MALAYSIAN JOURNAL OF LEARNING AND INSTRUCTION
https://e-journal.uum.edu.my/index.php/mjli

How to cite this article:
Tan Bee Sian, Tan Wee Hoe, Ahmad Zamzuri Mohamad Ali & Chong Kim Soon. (2025). Effects of digital game-based learning on product innovation skills development: Comparative analysis between applied arts and applied science undergraduate students. *Malaysian Journal of Learning and Instruction, 21*(2), 357-386. https://doi.org/10.32890/mjli2024.21.2.12

EFFECTS OF DIGITAL GAME-BASED LEARNING ON PRODUCT INNOVATION SKILLS DEVELOPMENT: COMPARATIVE ANALYSIS BETWEEN APPLIED ARTS AND APPLIED SCIENCE UNDERGRADUATE STUDENTS

[1]Tan Bee Sian, [2]Tan Wee Hoe,
[3]Ahmad Zamzuri Mohamad Ali, & [4]Chong Kim Soon
[1]Faculty of Information Technology and Computing
Tunku Abdul Rahman
University Management and Technology, Malaysia
[2]Faculty of Social Sciences & Liberal Arts
University College Sedaya International, Malaysia
[3]Faculty of Art, Computing and Creative Industry
Universiti Pendidikan Sultan Idris, Tanjong Malim, Malaysia
[4]Faculty of Engineering, Technology and Built Environment
University College Sedaya International, Malaysia

[1]*Corresponding author: tanbs@tarc.edu.my*

Received: 10/7/2023 Revised: 19/5/2024 Accepted: 13/6/2024 Published: 15/8/2024

ABSTRACT

Purpose -This study investigates how Digital Game-based Learning (DGBL) impacts the development of product innovation skills among undergraduate students, comparing the performance of students across different disciplines—Applied Arts (AA) and Applied Sciences (AS).

Methodology - The study involved 80 undergraduate students: 40 students pursuing an AA degree and 40 pursuing an AS degree. The design of the innovation game incorporated cognitivist learning strategies based on Bloom's taxonomy. Innovation skills were evaluated through an open-ended achievement test.

Findings- The study revealed that DGBL effectively enhances product innovation skills by integrating cognitive strategies, and Bloom's Taxonomy into guided answers, and open-ended achievement tests. AS students excelled in problem identification and idea creation, while AA students emphasised psychological, emotional factors and visualisation representation.

Significance - The findings suggest promoting interdisciplinary collaboration among educators and policymakers to integrate aesthetics and technological knowledge. This approach enables students from diverse disciplines to leverage their strengths for holistic innovation. For practical applications, game designers and educators can model product innovation steps, offer guided answers, track progress and award virtual badges. The open-ended achievement test is a valuable tool for assessing innovation skills across diverse student backgrounds. Future studies should focus on integrating cognitivism and constructivism in collaborative learning, using generative AI-assisted assessment, and bridging virtual idea generation with real-world product idea pitching using voice-input technologies. In conclusion, this study provides practical guidelines for implementing DGBL in product innovation, influencing education, policy-making, and design practices.

Keywords: Digital game-based learning, product innovation skills, undergraduates, problem-solving, creativity.

INTRODUCTION

In 2021, the World Economic Forum (WEF) projected that by 2025, 50% of the global workforce would require reskilling to adapt to technological advancements, particularly in innovation (WEF, 2024). WEF also identified innovation as a critical skill for future jobs (WEF, 2024). Innovation plays an important role in achieving sustainable development goals, including resilient infrastructure, sustainable industrialisation, and fostering innovation, as underscored by the United Nations Educational, Scientific and Cultural Organization (UNESCO), (2023). Without fostering innovation, challenges may arise in healthcare, sanitation, and access to quality education (UNESCO, 2023). It is clear that fostering innovation is crucial for individuals to navigate a rapidly changing world, address climate change, cope with inflation, disruptions in raw materials availability, and global economic downturns. Therefore, promoting innovation is not only important for individual job prospects but also ensures economic stability, influencing global competitiveness and sustainability.

Problem Statement

Both UNESCO (2022) and WEF underscored the crucial role of education in fostering innovation, especially in preparing students for the challenges and opportunities of the 21st century. However, integrating innovative learning approaches into undergraduate education presents several challenges. Innovation is not merely about content mastery, which challenges implementation and assessment (Jan & Gaydos, 2016). Traditional assessment methods may not effectively capture the diverse perspectives among learners (Jan & Gaydos, 2016).

Innovation demands higher-order thinking (HOT) skills with less predefined content, requiring a more self-directed learning process that could extend learning hours and potentially impact student engagement (Blanco-Herrera et al., 2019; Huang et al., 2022; Hwang et al., 2018; Jan & Gaydos, 2016; Küçüksayraç & Kirca, 2020; Lu et al., 2021). Moreover, the diverse academic disciplines such as applied arts (AA) and applied sciences (AS) bring distinct skill sets to the table (Horng et al., 2024; Ludwig et al., 2017). AA students excel in creative thinking and often contribute creative solutions during problem-solving, while AS students are adept in analytical and technical approaches (Broekhoven et al., 2020;

Rubenstein et al., 2020; Ulger, 2017). This diversity offers an opportunity to explore how the innovation process varies among students from different disciplines. To address these challenges, universities should devise strategies to integrate innovative learning into higher education effectively, to cater the needs of students from AA and AS disciplines.

Purpose of the Study

Aligned with the goals of WEF and UNESCO, this study aims to enhance students' innovation skills in preparation for a sustainable future. Higher education plays a pivotal role in cultivating problem-solving abilities and innovation (Martin, 2022). Innovatively designed learning approaches equip undergraduates with leadership skills for the industry (Horng et al., 2021; Huang et al., 2022; Hwang et al., 2018. Innovation education in community settings enables solving real-world problems for societal benefit (Jamieson & Shaw, 2020) identifying potential solutions for global issues (Huang et al., 2022; Paul et al., 2021; Solarte et al., 2021) and improving quality of life through innovative products and services (Kale & Akcaoglu, 2020; UNESCO, 2023). Prior research shows that effective teaching strategies are crucial in nurturing innovation skills (Horng et al., 2021). This study specifically explores the efficacy of game-based learning in developing innovation skills. Digital game-based learning (DGBL) integrates lesson plans into games environments, enhancing engagement and addressing motivational issues (Prensky, 2007; Bawa, 2019). Studies by Zichermann and Cunningham (2011) highlight students' preference for gaming, supporting effectiveness of DGBL (Alsawaier, 2017). Additionally, Barr (2018) found positive responses to using digital games for skills development. This study aims to explore how DGBL can effectively foster innovation skills among undergraduate students.

Significance of the Study

Given the pressing need to enhance innovation skills and the potential of DGBL to facilitate the learning process, this study investigates the effectiveness of DGBL in developing innovation skills among undergraduate students. Specifically, it compares the innovation skills between students in AS and AA. By examining the impact of DGBL on these two disciplines, this research aims to contribute to existing findings on DGBL's efficacy in fostering innovation skills. In addition, by investigating the variations in innovation skills between AS and AA students, this study provides valuable insights into the unique strengths and areas of improvement within each discipline. This comparison offers a different perspective on how DGBL can be customised to meet the specific educational needs and requirements of AS and AA students, potentially leading to more effective pedagogical approaches and skill development strategies in both fields. The findings from this study hold significant implications for educators and policymakers in guiding the design of targeted interventions and educational programmes that promote innovation and bridge the educational gap between AA and AS disciplines.

LITERATURE REVIEW

Digital Game-Based Learning

Digital Game-Based Learning (DGBL) is widely recognised for its engaging and enjoyable nature, garnering positive responses from undergraduates (Ng et al., 2021; Tan, W. et al., 2021). This method enhances engagement and fosters a positive learning experience through the implementation of clear goals, rules, and feedback mechanisms (Segaran et al., 2021). Research by Bereitschaft (2021) highlights that DGBL, specifically through simulation games, promotes critical thinking, spatial reasoning, and creativity as students engage in tasks like building virtual cities. Additionally, Mellor et al. (2018) suggested that DGBL can stimulate product development process, particularly in disciplines like chemistry, by providing interactive and practical learning experiences. DGBL is applicable across diverse classroom settings, effectively engaging students from various disciplines through structured game goals and rules. This approach aligns with the perspective that product innovation requires open-ended problem-solving skills (Tan & Yong, 2018). Effective implementation of DGBL necessitates alignment between intended learning outcomes, lesson plans, course structure and instructional materials (Tan & Maizatul Hayati, 2019).

Theoretical Foundation of Learning Innovation in DGBL

The theoretical foundation of learning innovation in DGBL derives from cognitivism, which evolved from behaviourism, emphasising how learning behaviour is influenced by an individual's thinking processes (Jan & Gaydos, 2016). Bloom's taxonomy, rooted in cognitivism, categorises thinking processes into six dimensions: remember, understand, apply, analyse, evaluate, and create (Anderson et al., 2001; Bloom, 1956; Jan & Gaydos, 2016; Saputra et al., 2019). Integrating Bloom's taxonomy within the context of the DGBL approach has proven to be effective in motivating and engaging students in problem-solving activities (Vahldick et al., 2020; Sharunova, et al., 2018). Prior research has successfully utilised Bloom's taxonomy in DGBL to teach complex skills, such as undergraduate level problem-solving (Jan & Gaydos, 2016; Sharunova, et al., 2018). The adaptability of this DGBL approach extends beyond traditional engineering disciplines (Sharunova et al., 2018), making it suitable for interdisciplinary and transdisciplinary domains, facilitating mastery of complex concepts and skills among students (Jan & Gaydos, 2016). Effective knowledge acquisition through DGBL requires game design that aligns with learning outcomes structured according to Bloom's taxonomy (Pitarch & Wang, 2022; Vahldick et al., 2020). In this study, the cognitive and behavioural tasks required for effective product innovation were identified using Bloom's taxonomy as a foundation for designing the game for this DGBL practice.

Product Innovation Skills

Product innovation, driven by R&D, plays a crucial role in transforming ideas into solutions (Bunduchi et al., 2022; Jamieson & Shaw, 2020; Schachter, 2018). In contrast, product design often prioritises customer-centric production but may lack innovative approaches (Paul et al., 2021). This study aims to foster problem-solving and creative skills within the product innovation process. It is important to distinguish between invention and product innovation; invention generates new ideas, which may remain irrelevant without commercialization, while product innovation results in viable products (Schachter, 2018). UNESCO (2022) underscores the economic significance of innovation, emphasising its reliance on education amid rapid global changes which pose challenges to innovation (Schachter, 2018). This study examines the problem identification and idea creation phases of product innovation, drawing from frameworks such as the innovator's DNA (Solarte et al., 2021) and HOTS (Hwang et al., 2018). These frameworks employ self-questioning techniques to foster experimentation and discovery (Hwang et al., 2018; Solarte et al., 2021). Insights from successful entrepreneurs like Jeff Bezos and Steve Jobs further validate the importance of developing innovation skills among undergraduate students (Solarte et al., 2021). Previous research has primarily used questionnaires, which may lack insight into students' cognitive perspectives (Huang et al., 2022; Martín-Hernández et al., 2021; Solarte et al., 2021). Thus, alongside designing an innovation game, this study focuses on assessing innovation skills from students' cognitive perspective.

Problem Identification

Problem identification is a critical initial phase in the HOTS problem-solving process, essential for selecting effective solutions (Huang, et al., 2022; Hwang et al., 2017; Solarte et al., 2021). It entails questioning, exploration, and the creation of opportunities (Rubenstein et al., 2020). Techniques such as self-questioning guide learners in analysing evidence, connecting it with prior knowledge, and reflecting on their findings (Cambridge Assessment International Education, 2021; Solarte et al., 2021; Yu et al., 2020). The Innovator's DNA framework integrates self-questioning techniques into the innovation process (Solarte et al., 2021). However, designing games for effective problem-solving is challenging due to the diverse nature of problems (Yu et al., 2020). Therefore, DGBL emerges as a suitable approach to learning problem-solving offering step-by-step instructions to guide players to solve challenges (Esteban et al., 2020). Problem identification aligns with the cognitive domain of Bloom's Taxonomy. "Remember" involves recognising problems and recalling pertinent information from memory (Anderson et al., 2001), while, "analyse" entails identifying relationships between components of a problem (Wang et al., 2020). This process includes distinguishing different parts of a problem statement, organising elements based on evidence, and determining a point of view (Anderson et al., 2001). These two cognitive domains are pertinent for inclusion in this study in identifying problems through self-questioning.

Product Idea Creation

Following problem identification, problem solvers engage in the creative process of generating product ideas, a process involving creativity and problem-solving skills (Huang et al., 2022; Kale & Akcaoglu, 2020; Rubenstein et al., 2020). This creative process involves developing innovative ideas or products (Huang et al., 2022; Hwang et al., 2017). According to Anderson et al. (2001), creativity skills are developed through higher education curriculum design, but Baker et al. (2001) argues that higher education's impact on creativity development is limited (Ulger, 2017). Learners must have the freedom to make decisions when solving problems, yet time constraints often restrict this freedom (Blanco-Herrera et al., 2019). Conversely, Fleury et al. (2021) suggests that freehand idea sketching facilitates rapid modification of ideas and supports the creation of product ideas and prototypes (Fleury et al., 2021). Incorporating freehand idea sketching as a game mechanic could enhance product innovation. Bloom's Taxonomy introduces the cognitive domain of creation, which involves synthesising elements to form new patterns, structures, or processes— including generating, planning, and inventing products (Anderson et al., 2001; Wang et al., 2020). This domain is integrated into learning objectives to ensure learners achieve the cognitive skills necessary for innovation. Creating missions within a game requires guidance, as it represents the highest cognitive domain in Bloom's Taxonomy (Vahldick et al., 2020). Therefore, the DGBL approach includes instructional support for assisting learners in innovating products.

Undergraduate Students

Undergraduates often face challenges in learning innovation due to constraints such as limited time and knowledge, requiring alternative pedagogical approaches (Küçüksayraç & Kirca, 2019). Horng et al. (2021) introduced a product innovation course tailored for tourism and hospitality students, highlighting the need for future research including students from diverse educational institutions to account for potential variations in educational impact. Paul et al. (2021) emphasised the role of problem identification in fostering creative outputs and suggested innovative pedagogical approaches. Jamieson and Shaw (2020) advocated grading based on product innovation to enhance students' innovation skills. Cristina et al. (2021) highlighted the development of entrepreneurial intentions through business serious games, while Ludwig et al. (2017) noted the enhancement of soft skills in students through innovation courses. However, research specifically on learning product innovation among AA and AS students is lacking. AA students in art-related courses such as graphic design and animation, are known for their creativity in visualising their ideas, which is important in completing artwork (Ulger, 2017). Rubenstein et al. (2020) found that AA students who spend more time on problem identification produce more innovative outputs, enhancing their prospects as successful artists in the future. The creative output in art-related fields emphasises novelty and uniqueness. In contrast, AS students in courses such as mathematics, algorithm structure and programming focus on logical thinking and the feasibility of solutions (Broekhoven et al., 2020; Ulger, 2017). Research indicates that AA students exhibit higher self-assessed creativity and generate more diverse ideas than AS students (Broekhoven et al., 2020). According to Kaufman and Beghetto (2013), creativity output can be divided into creativity in art, which includes the creation of visual arts, music, creative writing, and film. Meanwhile, creativity in science involves scientific discovery and invention (Ulger, 2017). In comparison to AA students, AS students often develop outputs based on identified problems, influenced by their approach to learning scientific subjects through probing open-ended questions (Ulger, 2017). Kaufman and Beghetto (2013) emphasised the pivotal role of the learning environment in fostering creativity skills (Ulger, 2017). Therefore, this suggests that DGBL provides a conducive learning environment for students to engage in self-directed learning while creating product ideas. Recognising these research gaps, this study introduces an achievement test instrument to measure the product innovation skills of undergraduate students across disciplines. This empirical approach aims to evaluate learning outcomes related to product innovation for undergraduates.

METHODOLOGY

Research Questions

This research aims to investigate the differences in product innovation between AA and AS students through exposure to DGBL. The research questions derived from the literature are as follows.

(i) Is there a significant difference in problem identification skills between AS and AA students after exposure to DGBL?

(ii) Is there a significant difference in product idea creation skills between AS and AA students after exposure to DGBL?

DGBL Strategy

To address the research questions, a DGBL strategy grounded in cognitive learning theory is applied to ensure alignment between the digital game and learning content. Given that product innovation is not a common subject in undergraduate curricula, the design of product innovation materials was adapted from the Innovator's DNA theory and HOTS theory. Validation of these materials was conducted by experts in game design, pedagogy, and content (Creswell, 2007; Tan B. S. et al., 2021). The "Inventors of Future" (*IoF)* mobile game is specifically designed and developed to simulate the process of product innovation guided by a Table of Specifications (ToS) adapted from Tan and Maizatul (2019). This ToS outlines domain-specific alignment of learning objectives, including game goals, rules, and feedback, as illustrated in Table 1. The alignment of learning objectives in terms of observable behaviour, conditions of attainment and degrees of attainment adheres to Bloom's taxonomy, reflecting principles from cognitive learning theory (Bloom, 1956; Sharunova et al., 2018).

Table 1

Alignment of Game Objectives with Goal, Rules and Feedback

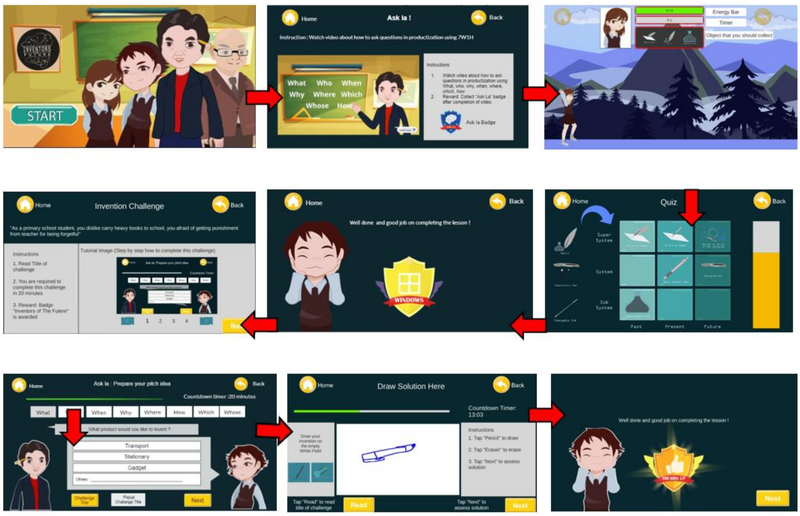
Learn	Outcome of extraction and alignment		
Extracting components of learning outcomes	Observable behaviour	Condition of attainment	Degree of attainment
	Undergraduate students are able to use questioning technique to…	…identify problems	…after playing digital game
Setting elements of game	Goal	Rules of Play	Feedback
	Players are able to apply questioning technique to…	… identify problems...	... and receive a virtual badge after mission is accomplished.

Inventors of Future (IoF) Mobile Game

Following recommendations to enhance relatability to the subjects (Tan B. S. et al., 2021), a mobile game titled "Inventors of Future" (*IoF*) was designed and developed for this study, based on a ToS adapted from Tan and Maizatul (2019). In this game, players engage in role-playing as students enrolled in invention academy, where they learn the process of problem identification and product idea creation. The gameplay involves watching videos and playing mini games. Upon completing these learning activities, players participate in a product innovation simulation challenge in the game. Virtual badges are awarded to players upon completion of collects of each task. The game content was validated by a game expert, with revisions made before conducting a quasi-experimental study. To access this game, players need a mobile phone running on Android operating system. For iOS users, players can access the game through *BlueStacks* installed on a computer. Figure 1, displays screenshots from the IoF game.

Figure 1

Screenshots of Game Flow for IoF



Scaffolding Methods of IoF

The *IoF* game employs scaffolding techniques to provide clear instructions to players, systematically breaking down the product innovation process into modules, with a primary focus on product idea identification and creation. The product identification module guides players through the process by breaking it down into smaller steps. Here, players learn problem identification through self-questioning techniques and detailed description of problems. Moving to the product creation module, players explore the creation of product ideas using self-questioning techniques, followed by illustrations and descriptions of their product ideas. Through these modules, players engage with mini games that explore past, current, and futuristic products, providing successful examples to enhance understanding of problem identification and product idea creation. The self-questioning techniques embedded in the game stimulate critical thinking and creativity during the product innovation process.

Through self-questioning techniques, players are encouraged to consider problems from various angles and think beyond their initial ideas. For example, instead of conventional questions like who, what, when, why, and where, players are prompted to answer questions such as “which specific components of the product would you improve?” and “whose product ideas are currently in the market?” To ensure effective scaffolding, the *IoF* content was validated by experts to ensure alignment of learning objectives with game goals, rules and feedback. This alignment focuses on achieving learning outcomes related to problem identification and product idea creation.

Achievement Test

An achievement test was developed in this study to assess the performance of participants in evaluating their product innovation skills. A ToS was created to define the learning objectives, time allocation and cognitive domains targeted in evaluating the product innovation skills of undergraduate students. The two research questions focus on higher cognitive levels, aligned with the cognitive domains, “analyse” and “create” (Vahldick et al., 2020). Each research question consists of three open-ended questions, each graded on a maximum of five points, contributing to a total score of 15 percent for each research question. The ToS guided the alignment of these questions with specific cognitive domains, as detailed in Table 2. The rubric for scoring the achievement test was adapted from Tan, B. S. et al. (2021).

To ensure validity, a face validity assessment was conducted to determine how well the instrument appeared to measure students’ product innovation abilities from a layman’s perspective (Creswell, 2007; Salkind, 2018). Based on this assessment, revisions were made to enhance the clarity and grammatical correctness of the achievement test questions and rubrics. Domain validity further ensured that the achievement test and rubrics effectively measured the variables pertinent to product innovation skills according to the research questions (Creswell, 2007; Salkind, 2018). The design of the achievement test was meticulously aligned with the research questions, as summarised in Table 1. An inter-rater reliability test revealed consistent scores between two raters for seven out of nine questions, with a Cronbach’s Alpha coefficient of r =.78 (Chang et al., 2020; Eggers et al., 2017). External validity was established by conducting the study across universities with students from diverse backgrounds (Creswell, 2007), enhancing generalisability of the findings.

Table 2

Design of Achievement Test and Alignment with Bloom's Taxonomy Level

No.	Tested Item	Bloom's Level	Total Score
Domain 1: Identify Problem			
Research question: Is there a significant difference in problem identification skills between AS and AA students after exposure to DGBL?			
a	Please identify a problem based on the above scenario.	C1	5
b	Why do you think the problem you identified is a problem?	C2	5
c	List down all the questions you asked yourself when searching for potential solutions to the problem you have identified.	C4	5
Domain 2: Create Product Idea			
Research question: Is there a significant difference in product idea creation skills between AS and AA students after exposure to DGBL?			
a	What would be your product idea for the problem you have identified?	C1	5
b	Please draw a picture or diagram of your product idea here.	C6	5
c	Please describe your product idea based on your visualisation.	C6	5

Participants

Undergraduate students were purposefully selected from AA and AS degree programmes for the study (Creswell, 2007). The participants' ages ranged from 21 to 27 years. Inclusion criteria of the study specified that participants must be pursuing a bachelor's degree, exclusion criteria listed individuals who are deaf, blind or have cognitive disorders due to the visual and creative nature of the tasks involved in illustrating product idea. A minimum of 30 participants per group was aimed for correlational analysis, as recommended by Creswell and Clark (2017) and Salkind (2018). Qualitative data collection focused on achieving the saturation of responses through open-ended achievement tests, following methods described by Creswell and Clark (2017) and Flick (2018). A total of 80 undergraduate students from two universities participated in the study, evenly split with 40 from AA degree programmes and 40 from AS degree programmes.

Procedure

This research employed a quasi-experimental research design as the current learning topic is not a formal curriculum or co-curriculum subject in the university. A pre- and post-test quasi-experimental research design was utilised, where participants were not randomly assigned but receive the same treatment (Creswell & Clark, 2017; Stratton, 2019). The significance of scores generated from the pre- and post-tests assesses the difference before and after treatment, evaluating participants' behavioural changes (Creswell & Clark, 2017; Stratton, 2019). This method allows for a rapid and immediate response to the intervention applied (Stratton, 2019). Participants completed achievement tests developed for this study (Tan B. S. et al., 2021) after obtaining ethical approval and providing signed consent for data analysis using SPSS. During the pre-test phased, participants completed a set of achievement tests within 30 minutes. Following this, participants engaged in a 30-minute session playing a mobile game to learn about product innovation. In the post-test phased, participants answered the same set of questions but with a different case study, also within 30 minutes. The entire intervention, including breaks between sessions, lasted approximately 90 minutes. An independent samples t-test was conducted to compare the product innovation skills in problem identification and product creation between AS and AA students. The p-value of Levene's test from the pre-test phased was analysed to determine whether variance scores differed significantly between the two groups of students. The results of Levene's test indicated no significant difference in variance scores for problem identification and product idea creation between the AS and AA student groups.

RESULTS

Descriptive Statistics

Problem Identification Skills

Table 3 presents the summary statistics for problem identification. The mean score for AS students is 10.075, while for AA students, it is 8.0250.

Table 3

Group Statistics for Domain 1: Problem Identification Domain

Domain 1	Group	N	M	SD	SE
Problem Identification	AS	40	10.0750	10.0750	.42575
	AA	40	8.0250	8.0250	.43924

Product Idea Creation Skills

Table 4 presents the summary statistics for product idea creation. The mean score for AS students is 11.7500, while for AA students, it is 8.9750.

Table 4

Group Statistics for Product Idea Creation Domain

Domain	Group	N	M	SD	SE
Product Idea Creation	AS	40	11.7500	2.44687	.38688
	AA	40	8.9750	3.72440	.58888

Inferential Statistics

Independent Samples t-test for Problem Identification Skills

Table 5 presents the results of Levene's test for equality of variances in the problem identification domain. The p-value from Levene's test indicates no significant difference in variance scores between AS and AA students. However, the p-value from the t-test for equality of means shows a significant difference in mean scores between AS and AA students t (78) = 3.351, p =.001. On average, AA students scored 2.05 points lower than AS students.

Table 5

Independent Samples Test Results for Identifying Problem Domain

Equal variances assumed Equal variances not assumed			Identify Problem	
Levene's Test for Equality of variances	F		.123	
	Sig.		.727	
t-test for Equality of Means	t		3.351	3.351
	df		78	77.924
	Sig. (2-tailed)		.001	.001
	Mean Difference		2.05	2.05
	Std. Error Difference		.61172	.61172
	95% Confidence Interval of the Difference	Lower	.83216	.83216
		Upper	3.26784	3.26786

Independent Samples t-test for Product Idea Creation Skills

Table 6 presents the results of Levene's test for equality of variances in the product idea creation domain. The p-value from Levene's test indicates a significant difference in variance scores between AS and AA students. Furthermore, the p-value from the t-test for equality of means indicates a significant difference in mean scores between AS and AA students t (67.380) = 3.938, p < .001. On average, AA students scored 2.775 points lower than AS students in product idea creation skills.

Table 6

Independent Samples Test Results for Product Idea Creation Domain

Equal variances assumed Equal variances not assumed			Product Idea Creation
Levene's Test for Equality of variances	F		11.283
	Sig.		.001
t-test for Equality of Means	T		3.938
	Df		78
	Sig. (2-tailed)		.000
	Mean Difference		2.77500
	Std. Error Difference		.70460
	95% Confidence Interval of the Difference	Lower	1.37225
		Upper	4.17775

Qualitative Data Interpretation

Root Cause Analysis

Both quantitative and qualitative findings converge in highlighting participants' ability to articulate problems clearly and accurately, along with their underlying issues. Commonly identified root causes encompass punishment, discomfort, fear, lack of exercise, social media disruption, slow computer speed, and network problems. While both groups utilised self-questioning techniques to identify problems, differences emerged in the nature of questions posed. AS students tended to raise technically-oriented questions related to technology in their daily lives, whereas AA students concentrated on questions related to product innovation and enhancement, focusing on improving product features or materials.

Creativity and Novelty

Quantitative analyses showed higher scores in product idea creation skills among AS students. AS students predominantly proposed innovative solutions, with a strong emphasis on technology-based approaches and provided detailed proposals of their solutions. Their solutions often included ideas for multi-functional products. In contrast, while both groups proposed a mix of innovative product ideas and ideas reminiscent of existing products on the market, AA students leaned more towards innovating existing designs or introducing novel features to improve them.

Visual Representation and Description

Both groups presented visual representations of their product ideas, each with distinct levels of detail. AA students demonstrated their ability in creating aesthetically pleasing visualisations and provided detailed descriptions of their product ideas, focusing on physical components and operational aspects. AS students also offered visual representations, with some focusing on software application interfaces and others providing simple sketches that illustrate the practical aspects of their product ideas. Figures 2 and 3 illustrate these product ideas from various perspectives.

Figure 2

Visualisation of the Product Idea by AA Students

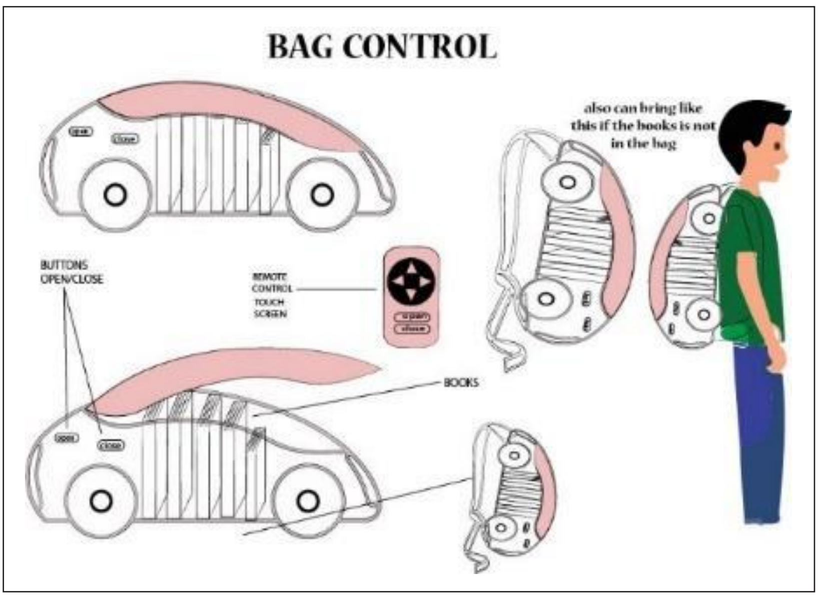
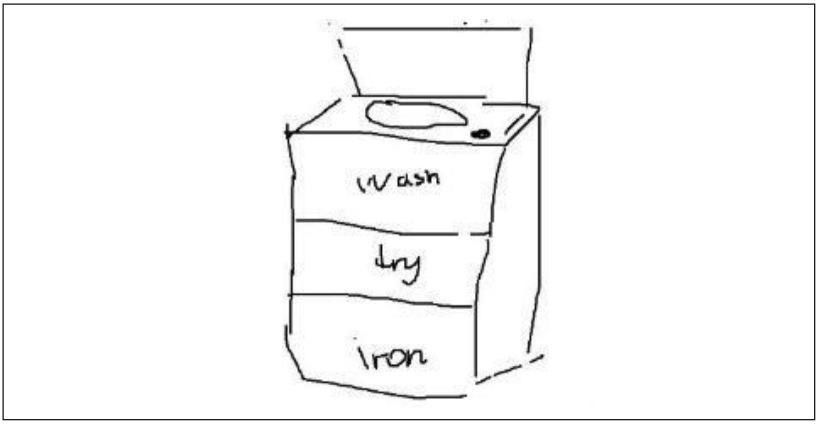


Figure 3

Visualisation of the Product Idea by an AS Student



DISCUSSION

The findings of this study revealed both the similarities and differences in problem identification and product idea creation between students from AS and AA backgrounds. The findings were analysed to address uncertainties in the innovation learning process, traditional assessment challenges in innovation, and variations in knowledge and cognitive perspectives among AS and AA students during the innovation process.

Comparison with Previous Research

Learning Strategies

Learning innovation entails more than just mastering content, it requires HOT skills that are self-directed and often involve extensive exploration. The findings indicate that students effectively acquired innovation skills by applying the cognitivist learning theory approach. Aligning Bloom's taxonomy with specific cognitive levels in problem identification and product idea creation structured learning tasks according to their difficulty levels within the game environment. Features such as progress bars and multiple-choice selections in the innovation game provided feedback and guided students through the innovation process. These findings support the alignment of this design with cognitivism and are consistent with studies by Sharunova et al. (2018), Vahldick et al. (2020), and Pitarch and Wang, (2022), which argue for the effective application of Bloom's taxonomy in complex learning tasks.

Assessment Strategies

Overall, the findings indicate that students from both groups developed innovation skills through the DGBL approach, consistent with findings from studies by Huang et al. (2022), Solarte et al. (2021) and Martin-Hernandez et al. (2021). In contrast to previous research that relied on questionnaires, this study employed an achievement test featuring open-ended questions to assess students' innovation skills. The use of open-ended questions effectively revealed the diverse knowledge and cognitive perspectives of students from different backgrounds in the innovative process. These findings address the issues related to measuring performance in innovation skills, which can vary significantly among learners.

Theoretical Framework

The results regarding problem identification demonstrated the use of self-questioning techniques, based on the Innovator's DNA framework (Solarte et al., 2021). These findings align with previous research where students, through guided prompting questions, demonstrated competence in linking the problem statement with the relevant knowledge discipline (Solarte et al., 2021). The step-by-step instructions provided to guide students in problem-identification positively influenced both groups of students. The cognitive processes involved in problem identification align closely with the cognitive domain of Bloom's Taxonomy.

Product Idea Creation

The study compared two student groups in product idea creation from pedagogical and cognitive perspectives. Both groups used freehand sketching and DGBL for decision-making and communication, in line with findings by Blanco-Herrera et al. (2019) and Fleury et al. (2021). The inclusion of sketching in games has been shown to enhance innovation skills. In contrast to research by Broekhoven et al. (2020), this study focuses on product innovation through a unified approach, emphasizing quick, visually appealing sketches that prioritise user experience. AS students concentrated on software applications, prioritising feasibility, and novelty, which aligns with findings of Broekhoven et al. (2020). DGBL plays a crucial role in developing visual and communication skills. AS students are encouraged to consider aesthetics to effectively present their ideas.

CONCLUSION

Practical and Theoretical Implications

The findings of this study underscore the benefits of adopting DGBL for learning innovation across diverse academic disciplines. Key highlights derived from the problem statements are summarised as follows:

Integration of Cognitivist Learning Strategies to Foster Innovative Skills

Cognitivist learning strategies effectively address uncertainties in learning product innovation by aligning Bloom's taxonomy with the game's content. Educators are encouraged to incorporate higher cognitive domains in Bloom's Taxonomy into DGBL assessments to cultivate problem-solving and creativity skills. Through interactive simulations and problem-solving scenarios, students engage deeply with real-world challenges, applying cognitive processes such as problem-solving and creativity to devise creative solutions. By incorporating techniques such as Bloom's taxonomy, learners not only acquire theoretical knowledge but also gain practical experience in navigating complex problems and generating novel ideas. These findings suggest that educators can customise curriculum content and learning experiences in DGBL to align with specific interests and needs of students group, by collaborating closely with game designers.

Designing Games for Product Innovation

Breaking down the steps of product innovation according to game levels, providing guided answers for self-questioning about product idea creation, tracking the innovation process using progress bars, and awarding virtual badges rewarded for each completed step has significantly supported students in completing complex tasks in product innovation. Game designers are encouraged to explore various game designs to optimise learning outcomes and enhance student engagement in the field of product innovation.

Utilising Open-ended Achievement Tests

Innovation skills assessment was conducted through an open-ended achievement test, revealing that DGBL holds the potential for developing product innovation skills among undergraduate students. The adoption of open-ended achievement tests has revealed differences in knowledge and cognitive perspective among students from diverse academic backgrounds.

Differential Performance of AS and AA students

AS students outperform AA students in problem identification and product idea creation, likely due to their science learning involving identifying problems and answering open-ended questions. Although AA students generally score lower in these areas, they demonstrate competence in product innovation by focussing on psychological and emotional factors during problem analysis. Additionally, AA students excel in producing visually compelling product ideas. Education policymakers can use these insights to advocate for interdisciplinary collaboration among students.

Limitation and Future Studies

This study developed a single product innovation game to enhance HOT skills among AA and AS discipline students. Future research could explore:

Integrating Cognitivism and Constructivism in Developing Product Innovation Skills

The current cognitivist approach focuses on mental processes in problem-solving and creativity for generating new product ideas. This approach prioritises individual mastery of content and skills through predetermined learning objectives and assessments. Incorporating a constructivist approach, learners could foster task collaboration among learners, enabling them to share ideas and provide feedback during problem-solving (Gampell et al., 2024). Gamification elements such as experience points (XP), badges, levels and leaderboards could track learning progress in product innovation (Gampell et al., 2024).

Transforming Assessment and Visualisation through Generative Artificial Intelligence (AI)

The open-ended achievement test effectively captures the cognitive process of AS and AA students during innovation. However, it has limitations since it relies on instructors to assess scores, which may introduce bias based on their backgrounds and knowledge. To address this, future studies should explore the use of generative AI technologies to automatically mark test scores (Holmström & Carroll, 2024). Generative AI, trained on extensive datasets, can assess tests using a vast repository of internet data, thereby enhancing validity and reliability of assessments (OpenAI, 2024). These technologies are not intended to replace instructors but rather to assist them in making informed decisions when evaluating problem-solving and creativity skills in product innovation. In comparison to AA students, AS students may face challenges in designing aesthetically appealing product ideas. However, the integration of generative AI tools presents an opportunity to support AS students by transforming text-based product concepts into visually compelling images. Furthermore, the findings suggest a potential area for improvement in product identification skills among AA students. Compared to providing guided answers, generative AI tools can play a constructive role by acting as judges or innovator non-player character (NPC)s, assisting AA students in problem identification and assessment tasks. For instance, students could describe their innovative ideas to a generative AI NPC, who would then generate personalised feedback based on their input (Mariani & Dwivedi, 2024). The generative AI NPC could also offer tips, suggestions, and examples to guide students in their innovation journey (Holmström & Carroll, 2024; Sundberg & Holmström, 2024). This can be achieved by crafting a generative AI NPC with the knowledge bank and brain of NPC (Convai, 2024; Mariani & Dwivedi, 2024).

Bridging the Gap between Virtual Product Idea Generation and Real-World Pitching

The current game design framework serves as a valuable platform for developing innovation skills through gamified elements. However, its current focus primarily revolves around text-based and image-based idea generation, which may not fully simulate real-world challenges that innovators face. In professional settings, securing funding for product implementation often requires effective communication and pitching skills. To address this gap, integrating voice input functionality for NPCs within the game presents a constructive solution (MetaQuest, 2024). Enabling players to practise communication skills while pitching their ideas offers a more immersive and realistic learning experience. By allowing players to articulate their ideas verbally and adapt to various audience responses, this feature enhances their ability to effectively present their innovations. Furthermore, compared to text-based interactions, incorporating voice-based NPC for questioning increases immersion in the innovation process, offering a more dynamic and engaging learning environment (Convai, 2024).

Research Design

This study focuses on comparing AS and AA students to measure product innovation skills. Future research could enhance validity by including a control group study and longitudinal analysis of the DGBL approach in learning product innovation skills.

In conclusion, the findings and discussion highlight the differences in approaches to product innovation skills between AA and AS students. They underscore the effectiveness of DGBL in enhancing these skills across diverse academic backgrounds, suggesting the adaptability of cognitivist learning strategies, game design elements and assessment methods for future applications. The findings also highlight unique strengths and areas for improvement in innovation among students from different disciplines, providing essential guidelines for educators, policymakers and designers when integrating DGBL into product innovation education. Future research may explore integrating various learning theories and technologies to overcome current game design and assessment limitations, thereby enhancing the applicability of DGBL in classroom settings for learning product innovation.

ACKNOWLEDGMENT

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

REFERENCES

Alsawaier, R. S. (2018). The effect of gamification on motivation and engagement. The International *Journal of Information and Learning Technology*, *35*(1), 56-79. https://doi.org/10.1108/IJILT-02-2017-0009

Anderson, L. W., Krathwohl, D. R., & Bloom, B. S. (2001). *A taxonomy of learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Allyn & Bacon.

Barr, M. (2018). Student attitudes to games-based skills development: Learning from video games in higher education. *Computers in Human Behaviour*, *80*(283-294). https://doi.org/10.1016/j.chb.2017.11.030

Bawa, P. (2019). Game On! Investigating digital game-based versus gamified learning in higher education. *International Journal of GBL*, *10*(31), 16-46. http://doi.org/10.4018/IJGBL.2020070102

Bereitschaft, B. (2021). Commercial city building games as pedagogical tools: What have we learned? *Journal of Geography in Higher Education*. https://doi.org/10.1080/03098265.2021.2007524

Blanco-Herrera, J., Gentile, D., & Rokkum, J. (2019). Video Games can increase creativity, but with caveats. *Creativity Research Journal*, *31*(2), 119-131. https://doi.org/10.1080/10400419.2019.1594524

Bloom, B. S. (1956). Taxonomy of educational objectives. *Cognitive Domain.* (1), pp (20-24). McKay, New York.

Broekhoven, K. V., Cropley, D., & Seegers, P. (2020). Differences in creativity across art and STEM students: We are more alike than unalike. *Thinking Skills and Creativity*, 36. https://doi.org/10.1016/j.tsc.2020.100707

Bunduchi, R., Mitra, C. C., Salanta, I. I. & Crisan, E. L. (2022). Digital product innovation approaches in entrepreneurial firms – the role of entrepreneurs' cognitive frames. *Technological Forecasting & Social Change*, 175. https://doi.org/10.1016/j.techfore.2021.121343

Cambridge Assessment International Education. (2021). Active learning. In *Cambridge Assessment International Education*. https://www.cambridgeinternational.org/Images/271174-active-learning.pdf

Chang, C. Y., Kao, C. H., Hwang, G. J., & Lin, F. H. (2020). From experiencing to critical thinking: A contextual GBL approach to improving nursing students' performance in electrocardiogram training. *Educational Technology, Research and Development*, *68*, 1225-1245. https://doi.org/10.1007/s11423-019-09723-x

CONVAI-Conversational AI for Virtual Worlds. (2024). Embodied AI characters for virtual worlds. https://convai.com/

Creswell, J. W. (2007). *Qualitative inquiry and research design: choosing among five approaches* (2nd ed.). London, United Kingdom: Sage.

Creswell, J., & Clark, V. P. (2017). *Designing and conducting mixed methods research.* London, United Kingdom: Sage.

Cristina, P., Thais, G. T., Juan-Jose, N. S. (2021). Boosting entrepreneurial intention of university students: Is a serious business game the key? *The International Journal of Management Education*, *19*(3). https://doi.org/10.1016/j.ijme.2021.100506

Eggers, F., Lovelace, K., & Kraft, F. (2017). Fostering creativity through critical thinking: The case of business start-up simulations. *Creativity and Innovation Management*, *26*(3), 266-276.https://doi.org/10.1111/caim.12225

Esteban, F., Torralbo, J., Casas, D., & García, M. (2020). Web gamification with problem simulators for teaching engineering. *Journal of Computing in Higher Education*, *32*(1), 135-161. http://dx.doi.org/10.1007/s12528-019-09221-2

Fleury, S., Blanchard, P., & Richir, S. (2021). A study of the effects of a natural virtual environment on creativity during a product design activity. *Thinking Skills and Creativity*, 40. https://doi.org/10.1016/j.tsc.2021.100828

Flick, U. (2018). *The SAGE Handbook of Qualitative Collection*. London, United Kingdom: SAGE Publications.

Gampell, A. V., Gaillard, J., Parsons, M., Dé, L. L., & Hinchliffe, G. (2024). Participatory minecraft mapping: Fostering students participation in disaster awareness. *Entertainment Computing*, *48*, 100605. https://doi.org/10.1016/j.entcom.2023.100605

Holmström, J., & Carroll, N. (2024). How organizations can innovate with generative AI. *Business Horizons.* https://doi.org/10.1016/j.bushor.2024.02.010

Horng, J. S., Hsiao, H. L., Liu, C. H., Chou, S. F., & Chung, Y. C. (2021). Learning innovative entrepreneurship: Developing an influential curriculum for undergraduate hospitality students. *Journal of Hospitality, Leisure, Sports & Tourism Education*, 100289. https://doi.org/10.1016/j.jhlste.2020.100289

Huang, Y.-M., Silitonga, L. M., & Wu, T.-T. (2022). Applying a business simulation game in a flipped classroom to enhance engagement, learning achievement, and higher-order thinking skills. *Computers & Education*, *183*, 104494. https://doi.org/10.1016/j.compedu.2022.104494

Hwang, G.-J., Lai, C.-L., Liang, J.-C., Chu, H.-C., & Tsai, C.-C. (2018). A long-term experiment to investigate the relationships between high school students' perceptions of mobile learning and peer interaction and higher-order thinking tendencies. Educational Technology Research & Development, *66(*1), 75–93. https://doi.org/10.1007/s11423-017-9540-3

Jamieson, M. V., & Shaw, J. M. (2020). Teaching engineering innovation, design, and leadership through a community of practice. *Education for Chemical Engineers*, 31, 54-61. https://doi.org/10.1016/j.ece.2020.04.001

Jan, M., & Gaydos, M. (2016). What is game-based learning? Past, present, and future. *Educational Technology, 56(3),* 6-11. https://www.jstor.org/stable/44430486

Kale, U., & Akcaoglu, M. (2020). Problem-solving and teaching how to solve problems in technology-rich contexts. *Peabody Journal of Education*, *95*(2), 127-138. https://doi.org/10.1080/0161956X.2020.1745612

Kaufman, J. C., & Beghetto, R. A. (2013). Do people recognize the four Cs? Examining layperson conceptions of creativity. *Psychology of Aesthetics, Creativity, and the Arts*, *7*(3), 229–236. https://doi.org/10.1037/a0033295

Küçüksayraç, E., & Kırca, L. N. E. A. (2020). Integrating sustainability into project-based undergraduate design courses. *International Journal of Sustainability in Higher Education*, *21*(2), 353-371. https://doi.org/10.1108/IJSHE-07-2019-0230

Ludwig, P. M., Nagel, J. K., & Lewis, E. J. (2017). Student learning outcomes from a pilot medical innovations course with nursing, engineering, and biology undergraduate students, *IJ STEM Ed* 4, 33. https://doi.org/10.1186/s40594-017-0095-y

Lu, K., Yang, H. H., Shi, Y., & Wang, X. (2021). Examining the key influencing factors on college students' higher-order thinking skills in the smart classroom environment. *International Journal of Educational Technology in Higher Education, 18*(1), 1–13. https://doi.org/10.1186/s41239-020-00238-7

Mariani, M., & Dwivedi, Y. K. (2024). Generative artificial intelligence in innovation management: A preview of future research developments. *Journal of Business Research*, 175, 114542. https://doi.org/10.1016/j.jbusres.2024.11454

Martin. M. (2022). *Higher education on the road to 2030*. Retrieved fromhttp://www.iiep.unesco.org/en/higher-education-road-2030

Martín-Hernández P., Gil-Lacruz M., Gil-Lacruz A. I., Azkue-Beteta J. L., & Lira E. M., Cantarero L. (2021). Fostering university students' engagement in teamwork and innovation behaviours through game-based learning (GBL). Sustainability, *13*, 13, 13573.https://doi.org/10.3390/su132413573

Mellor, K. E, Coish, P., Brooks, B. W., Gallagher, E. P., Mills, M., & Kavanagh, T. J. (2018). The safer chemical design game. Gamification of green chemistry and safer chemical design concepts for high school and undergraduate students. *Green Chemistry Letters and Reviews*, 2. https://doi.org/10.1080/17518253.2018.1434566

MetaQuest. (2024, April 28). Oculus Lipsync for Unity Development. https://developer.oculus.com/documentation/unity/audio-ovrlipsync-unity/

Ng, S. F., Dawie, D. D. S. A., Chong W. W., Jamal, J. A., Rahman, S. N. A. A. R., & Jamal, J. I. (2021). Pharmacy student experience, preference, and perceptions of gaming and game-based learning. *Currents in Pharmacy Teaching and Learning*, 13, 479-791. http://dx.doi.org/10.1016/j.cptl.2021.01.019

OpenAI. (2024, April 28). Get Answers. Find Inspiration. Be More Productive. https://openai.com/chatgpt/

Paul, B. K., Mears, L., & Shih, A. (2021). Teaching Manufacturing Processes from an innovative perspective. *Procedia Manufacturing*, *53*(814-824). https://doi.org/10.1016/j.promfg.2021.06.076

Pitarch, R. C., & Wang, L. (2022). Spanish B1 vocabulary acquisition among Chinese students with Guadalingo. *The International Journal of Information and Learning Technology*, 2056-4880. https://doi.org/10.1108/IJILT-07-2021-0101

Prensky, M. (2007). *Digital GBL*. New York: McGraw-Hill.

Rubenstein, L. D., Callan, G. L., Neumeister, K. L., Ridgley, L. M., & Finch, M. E. (2020). How problem identification strategies influence creativity outcomes. *Contemporary Educational Psychology*, 60, 101840. https://doi.org/10.1016/j.cedpsych.2020.101840

Salkind, N. J. (2018). *Exploring Research.* (9th ed). Essex, England: Pearson.

Saputra, M. D., Joyoatmojo, S., Wardani, D. K., & Sangka, K. B. (2019). Developing critical-thinking skills through the collaboration of jigsaw model with problem- based learning model. *International Journal of Instruction*, *12*(1), 1077-1094.

Segaran, K., Ahmad Zamzuri, M., Tan, W. H. (2021). Does Avatar design in educational games promotea positive emotional experience among learners? *e-learning and Digital Media*, *18*(5), 422-440. https://doi.org/10.1177%2F2042753021994337

Schachter, E. M. (2018). The nature and variety of innovation. *International Journal of Innovation Studies*, 2, 65-79. https://doi.org/10.1016/j.ijis.2018.08.004

Sharunova, A., Butt, M., & Qureshi, A. J. (2018). *Transdisciplinary design education for engineering undergraduates: Mapping of bloom's taxonomy cognitive domain across design stages*. [Paper presentation]. 28th CIRP Design Conference 2018, France. https://doi.org/10.1016/j.procir.2018.02.042

Solarte, H., Tobar, H., & Mesa, J. (2021). Changing perceptions about entrepreneurship and industry-related aspects and fostering innovation skills using a video game. *Interactive Technology and Smart Education*, *18*(1), 104-118. https://doi.org/10.1108/ITSE-10-2020-0220

Stratton, S. (2019). Quasi-Experimental Design (Pre-Test and Post-Test Studies) in prehospital and disaster research. *Prehospital and Disaster Medicine, 34*(6), 573-574. https://doi.org/10.1017/S1049023X19005053

Statista. (2020). Age Breakdown of Online Gamers. https://www.statista.com/statistics/1117575/malaysia-age-breakdown-of-online-gamers/

Sundberg, L., & Holmström, J. (2024). Innovating by prompting: How to facilitate innovation in the age of generative AI. *Business Horizons*. https://doi.org/10.1016/j.bushor.2024.04.014

Tan, B. S., Tan, W. H., & Ahmad Zamzuri, M. (2021). The study of using digital GBL to develop critical thinking skills through the self-assessment process. International *Journal of Creative Multimedia*. *2*(2), 30-50. https://dx.doi.org/10.37200/IJPR/V24I5/PR201780

Tan, W. H., & Maizatul Hayati, M. (2019). Gamification: GBL training module. Tanjong Malim, Malaysia: Universiti Pendidikan Sultan Idris.

Tan, W., Supian, N., & Kok S. C. (2021). *Game-based learning in improving English vocabulary and detecting metacognitive awareness among English for specific purposes undergraduates* [paper presentation]. Proceedings of the 2nd International Conference on Social Science, Humanities, Education and Society Development (ICONS 2021). https://dx.doi.org/10.2991/assehr.k.220101.021

Tan, W. H., & Yong, R. (2018). Mapping ARIZ against a conceptual model of how a grassroots innovator solved non-routine problems, *Proceedings of MyTRIZ Conference 2018*. 29-30 Nov, Multimedia University, Cyberjaya, Malaysia.

UNESCO. (2022, Jan 4). *UNESCO and Sustainable Development Goals*. Retrieved from https://en.unesco.org/sustainabledevelopmentgoals

UNESCO. (2023, Oct 24). Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation. https://www.un.org/sustainabledevelopment/infrastructure-industrialization/#:~:text=Goal%209%20seeks%20to%20build,sustainable%20industrialization%20and%20foster%20innovation.

Ulger, K. (2017). Comparing the effects of art education and science education on creative thinking in high school students. *Arts Education Policy Review*. https://doi.org/10.1080/10632913.2017.1334612

Vahldick, A., Farah, P. R., Marcelino, M. J., & Mendes, A. J. (2020). A blocks-based serious game to support introductory computer programming in undergraduate education. *Computers in Human Behavior Reports*, *2*. https://doi.org/10.1016/j.chbr.2020.100037

Wang, R., Lowe, R., Newton, S., & Kocaturk, T. (2020). Task complexity and learning styles in situated virtual learning environments for domainion higher education, *Automation in domainion*, 113. https://doi.org/10.1016/j.autcon.2020.103148

World Economic Forum. (2024, July 3). *These are the top 10 job skills of tomorrow – and how long it takes to learn them*. https://www.weforum.org/agenda/2020/10/top-10-work-skills-of-tomorrow-how-long-it-takes-to-learn-them/

Yu, Z., Gao, M., & Wang, L. (2020). The effect of educational games on learning outcomes, student motivation, engagement and satisfaction. *Journal of Educational Computing Research*, *59*(3), 522-546. https://doi.org/10.1177%2F0735633120969214