadap pencapaian kemahiran inovatif di kalangan prasiswazah. Kajian ini fokus dalam menggunakan pendekatan pembelajaran berasaskan permainan digital (DGBL) dalam menyelesaikan masalah pembelajaran inovasi dan menguji kemahiran yang diperlukan dalam pembangunan inovasi kapasiti. Kajian ini dibahagi dalam dua peringkat. Pada peringkat pertama, kajian penerokaan digunakan untuk membangun kerangka berdasarkan kandungan ilmu kajian. Pada peringkat kedua, eksperimen kuasi digunakan dalam kajian ini. Terdapat 106 prasiswazah mengambil bahagian dalam ujian pra dan pasca tunggal. Terdapat tiga instrumen dibangunkan dalam kajian ini iaitu permainan kemahiran insaniah *"Inventors of Future" (IoF)*, modul latihan berasaskan permainan dan ujian pencapaian berdasarkan ilmu kajian. Wilcoxon Signed Rank menunjukan perbezaan yang signifikan antara kedua-dua kumpulan prasiswazah terhadap skor ujian pasca dari segi kemahiran insaniah ($p < .001$), penyelesaian masalah ($p < .001$), pemikiran kreatif dan pemikiran kritis ($p < .001$). Hasil kajian dari ujian Kruskal Wallis H dan Mann Whitney U menunjukkan bahawa prasiswazah dari latar belakang sains gunaan yang mengikuti program ijazah sarjana muda menunjukkan penambahbaikan selepas pendedahan kepada kerangka. Keputusan juga menunjukkan bahawa prasiswazah dari kedua-dua universiti menunjukkan penambahbaikan dalam pemikiran kritis selepas belajar penilaian kendiri dalam permainan *IoF*. Kedua-dua keputusan ini mengimplikasikan bahawa kemahiran insaniah berasaskan permainan boleh dibangunkan dengan menyediakan persekitaran terbuka yang sedia ada dengan arahan perpadu dalam permainan. Satu prinsip panduan telah dibangunkan sebagai sumbangan kajian bagi pelajar, instruktur dan pereka permainan yang ingin menggunakan kerangka ini pada masa depan. Sebagai kesimpulan, kerangka ini boleh digunakan untuk belajar pemikiran kritis bagi pembangunan inovasi kapasiti.

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LIST OF ABBREVIATIONS

DGBL Digital Game-based learning

GBL Game-based learning

ILO Intended Learning Outcomes

IoF Inventors of Future

KPM Malaysia Ministry of Education

POPS Product-oriented Problem-solving

SPSS Statistical Packages for The Social Science

APPENDIX LIST

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CHAPTER 1

INTRODUCTION

1.1   **Overview**

The Ministry of Higher Education (MOHE) in Malaysia aims to enhance undergraduate students in soft skills development to produce high-quality human capital, knowledge and a competitive workforce that has the creative, innovative features and move in line with industry requirements and social needs of the country (Kenayathulla, Ahmad, & Idris, 2019).

The purpose of this study is to discover the effectiveness of using the game-based learning (GBL) approach in developing soft skills in terms of innovation capacity. This study begins by examining the background of using soft skills as a stimulant in creating innovative solutions in Section 1.2 research background. Next, Section 1.3 problem statement discusses the root causes that inhibit innovation and research gaps

of learning soft skills. Section 1.4 and 1.5 discusses the design of a conceptual framework to learn soft skills through a GBL.

This thesis is divided into six chapters. The first chapter provides an overview of the research background, hypothesis, scope, and limitation. The second chapter is the literature review of soft skills development among undergraduate students in Malaysia. Meanwhile, the third chapter is the methodology of developing the game-based framework, instrumentation, and experimental design of the study. Chapter 4 discuss the game design and development process and game module validation. Next, Chapter 5 discuss the results collected from the quasi-experiment, followed by Chapter 6 conclusions.

1.2 Research Background

Innovation and invention are important skills across the world. Innovation is an invention of a new product, process or service that are improved and commercialized (Hall, 2021; Kearney, 2017; Chandra, Tomitsch & Large, 2020; OECD, 2018). Countries and organizations seeking innovation and invention to cope with the complex and rapidly changing world (Chandra et al., 2020). Besides, innovation is a learning process that require solving process, where an individual requires to identify a problem, apply an idea to solve the problem (Panos-Castro & Arruti, 2020). Failing to cope with the rapidly changing needs in the world leads to the demise of many markets in the history (Chandra et al., 2020). For instance, Kodak, Nokia, Xerox, Blockbuster, and

BlackBerry as the companies that was demise as they failed to innovate products that cope with the new customer needs and expectations (Chandra et al., 2020).

Many policies and plans have been endorsed in worldwide in developing the innovation capabilities. The worldwide organization, UNESCO endorses policies that support productive activities, creativity, and innovation in the 9th goal of UNESCO framework (UNESCO, 2022). This goal aims to increase number of research and development (R&D) workers per million people by the year of 2030. In European country, Innovation Union set government policies in improving innovation (Chandra et al., 2020). Similar with Malaysia, 12th Malaysia Plan 2021-2025 set the policies to strengthen the economy based on innovation, creativity, and research activities (RMK12, 2021).

Figure 1.1. 17 Goals of UNESCO in Sustainable Development. Adapted from UNESCO, 2022

According to the World Economic Forum Future Job Report (2020), the current skills that the Malaysian companies focus on in reskilling programs includes analytical thinking and innovation, active learning and learning strategies and critical thinking

and analysis in strengthening the economy. The reskilling is aligned with the 12th Malaysia Plan 2021-2025 that aims to strengthen the economy based on innovation, creativity, and research activities (RMK12, 2021). One of the plans to strengthen the economy of Malaysia is to innovate products (Malaysia Productivity Corporation, 2021). The Product innovation may increase the competitiveness, productivity of the country and thus improve the standard of living for residents in Malaysia (Malaysia Productivity Corporation, 2021). In Malaysia, innovation activity can increase the commercialization of the product that increase the country's economy (RMK12, 2021). There are various strategies are recommended in developing innovation capacity-mainly through education, industry, research and development, government and culture and ambition (Chandra et al., 2020). However, development has not happened without the help of education (UNESCO, 2022). Thus, one of the education strategies deployed by UNESCO is to improve participation and the development of creativity and innovation (UNESCO, 2022).

1.3   Problem Statement

This section focuses on problem statement developing innovation capacity among undergraduate students. This section divides into two main problem statements. First, the challenges learning skills required for innovation capacity. Second, the problem of assessing the skills required for innovation capacity.

Academic institutions play and important roles in research in developing innovation capabilities in individuals (Chandra et al., 2020; Keinänen & Kairisto-

Mertanen, 2018). Country such as United states, Australia and China endorse learning innovation in the curriculum in promoting the importance of innovation (Chandra, et al., 2020). Meanwhile, United Arab Emirates (UAE) organized the Innovation and Entrepreneurship Program in the year of 2015 to create a curriculum to learn innovation among university students (Gilbert, 2022). It is believed that innovation capabilities can be developed through relevant education and training (Chandra et al., 2020; Keinänen & Kairisto-Mertanen, 2018). Therefore, innovation education is an emerging field in academic institution compares to the traditional content knowledge such as business, science, engineering, and social sciences (Candra et al., 2020; Hall, 2021). University students are essential part of innovation. Through innovation education, students transfer new knowledge to industry and create new business (Hall, 2021).

Employers today emphasize that a good worker should not only have basic academic skills; but also possess innovation competencies such as higher-order thinking skills such as creativity, decision making and problem-solving (Keinänen & Kairisto-Mertanen, 2018; Kenayathulla et al., 2019). Even a technical graduate masters sufficient technical skills, there is still 92.3 % of technical graduates are jobless due to a lack of critical thinking and problem-solving (Kenayathulla et al., 2019). In other words, of these skills will impact the development of innovation competencies among undergraduate students (Keinänen & Kairisto-Mertanen, 2018).

The innovation education is effective if the students constantly developing new ideas to increase the chances of innovation coming out of the university (Hall, 2021). Ideally, university should engage students more effectively as catalyst for innovation (Hall, 2021). Hence, the learning environment such as teaching and learning methods,

multidisciplinary learning environment or flexible curricula is important in developing innovation capability of the students from the aspects of soft skills (Keinänen & Kairisto-Mertanen, 2018). The ideal learning environment to develop innovation capacity includes creating a learning environment where learners can solve problems, be inquisitive and open-minded (Keinänen & Kairisto-Mertanen, 2018).

There are several studies suggested that university alone cannot fulfil the demand of developing innovation capacity among students (Keinänen & Kairisto-Mertanen, 2018). Undergraduate students hope to seek support, resources, and mentorship from university in the process of innovation (Hall, 2021). Undergraduate students suggested that support in terms of business plan, training, and market assessment from the university is important in the process of innovation (Hall, 2021).

Current difficulty in learning innovation lies in the traditional teaching method (Keinänen & Kairisto-Mertanen, 2018). Traditional teaching method such as reading and lecturing is negatively associated with learning innovation capabilities (Candra, et al., 2020; Keinänen & Kairisto-Mertanen, 2018). For instance, it is difficult to learn the problem-solving process in innovation because problem is unlimited and unpredictable (Hero, 2018). Besides, skills needed to learn in developing innovation capacity is challenging in terms of teaching and assessment (Hero, 2018; Keinänen & Kairisto-Mertanen, 2018; Panos-Castro & Arruti, 2020). Many studies focus on developing the generic soft skills such as critical thinking, creativity and problem-solving, there are fewer and narrower approaches in developing the skills required for innovation capabilities (Keinänen & Kairisto-Mertanen, 2018). Furthermore, previous studies are mostly focusing on students' self-perception instead of behaviour (Keinänen &

Kairisto-Mertanen, 2018). Besides, there was a disconnection issue between what is taught and what may experience in the process of learning innovation (Hall, 2021). The disconnection is due to lack of immersion in a learning environment that create the awareness of exploring innovation opportunities (Hall, 2021; Hero, 2018). Although previous study suggested that innovation capacity can be learnt and practices in an innovation lab, this learning environment does not enable innovation when it comes to equipment and venue preparation (Candra et al., 2020). Besides learning environment, another challenge find in innovation education is the development of standardized effectiveness measurement techniques (Candra et al., 2020). Therefore, there should be a tool to assess the innovation objective is achieved in the learning outcomes (Panos-Castro & Arruti, 2020).

The learning experience to learn innovation must go beyond the traditional pedagogical practices (Panos-Castro & Arruti, 2020). Innovation capacity can be fostered through the development of soft skills such as problem-solving, critical thinking and creativity skills (Hall, 2021; Hero, 2018). Therefore, it is suggested that innovation capacity can be developed through course-based teaching or experiential learning (Gilbert, 2022; Hall, 2021). Compared to the physical environment, it is suggested that technology or virtual tools can provide students an environment to learn and experience innovation process (Candra et al., 2020). Furthermore, assessment tools can be developed to help in identify individual innovation capability in terms of innovation process and outcome (Hero, 2018). In order to address the problem, this study focuses on developing the soft skills through a digital environment. The digital environment should provide an immersive learning experience to the undergraduate students. The learning process should be assessed using an assessment tool.

1.4 Theoretical Foundation

Digital game-based learning (DGBL) is an environment that provides interactive and immersive experience to the students in the process of learning a content. DGBL uses game as a learning material to provide guidance to the learners in the process of learning (Bawa, 2019; Jan & Gaydos, 2016). The learning theory of DGBL is adapted from behaviorism, cognitivism, or constructivism, depending on the learning content and approach that decided by the facilitator (Plass, Homer & Zinzer, 2015). Among the three learning theories, cognitivism learning is an approach adapted in this study. According to Piaget, cognitivism focuses on the information processing and factual knowledge that can be mastered by the learners in the process of learning (Jay & Gaydos, 2016). The detail of the cognitivism learning approach can be found in Chapter 2.

According to Prensky (2007), there are twelve game elements that makes the learning process fun and engaging. The twelve elements are fun, play activity, rules, goals, interactive, adaptive, feedback, winning state, conflict and challenges, problem-solving, social interaction, and representation and story. The details of the game elements explanation can be found in chapter 2. Although Prensky has proposed the concept of DGBL, DGBL framework is adapted in this study to ensure the learning goal is achieved. This study adapted the DGBL framework proposed by Tan and Maizatul Hayati (2019). According to Tan and Maizatul Hayati (2019), the learning goal should be achieved with the learning content that is aligned with game elements. The details of adapting DGBL framework in designing the game as a learning content can be found in Chapter 4.

1.5 Research Aim and Objectives

This research aims to create and validate a conceptual framework of game-based problem-solving skills development among undergraduate students. To achieve the aim the following two research objectives (RO) are formed:

RO 1: To design, develop and validate a game-based problem-solving framework on soft skills development for undergraduate students.

RO 2: To examine the differences of undergraduate students' soft skills before and after playing an instance of a game-based problem-solving framework on soft skills development, named *Inventors of Future (IoF)*.

RO 2.1: To examine the differences of undergraduate students' problem-solving skills after playing *IoF*.

RO 2.2: To examine the differences of undergraduate students' creative thinking skill after playing *IoF*.

RO 2.3: To examine the differences of undergraduate students' critical thinking skills after playing *IoF*.

Based on the problem statement, the research questions and hypotheses are designed as follows.

1.5.1   Research Questions

This study covers two main research questions. First, research question 1 (RQ1) is designed to discover the methods of design, develop, and validate the game-based problem-solving framework to measure the soft skills performance of undergraduate students. Next, research question two (RQ2) is designed to measure the performance of undergraduate students in problem-solving, critical thinking and creative thinking skills before and after playing an instance of a game-based problem-solving framework on soft skills development, named *IoF*.

RQ1: How to design, develop and validate a game-based problem-solving framework on soft skills development for undergraduate students?

RQ2: Is there a significant soft skills improvement among undergraduate students after playing *IoF*?

RQ 2.1: Is there a significant improvement of problem-solving skills among undergraduate students after playing *IoF*?

RQ 2.2: Is there a significant improvement of creative thinking skill among undergraduate students and after playing *IoF*?

RQ 2.3: Is there a significant improvement of critical thinking skills among undergraduate students after playing *IoF*?

RQ1: How to design, develop and validate a game-based problem-solving framework on soft skills development for undergraduate students?

A problem occurs when a person has a goal in a situation but does not know how to achieve the goal (Yayasan Innovasi Malaysia, 2019). A problem-solving algorithm is a procedure that is guaranteed to produce a solution if it is followed strictly (Britannica, 2022). The algorithm has four main characteristics which are i) each step of the algorithm must be presented clearly and precisely ii) must be able to solve a problem to get a result iii) must provide the correct solutions to solve the problem iv) must be general enough to use in any possible situation (National University of Singapore, 2019). An algorithm can be represented in pseudocodes and flowcharts to display step-by-step clearly (National University of Singapore, 2019).

In the previous study, it was stated that innovators may not use any special tools to solve problems (Tan & Yong, 2018). A provisional product-oriented problem-solving (POPS) algorithm was proposed by Tan and Yong (2018) to describe the problem-solving process for innovators. However, there is no empirical research have been done to measure the effectiveness of the algorithm. Therefore, this study focuses to understand this provisional algorithm from the perspective of innovators when they recognize a problem, convert the problem into a mental representation, develop a problem space, generate, and evaluate a method to solve the problem, execute the

planned operations of the solution, and self-regulate the process and the product of problem-solving (Tan & Yong, 2018).

To answer this research question, a qualitative interview was conducted to observe and report the algorithm of problem-solving from the innovators in Chapter 4. The recorded interviews from the innovators are collected to analyze the interview data. Through the coded theme, the algorithm and constructs of the POPS algorithm were recognized. The algorithm and constructs were applied in the digital game design and instrument to measure the soft skills performance.

Overall, this research question was planned to answer by identifying suitable gamification approaches and game production methods. A digital game was designed, developed, and validated for use as an instance to validate the framework. A one-group pre and post-test quasi-experiment have carried out with undergraduate students in two universities and reported in Chapter 5.

RQ 2.1: Is there a significant improvement of problem-solving skills among undergraduate students after playing *IoF*?

One of the main root causes of product commercialization failure is due to unresolved actual problems (Yayasan Innovasi Malaysia, 2019). To increase the chances of commercialization, Yayasan Inovasi Malaysia (2019) suggested innovators create solutions for the problem faced by everybody. Tan and Yong (2018) proposed the use problem identification techniques to identify and solve the actual problem. As

emphasized by Yayasan Inovasi Malaysia (2019), problem identification is the initial step in the problem-solving algorithm to innovate a solution. The research gap of problem identification is further discussed in Section 2.4.1 Problem-solving.

RQ 2.2: Is there a significant improvement of creative thinking skill among undergraduate students and after playing *IoF*?

Creative thinking helps students to adapt to the constantly and rapidly changing world (OECD, 2022). Through the development of creative thinking, students can contribute to society as future workers and facilitate innovation and knowledge creation to address new and complex challenges (OECD, 2022). PISA introduces a new assessment to measure creative thinking where the assessment requires students to produce a virtual artefact rather than a written response or select the correct answer (OECD, 2022). Besides, the new proposed creative thinking assessment includes open-ended tasks with multiple solutions and the performance is assessed based on rubrics (OECD, 2022). However, this new proposed assessment will be held in the year 2024, therefore, there is a lack of details of the test (OECD, 2022). The literature review of creative thinking can be referred to in Section 2.4.2 Creative thinking.

RQ 2.3: Is there a significant improvement of critical thinking skills among undergraduate students after playing *IoF*?

A critical thinker has the ability to focus on a question, analyze an argument, judge the creditability of a source, make and value judgments, clarify and refine their viewpoint, support their viewpoints appropriately, and imaginatively suppose and integrate the

logic of a viewpoint with sensitivity to others (Linda & Murawski, 2014). This study discussed the use of self-assessment process to develop critical thinking skills. The research gap of using self-assessment process is further discussed in Section 2.4.3 Critical Thinking.

1.5.2 Hypotheses

The null hypotheses and alternative hypotheses are formulated for statistical testing in search of answers as:

1. H_0: Undergraduate students' conception of soft skills shows no significant difference before and after playing *IoF*

2. H_1: Undergraduate students' conception of soft skills show a significant difference before and after playing *IoF*.

3. H_0: Undergraduate students show no significant difference in problem-solving skills before and after playing *IoF*.

4. H_1: Undergraduate students shows a significant difference in problem-solving skills before and after playing *IoF*.

5. H_0: Undergraduate students show no significant difference in creative thinking skills before and after playing *IoF*.

6.   H$_1$: Undergraduate students shows significant difference in creative thinking skills before and after playing *IoF*.

7.   H$_0$: Undergraduate students show no significant difference in critical thinking skills before and after playing *IoF*.

8.   H$_1$: Undergraduate students show significant difference in critical thinking skills before and after playing *IoF*.

1.6   Significance of the Study

The challenges of learning and assessing skills required for developing innovation capacity through traditional learning method is addressed in this study. The problem being addressed is very crucial as this environment affect the learning process of innovation.

Therefore, this study focuses on applying a digital and immersive environment to engage undergraduate students to develop innovation capability. The skills required for fostering innovation capability such as problem-solving, critical thinking and creative thinking is the focus of the study. Compared to the existing practice, this study focuses on using digital game-based learning as a strategy to learn and assess innovation skills among undergraduate students. Three hypotheses are designed measure the effectiveness of using digital game-based learning strategy in developing skills required for innovation capability. A conceptual framework is designed and developed in this

study to measure the effectiveness of using digital game-based learning in developing soft skills required for fostering innovation capability. Compared to the previous work, this study focuses on learning soft skills in fostering product-oriented innovation. Undergraduate students are beneficial from this study. Throughout this study, undergraduate students are exposed to more effective and engaging way to learn and practice innovation in university. Besides, soft skills are developed throughout the process of learning in digital game-based environment.

1.7   Research Scope and Limitation

Based on the study scope of the project is identified and illustrated (see Figure 1.2). The study is conducted in academic settings of soft skills development in the aspect of innovation capacity where the target participants are undergraduate students. A prototype of a digital game for innovating products were be designed and developed as an instance to validate the framework of game-based soft skills development among undergraduate students. A digital game prototype was be designed, developed, and tested to apply and evaluate this framework. The game incorporated a product innovation algorithm as a learning content. The learning and assessment of soft skills outcomes are measured in this study through the creation of assessment tool. In terms of limitations, this study is constrained by three matters, namely the participants, the device used to conduct the study and the mobile game. The scope of this research is not psychological study or neuroscience.
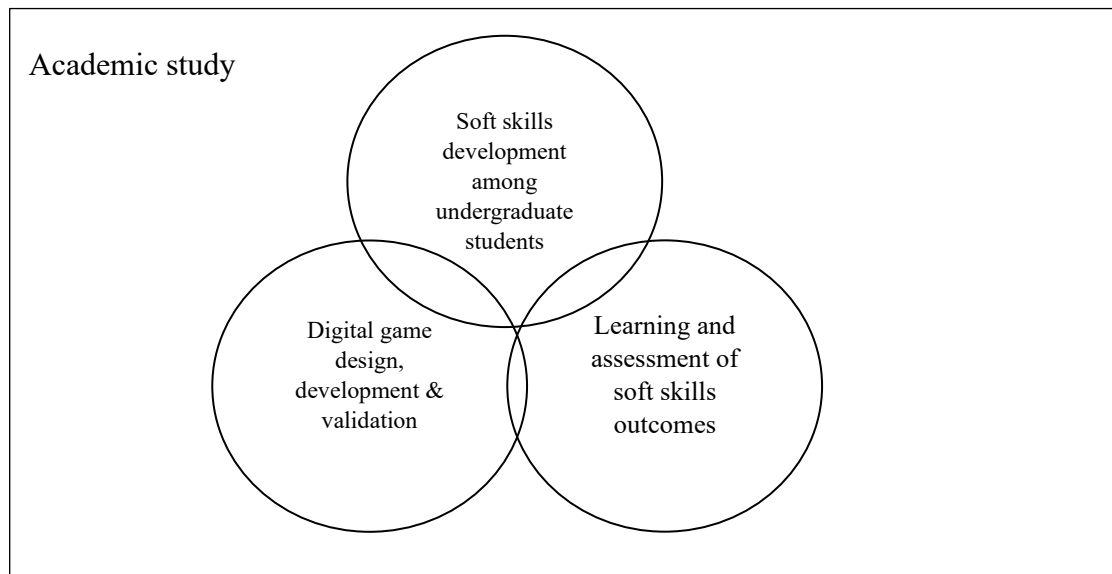
Figure 1.2.   Soft skills, digital game and learning assessment are three components of research scope in this academic study

1.7.1   The Participants

This study was limited to Malaysian undergraduate students in Malaysian universities. As depicted by MOHE, undergraduate students need to enhance soft skills to create new knowledge and workforce needed by the industry (Kenayathulla et al., 2019). In this study, undergraduate students learn the product innovation to develop soft skills.

1.7.2   The Device Used

A digital game is an interactive program that is played using electronic devices such as computers and mobile devices. Digital means items that involve or relating to the use of computer technology (Oxford, 2022). A smartphone is a digital mobile device that

is most popular in Malaysia as there are 89.4% of users use Smartphone to assess to the internet (MCMC, 2017). Among the internet users, there are 96.3% of users communicate by text. 89.3% of users use the internet to assess social networking sites, and 86.9% of users use the internet to gather information (MCMC, 2017). There are 53.6% of internet users are mostly coming from the age group between 20-34 (MCMC, 2017). Compared to the non-digital game, the digital game is easy to play and can be carried anyway without losing it. The result of the game can be saved permanently on a device or server compared to a non-digital game.

1.7.3 The Operating System Used

The operating system of the device used were be limited to only the Android system because the mobile game was designed and developed specifically for this platform.

1.8 Operational Definition

An operational definition is a description of the procedures, actions or processes by which it could be observed and measured (American Psychological Association, 2020). In this study, operational definition is the independent variable game that affects dependent variables that are soft skills, critical thinking, problem-solving and creativity.

1.8.1 Soft Skills

Soft-skill incorporates all aspects of generic skills that include cognitive elements associated with non-academic skills. Soft skills such as critical thinking, problem-solving and creativity skills can be developed through GBL (Gatti, Ulrich, & Seele, 2019). In this thesis, soft skills are measured through the aspect of problem-solving, creativity and critical thinking.

1.8.2 Problem-solving

Problem-solving skills is one of the key elements of developing innovative behaviour (Kim et al., 2018). From the aspect of innovative behaviour, a problem solver possesses the ability to identify, create and select a solution that can solve problems. The finding is similar to Kale and Akcaoglu (2020) who agreed that problem-solving can be developed through identifying problems (Kale & Akcaoglu, 2020). In this thesis, the methods of identifying the problem, the number of problems that are identified based on the scenario, the ability of the students to elaborate the problems in description is measured to determine the performance of a problem-solving skills.

1.8.3   Creative Thinking

According to The Future of Jobs Report, creativity is defined as a cognitive ability to produce unusual or clever ideas about a given scenario to develop creative ways to solve a problem World Economic Forum. (2020). As emphasized by Cambridge International,

"In the 21st-century creativity is increasingly viewed as a distributed and collaborative process of communal sense-making and problem-solving."

O'Sullivan (2022)

Creative thinking is one of the creativity constructs that focuses on the thinking process (OECD, 2019). According to OECD (2019), in the context of students, creative thinking involves the process of generating ideas, reflecting ideas from the aspect of relevance and novelty, and iterating ideas until the outcomes reach satisfactory. Creative thinking is a skill required to solve a problem from a technical and social perspective (OECD, 2019). The assessment of the creative thinking is designed to engage students in an open problem-solving task with a social focus or scientific knowledge, generate ideas for solutions based on a given scenario rather than on the application of taught knowledge and suggest improvements for the solutions (OECD, 2019).

1.8.4 Critical thinking

According to John Dewey, critical thinking is a process that begins with a problem and ends with a solution and self-interpretation (Alsaleh, 2020). This problem should induce the interest of the students to learn and solve the problem (Alsaleh, 2020). In this thesis, critical thinking is considered as part of the problem-solving process in interpreting the product idea that has been created.

1.8.5 Digital game

For this study, a digital game, namely *"Inventors of Future (IoF)"* was used as an instance to validate the framework. It is a digital two-dimensional (2D) role-playing game, to be played by undergraduate students through mobile phones.

1.9 Chapters Preview

The issues of soft skills development among undergraduates in Malaysia has been highlighted in this chapter. In Chapter 2, the research gap of using GBL and assessment of soft skills were being discussed. Meanwhile, Chapter 3 discusses the methodology of developing and validating the framework. The design and development of the provisional framework and game is discussed in Chapter 4. Chapter 5 discusses the data collection and statistical analysis result of the data. Chapter 6 discusses the findings of the result.