An Integrated Instrument for Measuring Science, Technology, Engineering, and Mathematics: Digital Educational Game Acceptance and Player Experience

Husna Hafiza R.Azami[1], Roslina Ibrahim[2], Suraya Masrom[3],
Rasimah Che Mohd Yusoff[4], Suraya Yaacob[5]
Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia[1, 2, 4, 5]
Computing Sciences Studies, College of Computing, Informatics and Media,
Universiti Teknologi MARA Perak Branch, Tapah Campus, 35400 Malaysia[3]

***Abstract*—Digital educational games (DEGs) are effective learning tools for subjects related to science, technology, engineering, and mathematics (STEM), yet they are still not widely used among students. Existing instruments typically assess player experience (PX) and acceptance separately, even though both are essential DEG evaluations that can be merged and analyzed concurrently in a thorough manner. This study, therefore, proposes an integrated instrument called DEGAPX that combines fundamental technology acceptance factors with a broad range of PX criteria. The proposed instrument can be used by educators and game designers in the selection and development of DEGs that satisfy the needs of target users. This article describes the process of developing the scale instrument and validating it through two rounds of expert judgment and among students after using three DEGs related to STEM. The proposed instrument, which comprised 15 constructs measured by 67 items, was proven to be reliable and valid.**

***Keywords*—Game; education; acceptance; experience; stem**

I. Introduction

The complexity of the modern world, which necessitates that the workforce be prepared with the knowledge and abilities to tackle cross-disciplinary problems, is argued to make science, technology, engineering, and mathematics (STEM) education necessary [1]. In contrast to the growing demand, there have been fewer STEM graduates in many countries [2]. STEM-related degrees accounted for six out of ten of the educational programs, with the highest percentage of dropouts among 44,406 students at 20 Malaysian public institutions [3]. A universal concern in education is learner's lack of enthusiasm in STEM fields.

The use of modern pedagogical approaches such as educational gaming technologies has been advocated by academics as a way to improve students' interest, engagement, and performance in learning [4], [5]. Among 408 university students in Malaysia, more than 60% of them prefer using online games to supplement their studies because they believe games can make their learning more enjoyable [6].

Moreover, it has been demonstrated that game-based learning applications may improve learners' understanding, interconnection, and exploration of scientific and mathematical concepts. This instructional tool can give students opportunities for experiential learning that let them apply the concepts learned in the classroom to actual situations while also developing their creativity, critical thinking, and problem-solving abilities [7]. Furthermore, the COVID-19 pandemic highlights the importance of educational technologies like DEGs as a preparation for an unpredictable future that may require remote instruction. These technologies enable the acquisition of knowledge and skills outside of the classroom [8], [9].

Digital educational games (DEGs) are online or offline applications in electronic devices that integrate fun and educational elements [10]. This technology is anticipated to be widely used and accepted because current learners are people who have grown up with a heavy reliance on the internet and other information technologies such as digital games [11]. It has been shown that around 80% of all internet users worldwide between the ages of 16 and 44 play video games in the year 2022 [12]. Therefore, DEGs are useful and pertinent technological applications that can support students' learning.

Although DEGs offer great promise and are a good fit for today's learners, they have not yet received widespread acceptance. Game developers face challenges in creating successful, well-received DEGs since they are more difficult to design than commercial entertainment games due to the need to serve both educational and recreational goals [13]. Numerous DEGs have fallen short of the expectations placed upon them in terms of learning or enjoyment outcomes [14].

With the growth of DEGs, more research is required to assist game developers, instructors, and policymakers in the design, development, selection, and implementation of DEGs that satisfy students' preferences as the key target users. When an information system is widely adopted by the intended audience, it can be considered successful [13]. Although there has been various researches that investigate the predictors of DEG acceptance, a systematic literature review shows that most of them primarily concentrate on technological acceptance viewpoints, which are insufficient to fully comprehend students' preferences for DEGs [15].

Given the distinctive and complex features of DEGs, a variety of player experience (PX) factors that contribute to players' pleasure should be incorporated into the acceptance model and instrument since it can affect users' decisions to utilize the technology [16]. Existing studies normally evaluate DEG acceptance and PX separately [19]. Performance expectancy, effort expectancy, and social influence are prevalent characteristics of technology acceptance [17], [18]. By incorporating PX factors, the assessment of acceptance can be expanded to include crucial DEG design features such as enjoyment, relevant content, feedback, and challenges.

Hence, the purpose of this research is to present an inclusive DEG acceptance instrument called DEGAPX that integrates PX factors. The instrument is crucial and helpful in designing and developing potentially popular DEGs. The instrument can be used by DEG developers to adapt the design that suits users' needs to boost the likelihood of DEG success. The instrument can also be utilized as a guide by instructors when identifying which DEGs could appeal to their students. The subsequent sections of this paper comprise a literature review, methods, results, and discussion, followed by a conclusion in the last section.

II. Literature Review

A. Digital Educational Game Acceptance Factors

According to Dillon and Morris [20], acceptance refers to the willingness of individuals to use an information system that has been created for them. Current approaches to technology development and adoption have considered the requirement for predictive measures of users' likely usage in order to judge the success of a technology. The technology may be deemed unsuccessful if the majority of the population rejects it. By analyzing the data obtained for the measurement scales in questionnaires, previous studies have frequently been able to forecast and explain why people want to use a particular technology [17], [18].

One of the most well-known theories for predicting human behavior when it comes to probable technology acceptance or rejection is the unified theory of acceptance and use of technology (UTAUT). The theory combines eight other renowned theories such as the technology acceptance model (TAM) for explaining and forecasting technology usage [18]. Three independent variables in UTAUT namely performance expectancy, effort expectancy, and social influence predict behavioral intention that affects use behavior.

UTAUT had previously been used to investigate what criteria led Malaysian university students to choose DEGs for learning programming [21]. In place of social influence and facilitating condition variables from the original UTAUT model, the research added attitude, self-efficacy, enjoyment, and anxiety. With the exception of self-efficacy and anxiety, all other independent variables were seen to have a substantial impact on students' intention to utilize the DEG. The use behavior construct was left out with justification that DEG was still a relatively new technology in the area where the study took place and the students were still unfamiliar with it.

Wan et al. [22] look into what influences undergraduate students' acceptance of six digital board games and their ability for independent learning. The instrument was derived from the integration of UTAUT with flow theory as well as the motivated strategies for learning questionnaire (MSLQ). To identify the causes of primary school students' intentions to continue using mobile games for learning mathematics, another study also made an effort to combine multiple theories such as flow theory and the game-based learning model [23]. Nevertheless, the only variable from technology acceptance was the ease of use.

B. Digital Educational Game Player Experience Factors

According to ISO 9241-210:210 (clause 2.15), user experience (UX) is defined as the way a person feels and behaves after using or anticipating the use of a system, product, or service. For digital educational games (DEGs), UX is sometimes referred to as player experience (PX). Assessment of PX broadens game usability evaluation by focusing on meaningful and enjoyable experiences of users rather than only getting rid of technological barriers [24].

PX is a crucial factor in determining how long a person will play DEGs which will determine the DEG's success [25]. When a game has a strong PX, consumers are more likely to play it frequently, stay engaged for a longer duration, and recommend it to others [26]. Despite the wide variety of learning games available today, some of them are unattractive to consumers and have low retention rates, as consumers get bored after a few gaming sessions [27]. The absence of elements that can improve PX may be one of the causes. Consumers may lose interest when their playing experience falls short of their expectations. Therefore, it is critical to include PX in DEG evaluation.

There have been many different methods for evaluating PX, including questionnaire scales, field studies in real-world settings, lab studies, and online studies where participants can be anonymous [28]. Since studies on the variables that determine user acceptance generally use measurable constructs evaluated using Likert scale questionnaires, prior literature that assessed PX in DEG using a similar method was reviewed. The PX factors derived from those studies can then be analyzed in the same manner as the acceptance factors without any problems.

One of the most popular measurement scales used by researchers to gauge how consumers feel while playing games is the game experience questionnaire (GEQ) [29]. Seven different factors are measured by the questionnaire's items, including the positive affect (enjoyment), negative affect, flow, challenge, tension, as well as sensor and imaginative immersion, which relates to a rich gaming experience, beautiful design, and engaging game plot. However, there were no learning-related factors in the GEQ scale.

Nagalingam et al. [31] proposed one of the recent instruments to thoroughly assess PX in digital learning games called the educational game experience (EDUGX). The instrument which had been reviewed by experts and tested among 273 computer science diploma students, had demonstrated content validity, internal consistency, convergent validity, and discriminant validity. There were six components to the instrument including immersion, usability, flow, player context, and learnability, each of which was broken down into a number of sub-components. The immersion component gauges how invested individuals feel in the game they play, whereas usability measures the extent to which players found the game to be effective and satisfying. On the other hand, learnability represents the educational aspect of the game; player context pertains to the user background and the social interaction that the game supports, while flow indicates the state of total focus.

III. Methods

A. Instrument Development

The development of the DEGAPX scale instrument for this research follows the guideline by DeVellis [32], where the first step entails reviewing theories from past studies relevant to the research objective. Since this research intends to propose a comprehensive instrument for measuring the acceptance of DEGs with the integration of PX components, constructs that evaluate DEG acceptance and PX in prior studies were identified from two separate systematic literature reviews [15].

1) Determination of constructs: Performance expectancy, effort expectancy, and social influence are the constructs in UTAUT by Venkatesh et al. [18] which had been proven by many studies to have an impact on students' intention to use DEGs [22], [33], [34]. Hence, this study chooses these three constructs together with behavioral intention from UTAUT to represent the core technology acceptance constructs in the proposed DEGAPX instrument.

From the review of PX constructs used by scholars [27], those proposed by Nagalingam et al. [31] in the EDUGX framework can be considered for this research since they were developed after taking into account diverse PX criteria in other studies. However, some adjustments were made.

For instance, EDUGX [31] and the frameworks in other existing research [35], [36] used a control factor to assess the extent of freedom felt by players over the game menu, character movement, actions, and strategies. Since DEG is an instructional tool, this study decides to transform the construct into a learning control construct that focuses on players' perceptions of control over their learning recovery, problem-solving approaches, and ability to choose the game content that they want to learn and the difficulty level.

Apart from that, under the game usability component in EDUGX [31], operability was defined as the game performance including its accessibility, ease of use, and lack of technological glitches, while understandability was defined as the game's messages, functions, inputs, and outputs being simple to understand. On the other side, the game system sub-component indicated how well a gaming gadget operated in terms of being simple and comfortable to use. These revealed that operability, game system, and understandability from the EDUGX framework [31] and effort expectancy from the UTAUT model [18] were comparable. Therefore, this research chose to use the effort expectancy construct to cover the game usability measurement items in EDUGX. In addition, knowledge improvement under the learnability component of EDUGX is similar to the UTAUT model's performance expectancy construct, which measured the game's capacity to enhance students' learning performance.

As a result, 14 constructs were considered for this study, as shown in Fig. 1, including performance expectancy, effort expectancy, social influence, and behavioral intention from UTAUT [18], as well as learning relevance, attractiveness, enjoyment, challenge, clear goal, learning control, social interaction, feedback, concentration, and immersion modified from EDUGX [31] for player experience measurement.

Construct	Definition
Player experience	
Learning relevance	The degree to which the game instructions are appropriate with user's learning goals, previous knowledge and preferred way of learning.
Attractiveness	The level of player attraction to the game as a result of its sensory elements, such as audio and visual.
Enjoyment	The degree to which an individual perceives the activity of using the game is enjoyable.
Challenge	The degree to which users believe the game is difficult enough and appropriate for their skill level.
Clear goal	The extent to which a player perceives the goals are clearly presented.
Learning control	The extent to which users believe they have control over their learning in the game.
Social interaction	The extent to which the game supports and encourages social connection and interaction.
Feedback	The degree that individuals perceive the game provides feedback on progression and accomplishment.
Concentration	The ability of the game to deliver stimuli that will pique players' attention and encourage player's focus.
Immersion	A state in which players believe they are actively participating in the content of the game and completely involved in the game world.
Technology acceptance	
Performance expectancy	The extent to which individuals perceive that using the game will help improve their performance in STEM learning and skills.
Effort expectancy	The extent of ease related to the use of the game.
Social influence	The extent to which individuals perceive that important others believe DEGs should be used.
Behavioral intention	Degree of an individual's intention to use DEGs related to STEM.

Fig. 1. Definition of the 14 constructs in the DEGAPX instrument that integrates technology acceptance and player experience measurement.

2) Determination of items and measurement format: After a thorough examination of the validated items used in prior studies, a scale which consisted of 87 items in total was generated to measure the constructs in the DEGAPX instrument. Some items were modified from previous research to suit the context of this study. New items were also proposed, including those under the performance expectancy construct that measure the perception of students on their STEM learning and skill improvement through the DEG.

For the format of responses, students were required to indicate their agreement on each questionnaire item using the five-point Likert scale with 1 (strongly disagree), 2 (disagree), 3 (not sure), 4 (agree), and 5 (strongly agree). The instrument questions were prepared in Malay, as well as in English language as the respondent's first and second language, respectively. The instrument had been proofread by an English lecturer with a master's degree in Teaching English as a Second Language (TESL), and the Malay translation had also been examined by the Malaysian Institute of Translation and Books (ITBM) to ensure accurate translation.

B. Content Validation through Expert Judgment

For evaluating a new or updated measurement instrument, the establishment of content validity is a crucial first step before performing other validation techniques [37]. Based on the opinions of subject-matter experts, the content validation procedure enables researchers to acquire data on the relevancy, clarity, and comprehensiveness of an instrument.

The instrument for this research was scrutinized by experts in the field pertinent to this research, as shown in Table I. Two rounds of expert review were conducted, following Polit et al. [38] and Tojib [37]. The documents for the expert panel were prepared following the detailed guideline by Elangovan & Sundaravel [39] to ensure that the experts understand what is expected of them and to facilitate the validation process.

TABLE I. EXPERTS PROFILE

Expert	Field of Expertise	Years of Experience
E1	Game-based learning, creative content	20
E2	Game design, educational technology, visual informatics	19
E3	Educational games design and evaluation, acceptance and use of information system, usability, user experience	15
E4	Human computer interaction, science, technology, engineering, and mathematics	15
E5	Game-based learning, e-learning, learning technologies, gamification, augmented reality, virtual reality games	15
E6	Technology acceptance, multimedia in education, augmented reality, science, technology, engineering, and mathematics	15
E7	User experience in educational games	8
E8	Mobile application and games development	6
E9	Information system, technology acceptance and adoption	4

The first round involved nine experts, and the second round was conducted with three of the experts to validate the refined instrument. These numbers of experts are within the suggested range by Polit et al. [38]. The selection criteria for the content experts were those who hold a Ph.D. qualification and actively conduct research in the field of interest or have experience developing DEGs [37].

The content validity index (CVI) is a reliable approach to judge whether the content of a new or revised scale is valid. Another commonly used method for measuring content validity is the content validity ratio (CVR) by Lawshe [40]. The goal of the content validation for this research was to ascertain whether any item needed to be revised or eliminated based on the CVR value, the CVI value of individual items (I-CVI), as well as whether more items were required in order to fully explore the construct in light of expert opinion from the comment section [38], [40].

The CVR threshold is influenced by the number of experts. For nine panel of experts, items that achieve the CVR value of 0.78 and above can be retained, while the rest can be considered for elimination [40]. Similarly, items with I-CVI values are higher than 0.78 which shows that the scale has excellent content validity, whereas values below 0.78 indicate that the items need to be revised or eliminated. I-CVI can be calculated by dividing the number of experts who gave a three or four rating on a four-point relevance scale by the total number of experts [41].

Low CVI values could indicate that the operationalization of the underlying construct in the items was not good, or information and directions given to the experts were insufficient, or the experts themselves were biased or inadequately skilled [38]. Hence, a lot of effort was put to create high-quality items as well as to choose a strong panel of expert judges. CVI for the overall scale (S-CVI/AVE) can then be determined. While 0.80 is the minimum acceptable value for S-CVI/AVE, 0.90 or above is advised for a scale to be deemed to have great content validity [38].

C. Instrument Testing among Target Respondents

It is important to conduct a pilot study among target respondents to determine whether a specific research instrument is appropriate for use without any errors or shortcomings before it can be employed in a larger scale research. The reliability and validity of the questionnaire items and how well respondents understood the items need to be judged during this stage [42].

The research sample consists of 14 years old students from a public school in Terengganu, one of the states in Malaysia. Approval from the Ministry of Education (MOE) Malaysia and the Terengganu State Education Department was requested before the data collection. Following that, a meeting was held with the school principal to obtain permission and discuss the schedule. All students were given a form for parental or guardian consent.

The research objectives were briefly explained to the participants including the games that they need to play and evaluate, as well as the confidentiality and anonymity of their feedback. They were reminded of the significance of this study, the necessity of reading each survey question thoroughly before responding and to avoid providing incomplete or straight-lining (identical) responses.

Three DEGs were chosen for testing, based on the DEGAPX instrument, such as having relevant content, clear goals, attractive features, and ability to improve students' learning and skills pertinent to STEM. The first DEG decided for this research is a simulation game called Poly Bridge 2 (https://www.polybridge2.com/) by Dry Cactus that lets players learn the foundations of bridge design. Players need to construct bridges that work well under specific conditions using the materials provided.

The second DEG in this study, RoboCo (https://roboco.co/) by Filament Games, requires students to design robots that can complete a range of tasks. Students can practice their coding skills using Python language when automating their robots. The two games, Poly Bridge and RoboCo, can help players become more creative as well as better at problem-solving and design-thinking, which are important skills in STEM. On the other hand, the third game, Moonbase Alpha (https://www.nasa.gov/offices/education/programs/national/ltp/games/moonbasealpha/index.html) was published by NASA and free-to-play. Students can play alone or collaborate in a team with other players to repair equipment and resume oxygen production at the moon outpost. The screenshots of the three games were shown in Fig. 2.

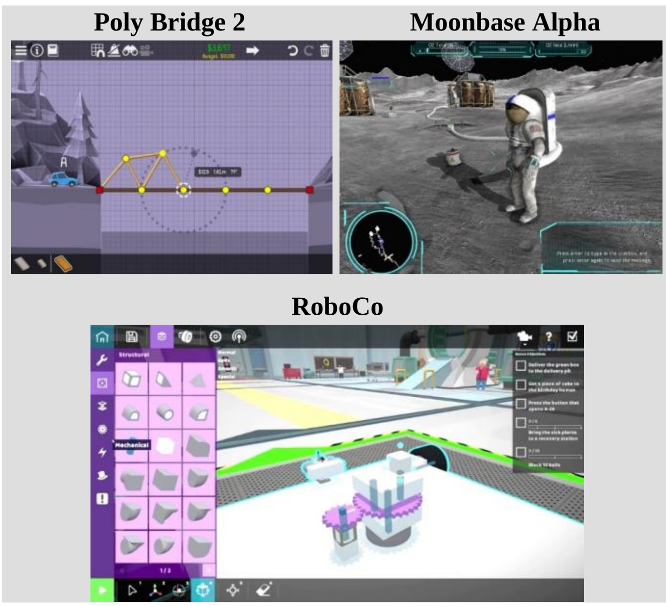

Fig. 2. The images of the three STEM DEGs used in this research.

While some students played all three games, others engaged in one or two games only. They need to answer a self-administered paper-based questionnaire after playing the game for about 90 minutes in the school computer laboratory. There were 281 valid responses obtained from students. RoboCo received 87 responses, Moonbase Alpha received 93 responses, and Poly Bridge 2 received 101 responses.

D. Reliability and Validity Assessment from Instrument Testing

Using SmartPLS 3, reliability was examined based on outer loading of items, Cronbach's alpha (α), and composite reliability (CR). Outer loadings denote the proportion of the item variance that is explained by the construct, while α and CR assess the intercorrelation between items.

On the other hand, average variance extracted (AVE) can be used to evaluate convergent validity, which refers to the strength of a positive correlation between items. For discriminant validity, heterotrait-monotrait (HTMT) can determine how distinct one construct is from other constructs. Table II showcases the criteria by Hair et al. [43].

Exploratory factor analysis (EFA) with principal component extraction and varimax rotation can also be carried out in IBM SPSS Statistics 27 software to assess construct validity. The data set is appropriate for factor analysis if the Keyser-Meyer-Olkin (KMO) value surpasses 0.5 with a significant Bartlett's test of sphericity result below 0.05.

TABLE II. RELIABILITY AND VALIDITY ASSESSMENT CRITERIA BY HAIR ET AL. [43]

Criteria	Guidelines
Outer loading	- Remove items with loadings less than 0.4 - Retain items if their loading exceeds 0.7. - Remove items with loadings between 0.4 and 0.7 if AVE and CR can be satisfied.
Cronbach's alpha (α)	- More than 0.70 is satisfactory. - Between 0.6 and 0.7 is acceptable.
Composite reliability (CR)	- Must exceed 0.70.
Average variance extracted (AVE)	- Must exceed 0.5.
Heterotrait-Monotrait (HTMT)	- Should be less than 0.9

IV. RESULTS

This section describes the results from the expert judgment and instrument testing of the DEGAPX instrument.

A. Content Validity

In terms of the constructs, all experts remarked them to be adequate in representing the whole aspect of DEG, and that none need to be added or removed. Thus, the proposed 14 constructs remained.

In light of first round of content validation results by nine experts for the items used to measure each construct, the CVI of the entire scale (S-CVI/AVE) was found to be 0.97, which passed the minimum acceptability limit. Five items did not meet the 0.78 content validity ratio (CVR) cut off, so they were regarded as weak in representing the particular constructs and can be eliminated. Some experts had issues with the items, and while certain research used them to measure the construct, their inclusion was not deemed vital since they were not included in other studies.

Among 87 items in the initial pool, 65 of them can be accepted without any necessary changes as all of them displayed excellent content validity based on the I-CVI and CVR value and were deemed relevant and clear by the experts. 17 items that also exceeded the 0.78 threshold for I-CVI and CVR, however, need to be refined according to experts' comments and ratings on clarity. The improvement included rewording, rephrasing, elaborating, and providing examples to improve the comprehensibility of the items. From the experts' comments, the proposed questionnaire items were deemed adequate, with no additional items needed.

The modified scale underwent a second round of validation with the help of experts E2, E3, and E6. They were one of those who provided a lot of input in the preliminary round. With a 1.00 average scale content validity (S-CVI/AVE) score, the findings showed agreement on all 84 items in the revised DEGAPX instrument, with no additional adjustments being recommended.

B. Reliability, Convergent Validity and Discriminant Validity

During the pilot test, none of the students had any trouble understanding the survey questions. When 281 survey responses obtained were analyzed in SmartPLS 3.0, 17 items need to be removed to satisfy the criteria in Table II. Apart from that, the performance expectancy construct also needs to be separated into two categories based on EFA rotated component matrix to achieve the required value of AVE. As a result, the DEGAPX instrument with 15 constructs measured by 67 items achieved the requirement for reliability and validity, as displayed in Table III. The 67 items are listed in Table IV, with their outer loadings above 0.40.

The suitability for factor analysis was demonstrated from the 0.875 value of KMO and a significant result of Bartlett's test (n=281; χ^2 = 11,997.707; d.f. = 3,486; p < 0.001). Next, the relationship between the constructs can be investigated to determine the significant predictors of STEM DEG acceptance.

TABLE III. RELIABILITY AND VALIDITY ASSESSMENT RESULTS

Construct	Items	α (>0.6)	CR (>0.7)	AVE (>0.5)
Attractiveness (AT)	5	0.808	0.866	0.566
Challenge (CH)	4	0.711	0.820	0.533
Clear goal (CG)	3	0.688	0.827	0.615
Concentration (CN)	4	0.674	0.802	0.507
Effort expectancy (EE)	7	0.842	0.881	0.514
Enjoyment (EJ)	5	0.784	0.854	0.544
Feedback (FB)	4	0.743	0.833	0.559
Immersion (IM)	5	0.757	0.836	0.506
Behavioral intention (IN)	5	0.754	0.835	0.505
Learning control (LC)	3	0.606	0.793	0.563
Learning performance expectancy (LE)	5	0.749	0.833	0.503
Learning relevance (LR)	4	0.728	0.830	0.553
Skill performance expectancy (SE)	4	0.729	0.831	0.553
Social influence (SF)	4	0.675	0.803	0.507
Social interaction (ST)	5	0.841	0.886	0.609

TABLE IV. DEGAPX INSTRUMENT CONSISTING OF 67 ITEMS

Code	Item Statement	Loading
Learning Relevance Construct		
LR1	DEG content is relevant to my learning need.	0.851
LR2	The way the DEG works suit my way of learning.	0.779
LR3	The DEG content is connected to the other knowledge I already had.	0.652
LR4	Most of the gaming activities are related to the learning task in the DEG.	0.678
Attractiveness Construct		
AT1	I like the general appearance of the DEG.	0.778
AT2	I am attracted to the DEG as a whole.	0.774
AT3	Generally, I find the DEG to be visually appealing.	0.781
AT4	The DEG design is attractive.	0.776
AT5	I like the graphic used in the DEG.	0.642
Enjoyment Construct		
EJ1	I think the DEG is enjoyable.	0.836
EJ2	There were moments when I had fun playing the DEG.	0.795
EJ3	I find the DEG interesting.	0.782
EJ4	Something happened during the DEG playing session that made me smile.	0.651
EJ5	The DEG does not become repetitive or boring as it progresses.	0.592
Challenge Construct		
CH1	My skill gradually improves through the course of overcoming the challenges in the DEG.	0.760
CH2	The difficulty level of challenges increases as my skills improved.	0.707
CH3	The DEG provides new challenges at an appropriate pace.	0.770
CH4	The DEG provides different levels or types of challenges, according to player's preference.	0.679
Clear Goal Construct		
CG1	Overall game goals are presented in the beginning of the DEG.	0.797
CG2	The intermediate game goals or sub-goals are mostly presented at appropriate times.	0.775
CG3	The game goals are generally clear.	0.780
Learning Control Construct		
LC1	I feel a sense of control over the actions that I take to solve the problems or to achieve better results in the DEG.	0.794
LC2	I feel a sense of control over the strategies that I use to solve the problems or to achieve better results in the DEG.	0.806
LC3	The DEG supports my recovery from errors or mistakes.	0.639
Social Interaction Construct		
SF1	I am able to interact with other people such as other players or friends or online community when playing the DEG.	0.774
SF2	The DEG makes me interact with other people such as for getting help or sharing information.	0.821
SF3	I like to play the DEG with other people.	0.780
SF4	I am able to play the DEG with other players if I choose to.	0.737
SF5	I would enjoy the social interaction through the DEG.	0.786
Feedback Construct		
FB1	I receive feedback on my game progress.	0.855
FB2	I receive immediate feedback on my actions in the DEG.	0.780

FB3	The DEG notifies me immediately when there are new tasks.	0.634
FB4	The DEG notifies me immediately when there are new events.	0.702
Concentration Construct		
CN1	The DEG provides content that stimulates my attention.	0.773
CN2	The DEG provides various stimuli to maintain my attention.	0.818
CN3	Generally, I am not distracted from tasks that the player should concentrate on.	0.592
CN4	I am not burdened with unrelated tasks.	0.637
Immersion Construct		
IM1	I can become less aware of my surroundings if I play the DEG for a long time.	0.643
IM2	The DEG can make me temporarily forget worries about everyday life.	0.788
IM3	I think the DEG can sometimes make me not notice the time passes when playing.	0.761
IM4	I feel emotionally involved in the DEG.	0.633
IM5	I think the DEG can make me spend more time playing than my initial plan.	0.720
Learning Performance Expectancy Construct		
LE1	I would find the DEG useful in my study.	0.709
LE2	Using the DEG would enable me to learn the related subject or concept more quickly.	0.768
LE3	Learning through the DEG would help me to understand the related subject or concept better.	0.784
LE4	The DEG can help me relate the knowledge learnt to real world situations.	0.550
LE5	The DEG would allow me to relate knowledge from multiple learning subjects.	0.710
Skill Performance Expectancy Construct		
SE1	The DEG can help me apply knowledge or skills to situations or practices related to technology or engineering.	0.685
SE2	The DEG can improve my skill in problem-solving.	0.742
SE3	The DEG can improve my creativity skills.	0.722
SE4	The DEG can increase my ability to design, test, and evaluate solutions.	0.819
Effort Expectancy Construct		
EE1	It is easy to learn the related subject or concept or skill through the DEG.	0.656
EE2	I find the DEG easy to use.	0.780
EE3	Learning to use the DEG is easy for me.	0.725
EE4	I think it will be easy for me to become skillful at using the DEG.	0.686
EE5	The interaction with the DEG is clear and understandable.	0.695
EE6	The DEG rules are generally clear and understandable.	0.722
EE7	The DEG instructions are mostly clear and understandable.	0.747
Social Influence Construct		
SF1	People who are important to me think that I should use DEG.	0.654
SF2	I think my school will support the use of DEG.	0.614
SF3	I think my friend or classmate will support the use of DEG.	0.757
SF4	My friend or classmate thinks playing DEG is a good idea.	0.808
Behavioral Intention Construct		
IN1	I intend to use DEG related to STEM in the future.	0.611
IN2	I predict I would use DEG related to STEM in the future.	0.656
IN3	I am interested to play the DEG again.	0.761
IN4	I plan to use the DEG to expand my learning or improve my skill.	0.716
IN5	I am willing to play the DEG frequently.	0.793

V. Discussion

This section discusses the validated 15 constructs of the DEGAPX instrument and the items used to measure them.

A. *Learning Relevance*

This construct was altered from Luyt et al. [44] and Sideris and Xinogalos [45] with some extensions, where learning relevance was measured not only by players' perceptions of how well the game content corresponds to their existing knowledge and learning needs but also by how closely the game activities matched the learning tasks in the DEG and players' learning styles. Students in this study mostly participated in quiz learning games, which are effective educational interventions for drill-and-practice activities and receiving immediate performance feedback on knowledge learned in classrooms. Because of that, the different learning objectives and approaches of the three STEM DEGs in this study may have an impact on students' perceptions of the learning relevance of the games.

Students may perceive the STEM DEGs have a little amount of instructional content relevant to their prior knowledge since the games place more emphasis on the application of knowledge to solve real-world problems. In addition, students might not find the games meet their educational needs unless they already have a keen interest in pursuing careers pertinent to the games. Nonetheless, students might find the games suit their learning styles and offer appropriate activities, which results in items LR2 and LR4 being added. The four items proposed, which had been proven to be reliable and valid can gauge how players feel about the DEGs' learning relevance from various angles.

B. *Attractiveness*

This construct was judged based on the overall appearance and design of a DEG, particularly its virtual aesthetics, as derived from Phan [30] and Tao [46]. One of the experts raised the possibility of other multimedia forms that can fall under this attractiveness construct, but the proposed items were deemed sufficient for this research.

There are many different types of DEG multimedia, such as texts, images, and animations, which would result in too many items if they were measured separately and could cause respondent fatigue when answering the survey. Future research that evaluates DEG with fewer constructs can include more items for measuring specific features of DEGs that users can find appealing.

Attractiveness had been demonstrated to have a significant correlation with students' enjoyment when playing DEGs [46]. The suggested items are beneficial for developers to determine the attraction level of their game prototype designed for teaching and learning purposes.

C. Enjoyment

All experts agreed that the five items in Table IV were pertinent for assessing the degree of enjoyment felt by players. Several studies have revealed that students' willingness to play DEGs is significantly influenced by their level of enjoyment [13], [47], [48]. Hence, this construct is one of the most important criteria for a successful DEG.

D. Challenge

The four items proposed were found reliable and valid for representing the challenge construct. This construct is intended for ensuring a DEG provides suitable challenges for players' skill level, which are neither too easy, making players bored, nor too difficult, causing players distress [49]. RoboCo and Poly Bridge 2 games offer a variety of challenges, where players can only access the next challenge after completing the one before it. While some students enjoy demanding games, others might favor easy, relaxing games that do not require much mental effort. Thus, games that allow users to select their preferred difficulty level might appeal to a wide range of consumers.

E. Clear Goal

This research offers three items, as presented in Table IV, for assessing the goal clarity of a DEG as adapted from the validated items in prior research [30]. The items were all regarded as relevant by the experts and can influence students' willingness to play learning games [22].

F. Learning Control

It is believed that players' learning performance can be enhanced when they have control over their learning in the game. Hence, the learning control construct put forth in this study embodies the assistance provided by a game for players to learn from their mistakes as well as the freedom to select their preferred course of action and problem-solving tactics.

G. Social Interaction

The items for this construct were modified from Phan and Keebler [30] and G Petri et al. [14] to measure the extent to which students believe the game promotes social connection, whether it be for knowledge sharing or help-seeking. Additionally, this construct gauges how much students think the game allowed them to play with other players if they want to and how much they enjoy the interaction.

Social interaction is a wonderful game design element that can boost students' enjoyment and motivate them to play a game repeatedly to engage with other players through communication, cooperation, and competition in the game.

Not all games have a multi-player feature, but even without it, social interaction can still be encouraged when players can communicate with other people, such as when getting help or sharing information through an online chat room, discussion forums, or game-based learning activities in classrooms. Hence, the proposed five items listed in Table IV are generic enough and adequate to measure players' perception of social interaction through a DEG.

H. Feedback

Playing a DEG will be more pleasurable if it offers consumers immediate feedback and informs them of their progress, achievements, failures, and new tasks. The four items in Table IV, which had been constructed based on Nagalingam et al. [31] and Fu et al. [35], were proven reliable and valid.

I. Concentration

The four items for measuring the extent of concentration perceived by students when playing a DEG were developed based on previous research [22], [35]. The items evaluate how much players believe a DEG does not burden them with unnecessary duties, does not take their attention away from activities they should be concentrating on, and provide a variety of stimuli to keep players interested. Concentration was established as a significant determinant of students' instructional computer games acceptance [13]. Thus, it is a crucial factor to consider when developing DEGs.

J. Immersion

Immersion had been demonstrated to have a substantial impact on students' intention to continue using mobile learning games in a previous study [23]. Hence, game creators should design DEGs with fun, challenging activities and interesting features that can make players feel immersed. Items presented in Table IV can be used in the assessment of a DEG since they appropriately reflect the immersion criteria.

K. Performance Expectancy

Due to the focus of this study being STEM DEGs, the survey items from prior research [50] were expanded to incorporate performance expectancy from two categories including knowledge and skill improvement. DEGs for STEM must not only facilitate and improve students' comprehension and performance in learning certain concepts or topics, but also fostering their abilities pertinent to STEM like designing, creativity, and problem-solving.

Given that performance expectancy is one of the most important factors in predicting whether or not students will accept DEGs [51], it is imperative to ensure that any DEG being developed for STEM will benefit students in some way beyond simply enhancing their academic performance. Games' potential should be utilized to provide students with learning opportunities that go beyond a straightforward replication of what is taught from the pedagogical tools traditionally used in classrooms [52].

All items suggested for representing performance expectancy were deemed relevant by experts. The items can be utilized by game developers when designing games intended to enhance students' learning performance and skill development.

L. Effort Expectancy

This construct measures the degree of ease associated with using DEG. Past research typically represents this construct with questionnaire items that gauge how simple it is to learn how to use a game and acquire knowledge or skills through it

[46], [48]. The scope of the items employed in existing literatures when measuring effort expectancy was widened to include game usability components linked to user-friendliness, such as unambiguous rules and instructions.

Since many studies have shown that effort expectancy is a significant predictor of students' intention to use DEGs [15], game developers can consider integrating various game design elements that encourage ease of playing and assess target users' perception using the items shared in Table IV.

M. Social Influence

The survey questions used in existing research [18], [34] that typically measure social influence using items like SF1 in Table IV were expanded to include specific people that may have an influence on students, such as their school, friends, and classmates. Past research had displayed strong association between social influence and students' intention to play DEGs [22][33]. Therefore, positive peer perception and school support towards the use of DEGs may encourage students to use them. Game designers can also consider utilizing community forums, social media pages, and advertisements that improve the game impression and social influence.

N. Behavioral Intention

The sample students of this study had never played the three STEM DEGs, namely Moonbase Alpha, RoboCo, and Poly Bridge 2, before the instrument testing. They were allowed to play the games for about 90 minutes before completing the questionnaire. The opening hour of a game is known to be crucial for hooking and enticing players to keep playing and recommend it to others. A lot of DEGs had been abandoned for the reason that they were not captivating enough to hold players' interest. The initial user experience can have an impact on retention and the possibility that the player will suggest the game to other people.

Hence, five items were proposed to measure students' interest to play a DEG again and frequently, as well as their willingness to use DEGs related to STEM in the future. From the ratings and comments by experts, all five items were found to be relevant and clear for measuring the early acceptance of STEM DEGs among students.

VI. Conclusion

This paper describes the development of a scale instrument called DEGAPX and its evaluation through expert judgment and instrument testing. The instrument integrates technology acceptance and player experience (PX) factors for studying and understanding students' perception of digital educational games (DEGs) associated with science, technology, engineering, and mathematics (STEM).

Among the 15 constructs suggested in the DEGAPX instrument, five of them, namely learning performance expectancy, skill performance expectancy, effort expectancy, social influence, and behavioral intention, were derived from the unified theory of acceptance and use of technology (UTAUT). The other ten constructs include learning relevance, attractiveness, enjoyment, challenge, clear goal, learning control, social interaction, feedback, concentration, and immersion.

The instrument with 67 items was found to be reliable and valid after going through two rounds of expert judgment and being tested among 14 years old students after they played three DEGs applicable to STEM, including Poly Bridge 2, Moonbase Alpha, and RoboCo.

The proposed DEGAPX instrument can enrich existing literature on DEG acceptance and PX, especially for STEM education. Despite the various studies available on DEG acceptance, most of them concentrated largely on common technology acceptance factors without thoroughly taking into account the PX elements that are crucial in the design of successful DEGs. Prior research typically evaluates acceptance and PX separately, even though both evaluations can be combined and measured simultaneously in a comprehensive manner. Game developers can utilize the instrument proposed in this research for designing promising DEGs that have the potential to be widely received by students.

For future work, the proposed instrument will be further analyzed using the partial least squares structural equation modeling (PLS-SEM) method to study the relationship between the constructs and figure out the significant determinants of DEG acceptance. This research contains a few limitations. First, because the research sample consisted of 14-year-old Malaysian secondary two students, other research can improve the generalizability by widening the scope to include students from different education levels and learning institutions. This study also emphasizes students' evaluation of DEGs. Future research may look into investigating the perception of other educational stakeholders, including parents, teachers, school administrators, and policymakers.

Acknowledgment

The authors thank the Ministry of Higher Education Malaysia for the research opportunity and fund provided under the Fundamental Research Grant Scheme (grant number FRGS/1/2020/ICT10/UTM/02/2) and Universiti Teknologi Malaysia for the support given.

References

[1] A. Kiray and M. Shelley, Research Highlights in STEM Education. USA: ISRES Publishing, International Society for Research in Education and Science (ISRES), 2018. Available online: https://www.isres.org/research-highlights-in-stem-education-7-b.html#.Yvwosi5ByxU (accessed on 20 March 2023).

[2] E. Mellander and P. Lind, "Recruitment to STEM studies : The roles of curriculum reforms , flexibility of choice , and attitudes," Rev. Educ., vol. 9, no. 2, pp. 357–398, 2021, doi: 10.1002/rev3.3262.

[3] O. Wooi Leng, N. Vaghefi, N. Kar Yong, and Y. Jo-Yee, "Student's Choice of STEM Study in Secondary and Tertiary Education in Penang," 2020. Available online: https://penanginstitute.org/publications/books-and-reports/students-choice-of-stem-study-in-secondary-and-tertiary-education-in-penang/ (accessed on 22 March 2023).

[4] I. Araújo and A. A. Carvalho, "Enablers and Difficulties in the Implementation of Gamification: A Case Study with Teachers," Educ. Sci., vol. 12, no. 3, 2022, doi: 10.3390/educsci12030191.

[5] J. K. Acosta-Medina, M. L. Torres-Barreto, and A. F. Cárdenas-Parga, "Students' preference for the use of gamification in virtual learning environments," Australas. J. Educ. Technol., vol. 37, no. 4, pp. 145–158, 2021, doi: https://doi.org/10.14742/ajet.6512.

[6] H. H. Razami and R. Ibrahim, "Distance Education during COVID-19 Pandemic : The Perceptions and Preference of University Students in

Malaysia Towards Online Learning," Int. J. Adv. Comput. Sci. Appl., vol. 12, no. 4, pp. 118–126, 2021, doi: 10.14569/IJACSA.2021.0120416.

[7] Z. Akimkhanova, K. Turekhanova, and G. P. Karwasz, "Interactive Games and Plays in Teaching Physics and Astronomy," Educ. Sci., vol. 13, no. 4, pp. 1–22, 2023, doi: 10.3390/educsci13040393.

[8] K. Cook-Chennault, I. Villanueva Alarcón, and G. Jacob, "Usefulness of Digital Serious Games in Engineering for Diverse Undergraduate Students," Educ. Sci., vol. 12, no. 1, 2022, doi: 10.3390/EDUCSCI12010027.

[9] F. Dahalan, N. Alias, and M. S. N. Shaharom, Gamification and Game Based Learning for Vocational Education and Training: A Systematic Literature Review, no. 0123456789. Springer US, 2023. doi: 10.1007/s10639-022-11548-w.

[10] N. Whitton, Learning with Digital Games: A Practical Guide to Engaging Students in Higher Education. Routledge, New York, 2010. Available online: https://www.routledge.com/Learning-with-Digital-Games-A-Practical-Guide-to-Engaging-Students-in-Higher/Whitton/p/book/9780415997751 (accessed on 22 March 2023).

[11] S. Aslan and O. Balci, "GAMED: digital educational game development methodology," Simul. Trans. Soc. Model. Simul. Int., vol. 91, no. 4, pp. 307–319, 2015, doi: 10.1177/0037549715572673.

[12] J. Clement, "Share of internet users worldwide who play video games on any device as of 3rd quarter 2022, by age group and gender," Statista, 2023. Available online: https://www.statista.com/statistics/326420/console-gamers-gender/ (accessed on 9 March 2023).

[13] Y. Huang, "Exploring students' acceptance of educational computer games from the perspective of learning strategy," Australas. J. Educ. Technol., vol. 35, no. 3, pp. 132–149, 2019, doi: https://doi.org/10.14742/ajet.3330.

[14] G. Petri, C. G. von Wangenheim, and A. F. Borgatto, "A Large-Scale Evaluation of a Model for the Evaluation of Games for Teaching Software Engineering," in 2017 IEEE/ACM 39th International Conference on Software Engineering: Software Engineering Education and Training Track (ICSE-SEET), 2017, pp. 180–189. doi: 10.1109/ICSE-SEET.2017.11.

[15] H. Hafiza Razami and R. Ibrahim, "Models and Constructs to Predict Students' Digital Educational Games Acceptance: A Systematic Literature Review," Telemat. Informatics, vol. 73, no. 2022, p. 101874, 2022, doi: https://doi.org/10.1016/j.tele.2022.101874.

[16] P. I. Davidsen and F. Barnabè, "Exploring the potentials of behavioral system dynamics: insights from the field," J. Model. Manag., vol. 15, no. 1, pp. 339–364, Jan. 2019, doi: 10.1108/JM2-03-2019-0081.

[17] F. D. Davis, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," MIS Q., vol. 13, no. 3, p. 319, 1989, doi: 10.2307/249008.

[18] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User Acceptance of Information Technology: Toward a Unified View," Source MIS Q., vol. 27, no. 3, pp. 425–478, 2003, doi: 10.2307/30036540.

[19] Y. T. Lin and T. C. Wang, "A Study of Primary Students' Technology Acceptance and Flow State When Using a Technology-Enhanced Board Game in Mathematics Education," Educ. Sci., vol. 12, no. 11, 2022, doi: 10.3390/educsci12110764.

[20] A. Dillon and M. G. Morris, "User Acceptance of Information Technology," Inf. Today, vol. 31, no. January 2001, pp. 3–32, 1996, doi: 10.1006/imms.1993.1022.

[21] R. Ibrahim, S. Masrom, R. C. M. Yusoff, N. M. . Zainuddin, and Z. I. Rizman, "Student acceptance of educational games in higher education," J. Fundam. Appl. Sci., vol. 9, no. 3S, pp. 809–829, 2018, doi: 10.4314/jfas.v9i3s.62.

[22] K. Wan, V. King, and K. Chan, "Examining flow antecedents in game-based learning to promote self-regulated learning and acceptance," Electron. J. e-Learning, vol. 19, no. 6, pp. 531–547, 2021, doi: 10.34190/ejel.19.6.2117.

[23] M. Venter, "Continuance Use Intention of Primary School Learners Towards Mobile Mathematical Applications," in IEEE Frontiers in Education Conference (FIE), 2016. doi: 10.1109/FIE.2016.7757539.

[24] K. Kiili, T. Lainema, S. De Freitas, and S. Arnab, "Flow framework for analyzing the quality of educational games," Entertain. Comput., vol. 5, no. 4, pp. 367–377, 2014, doi: 10.1016/j.entcom.2014.08.002.

[25] M. Ashfaq, Q. Zhang, A. U. Zafar, M. Malik, and A. Waheed, "Understanding Ant Forest continuance: effects of user experience, personal attributes and motivational factors," Ind. Manag. Data Syst., vol. 122, no. 2, pp. 471–498, 2022, doi: 10.1108/IMDS-03-2021-0164.

[26] R. Power, Technology and the Curriculum: Summer 2019. Lethbridge, AB, Canada: Power Learning Solutions, 2019. Available online: https://techandcurr2019.pressbooks.com/ (accessed on 12 February 2023).

[27] H. H. Razami, R. Ibrahim, and N. M. Aljuaid, "A Review of Models and Factors for Digital Educational Games Acceptance and User Experience," ISMSIT 2022 - 6th Int. Symp. Multidiscip. Stud. Innov. Technol. Proc., no. 21, pp. 37–42, 2022, doi: 10.1109/ISMSIT56059.2022.9932728.

[28] A. H. Allam, A. Razak, and C. Hussin, "User Experience: Challenges and Opportunities," J. Res. Innov. Inf. Syst., pp. 28–36, 2009. Available online: http://seminar.spaceutm.edu.my/jisri/download/F_FinalPublished/Pub20_UserExperienceChallenges.pdf%5Cnhttp://seminar.utmspace.edu.my/jisri/download/F1_FinalPublished/Pub4_UserExperienceChallenges.pdf (accessed on 22 March 2023).

[29] K. Poels, Y. A. W. de Kort, and W. A. Ijsselsteijn, "D3.3 : Game Experience Questionnaire: Development of a self-report measure to assess the psychological impact of digital games," Tech. Univ. Eindhoven, 2007. Available online: https://www.semanticscholar.org/paper/D3.3-%3A-Game-Experience-Questionnaire%3Adevelopment-of-Poels-Kort/f9a9396fb48f6bcbb942dc0a5cf7faaf7474dbe9 (accessed on 25 March 2023)

[30] M. H. Phan and J. R. Keebler, "The Development and Validation of the Game User Experience Satisfaction Scale (GUESS)," Hum. Factors Ergon. Soc., vol. 58, no. 8, pp. 1217–1247, 2016, doi: 10.1177/0018720816669646.

[31] V. Nagalingam, R. Ibrahim, and R. Che Mohd Yusoff, "EDUGXQ: User Experience Instrument for Educational Games' Evaluation," Int. J. Adv. Comput. Sci. Appl., vol. 11, no. 1, pp. 562–569, 2020, doi: 10.14569/IJACSA.2020.0110170.

[32] R. F. DeVellis, Scale development: Theory and applications. SAGE Publications, Inc., 1991. Available online: https://us.sagepub.com/en-us/nam/scale-development/book269114 (accessed on 23 January 2023).

[33] F. R. López, M. Arias-Oliva, J. Pelegrín-Borondo, and L. M. Marín-Vinuesa, "Serious games in management education: An acceptance analysis," Int. J. Manag. Educ., vol. 19, no. 3, 2021, doi: 10.1016/j.ijme.2021.100517.

[34] R. F. Malaquias, F. F. O. Malaquias, and Y. Hwang, "Understanding technology acceptance features in learning through a serious game," Comput. Human Behav., vol. 87, no. June, pp. 395–402, 2018, doi: 10.1016/j.chb.2018.06.008.

[35] F. Fu, R. Su, and S. Yu, "EGameFlow: A scale to measure learners' enjoyment of e-learning games," Comput. Educ., vol. 52, no. 152, pp. 101–112, 2009, doi: 10.1016/j.compedu.2008.07.004.

[36] K. Cagiltay and S. Yeni, "A heuristic evaluation to support the instructional and enjoyment aspects of a math game," Progr. Electron. Libr. Inf. Syst., vol. 51, no. 4, pp. 406–423, Jan. 2017, doi: 10.1108/PROG-07-2016-0050.

[37] R. D. Tojib, "Content Validity of Instruments in IS Research," J. Inf. Technol. Theory Appl., vol. 8, no. 3, pp. 31–56, 2006. Available online: https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1057&context=jitta (accessed on 7 February 2023).

[38] D. F. Polit, C. T. Beck, and S. V. Owen, "Focus on Research Methods: Is the CVI an Acceptable Indicator of Content Validity? Appraisal and Recommendations," Res. Nurs. Health, vol. 30, pp. 459–467, 2007, doi: 10.1002/NUR.20199.

[39] N. Elangovan and E. Sundaravel, "Method of preparing a document for survey instrument validation by experts," MethodsX, vol. 8, no. April, p. 101326, 2021, doi: 10.1016/j.mex.2021.101326.

[40] C. H. Lawshe, "A Quantitative Approach To Content Validity," Pers. Psychol., vol. 28, no. 4, pp. 563–575, 1975, doi: 10.1111/j.1744-6570.1975.tb01393.x.

[41] A. Ibiyemi, Y. Mohd Adnan, M. N. Daud, A. Jogunola, and S. Olanrele, "A content validity study of the test of valuers' support for capturing sustainability in the valuation process in Nigeria," Pacific Rim Prop. Res. J., vol. 25, no. 3, pp. 1–17, 2019, doi: 10.1080/14445921.2019.1703700.

[42] J. Martí-Parreño, A. Galbis-Córdova, and M. J. Miquel-Romero, "Students' attitude towards the use of educational video games to develop competencies," Comput. Human Behav., vol. 81, no. 2018, pp. 366–377, 2018, doi: 10.1016/j.chb.2017.12.017.

[43] J. F. Hair, G. T. M. Hult, C. M. Ringle, and M. Sarstedt, A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM), 3rd ed. Thousand Oaks: Sage, 2022. [Online]. Available: https://www.pls-sem.net/pls-sem-books/a-primer-on-pls-sem-3rd-ed/.

[44] B. Luyt, Y. R. Guo, and D. H.-L. Goh, "Tertiary students' acceptance of a game to teach information literacy," Aslib J. Inf. Manag., vol. 69, no. 1, pp. 46–63, Jan. 2017, doi: 10.1108/AJIM-08-2016-0131.

[45] G. Sideris and S. Xinogalos, "Py-Rate Adventures: A 2D Platform Serious Game for Learning the Basic Concepts of Programming With Python," Simul. Gaming, vol. 50, no. 6, pp. 754–770, 2019, doi: 10.1177/1046878119872797.

[46] Y. Tao, C. Cheng, and S. Sun, "What influences college students to continue using business simulation games? The Taiwan experience," Comput. Educ., vol. 53, no. 3, pp. 929–939, 2009, doi: 10.1016/j.compedu.2009.05.009.

[47] R. Ibrahim, S. Masrom, R. C. M. Yusoff, N. M. M. Zainuddin, Z. I. Rizman, and M. Sciences, "Student Acceptance of Educational Games in Higher Education," J. Fundam. Appl. Sci., vol. 9, no. 3S, pp. 809–829, 2017, doi: http://dx.doi.org/10.4314/jfas.v9i3s.62.

[48] Y. Wang, Y. Wang, and S. Jian, "Investigating the Determinants of Students' Intention to Use Business Simulation Games," J. Educ. Comput. Res., vol. 58, no. 2, pp. 433–458, 2020, doi: 10.1177/0735633119865047.

[49] R. F. Resende and C. I. P. S. Pádua, "Evaluating Software Engineering Simulation Games: the UGALCO framework," in IEEE Frontiers in Education Conference (FIE) Proceedings, 2014. doi: 10.1109/FIE.2014.7044204.

[50] Y. M. Huang, "Students' Continuance Intention Toward Programming Games: Hedonic and Utilitarian Aspects," Int. J. Hum. Comput. Interact., vol. 36, no. 4, pp. 393–402, 2020, doi: 10.1080/10447318.2019.1647665.

[51] Y. Wirani, T. Nabarian, and M. S. Romadhon, "Evaluation of continued use on Kahoot! as a gamification-based learning platform from the perspective of Indonesia students," Procedia Comput. Sci., vol. 197, no. 2021, pp. 545–556, 2022, doi: 10.1016/j.procs.2021.12.172.

[52] C. Udeozor, F. Russo-Abegão, and J. Glassey, "Perceptions and factors affecting the adoption of digital games for engineering education: a mixed-method research," Int. J. Educ. Technol. High. Educ., vol. 20, no. 1, 2023, doi: 10.1186/s41239-022-00369-z.