

Evaluating Feasibility and Effectiveness of Digital Game-Based Instructional Technology

<https://doi.org/10.3991/ijet.v16i16.23829>

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Abstract—Higher education institutions encounter difficulties when the Covid-19 pandemic happens because learners cannot go to class and absorb knowledge directly. In Vietnam, universities have used online learning to help learners keep learning in this pandemic context. However, students and teaching staff have expressed concerns about the quality of the learning process. In this context, our research is looking for solutions to apply new technology in the teaching process to ensure the quality and effectiveness of learning. Among these new technologies, we consider digital games because most students play digital games and their positive effects on teaching, as evidenced by recent publications. Under the approach of technological process, our team evaluated the feasibility and effectiveness of the digital game-based instructional technology at HUST. In terms of feasibility, research shows that most students agree that digital games can contribute to learning skills. In terms of effectiveness, there are three key findings. First, although male students play video games more than female students, the results show that both men and women have the same rate of digital games' effectiveness in learning. Second, there is no difference in assessing the effectiveness of digital games in learning between IT students and non-IT students although IT students are more exposed to technology. Third, there is a difference in the views of second-year students and third-year students. This difference illustrates the need for blended-learning courses that utilize digital games effectively for third-year engineering students who start more specialized engineering courses at universities.

Keywords—digital game-based learning, instructional technology, learning skill

1 Introduction

The Covid-19 pandemic had a strong impact on the teaching process, creating an inevitable trend of digital transformation in teaching and learning process. In Vietnam, during the complicated Covid-19 epidemic, there were nearly 80% of students studying online, ranking 17th among 200 countries and territories. With the advantage of a country with a large proportion of people owning and using technology, being in the top 20 countries with the highest number of Internet users in the world, 49 million people connected to the Internet, 55% of Vietnamese people owning smartphones and

46% owning personal computers, Vietnam is considered a bright spot for students to easily access technology in education [1]. In this process of bringing digital technology into teaching, digital game-based learning is a method that creates a lot of excitement for learners but also requires creativity of the teachers. Therefore, it is necessary to produce in-depth studies on the feasibility and effectiveness to deploy teaching using digital games, especially in higher education, Vietnam.

In higher education, students are adults and they have equipped themselves with high school learning experiences and skills. In addition, they have the habit of using technology in learning and relaxing, especially playing video games. According to the survey results of online game services in Vietnam in the context of international integration of the Institute of Sociology proposed by the National Assembly's Committee for Culture, Education, Youth, Adolescents and Children, game players are mostly children under 20 years old, accounting for 68.4%, and 42.1% are children in the 16-20 group and more than 26% in the group from 10 to 15 years. The proportion of game players who are attending school accounts for two thirds (71.7%) and the majority are pupils and students. Researchers at the Institute of Sociology also asked [2]: How can video games be valuable and effective? 71.5% of respondents think that video games should be composed with attractive and educational scripts. 67.2% suggest classifying video games according to age groups. 65% encourage video games with healthy contents to educate about national cultural traditions and history. 51.6% support controlling internet use for children under 14 years old. 50.4% recommend more strongly the negative side of video games. We think it is an excellent advantage for universities in Vietnam to utilize digital games in their teaching. We take this opportunity to survey students from Hanoi University of Science and Technology (HUST) to determine how well they could form learning skills from various digital games, including adventure, multi-level, puzzle, role-playing, shooting, sports and strategy games. The learning skills that could be formed by playing digital games include Recalling facts, Critical thinking, Problem-solving, Planning and strategy, Cooperation and teamwork, Decision making, Negotiation, System management, Hand and eye coordination (Ingenuity practice). Furthermore, the research team also asked the students how much they improved their learning efficiency, whether learning would become more straightforward, and students would have the opportunity to apply knowledge into real life or experience practical situations and improve learning outcomes for learners when using digital games in the teaching process. These research results show positive signals about the feasibility of developing learning skills and the effectiveness of applying digital games into higher education from the learners' points of view.

The next part of the paper will introduce the concept of digital games and digital game-based learning, the approach of digital game-based instructional technology and general evaluation of research on effectiveness of game-based learning gained so far. The article also describes the research process conducted at HUST on digital game-based instructional technology on both feasible and effective aspects; and discusses the current situation and recommendations for the effective implementation of digital game-based learning in higher education. Specific structures of this paper include:

- Literature review of digital game-based learning.
- Design research for survey on the feasibility and effectiveness of digital game-based instructional technology.
- Population and sample for survey.
- Data collection tools and methods.
- Description of data.
- Survey results achieved.
- Discussion and recommendations.

2 Literature review

2.1 Definition of digital games and digital game-based learning

Serious games have been used for physics education since the early 1980s ([3], [4]). With the proliferation and availability of technology devices, digital games have become more widely used than traditional games. Referring to the concept of a digital game, Prensky (2001) described six structural elements of the game: rules, goals, results and feedback, competition or challenge, interaction and representation, or story [5]. Dempsey et al (2002) defined: “A game is an activity involving one or more players, with objectives, constraints, rewards and outcomes, guided by rules, artificially in some aspects and there is an element of competition” [6].

In 2005, a serious game was defined by Zyda as “a mental contest, played against the computer according to specific rules, using entertainment for further training to the government, or corporate, education, health, public policy and strategic communication goals.” [7] Unlike an entertaining game, a serious game is designed for educational rather than entertainment purposes [8]. Serious games are considered as entertainment tools for educational purposes, where players sharpen their knowledge and skills by overcoming many obstacles during the game. The player's performance is scored over the course of the game [9]. In case the player gets over an obstacle, he will receive several rewards such as score, promotion and strength. Educational elements can be integrated into the game, which the player will subconsciously absorb during the game. Extending the definition of digital games used in teaching, De Freitas (2006) defined: “Applications use the features of computer and video games to create attractive and engaging learning experiences to gain specific learning goals, outcomes and experiences” [10].

Alternate Reality Game (ARG) is a game that requires participation in the real world (McGonigal, 2011 [11]). Unlike most other game genres, ARG uses real-world media to provide its composition. Media include text messaging, email, social networking services and websites (Gilliam et al., 2017 [12]). Barlow argues that ARG is a game in which gamers can play in both real and online virtual worlds under the assumption that a virtual event occurs in the real world [13]. Awareness of some of the basic concepts associated with ARG, such as puppet masters, veils and predecessors, will help to better understand ARG (Dominik, 2008 [14]; Olbrish, 2011 [15]).

Gamification is the alteration of something that is not a game through a game or the use of game elements (van Grove, 2011 [16]; Werbach & Hunter, 2012 [17]). Gamification can be a means of engaging employees on tasks (Reeves & Read, 2009 [18]), fostering collaboration (McGonigal, 2011 [19]) or improving motivation (Zichermann & Linder, 2013 [20]). Deterding, Dixon, Khaled, and Nacke defined "gamification" as "the use of game design elements in a non-game context" [21]. In other words, gamification is a set of activities and processes to solve problems by using or applying the characteristics of game elements.

According to Alsubhi et al. (2020), today's university students use e-learning resources to access information and perform general questions solving learning problems. Such online environments offer alternatives to the traditional way of learning, currently considered expensive and time-consuming with mixed results. Students' online dropout is believed to have stemmed from the e-learning foundations of university education. Therefore, e-learning developers use Gamification to minimize this limitation of e-learning. [22]

Through the different definitions above, we can see that digital games in teaching have such roles as a positive learning environment, motivational tools, as a playground and as an instructional and discovered technology designed by educators for learning purposes (Nicola Whitton (2014), [in 23]). To apply effectively in teaching, the field of digital game-based learning needs to be evaluated from a multidisciplinary point of view, considering research from different fields such as computer science, psychology, and education, neuroscience and game design. In the perspective of the authors, we would like to evaluate digital game-based learning according to the technology approach.

2.2 Digital game-based learning as a technological process

The influence of technology is becoming more and more common in the academic process at the university level, all learners adapt to the way they interact with computers and we cannot make broad assumptions about a specific generation or any group of learners. Instead, we should cater to all levels of technical competence and accept that many learners (of all ages) simply enjoy communicating, playing, and learning in ways not relating to technology. Digital game-based learning is not a simple solution but will revolutionize teaching and learning in higher education by attracting a new 'generation' of learners depending on the circumstances. It is important to view digital games as tools and simple means available to lecturers. When reviewed and implemented in relation to the limitations of the educational system and appropriate pedagogical models, they can provide an attractive way of learning. To deploy digital game-based learning, according to the approach of instructional technology, each plan of instructional design will be a combination of means, methods and skills. This combination is how to create the teaching games satisfying certain learning goals (such as the formation of learning skills at different levels), therefore whole instructional technology for how to make teaching game in the certain learning circumstance is known as the possible option. All possible options for making digital game-based learning to meet the teaching effectiveness criteria such as How suitable is it? Is it easy to learn?;

How is the level of access to knowledge and experience? that is called an efficient option (low to high) [24]. Thus, the digital game-based learning instructional technology is a system of teaching means, teaching methods and teaching skills for teaching using digital games to apply many objective laws such as cognitive neuroscience, psychology and pedagogy influencing learner to create his/her definite personality. [25] So digital game-based learning can be called by digital game-based instructional technology.

Each teaching plan combines teaching means, teaching methods and teaching skills to create a corresponding technological achievement. Depending on the specific effectiveness criteria (quantity or quality) set out before the implementation of the technology, this will be acceptable or not. Thus, feasibility and efficiency are two typical properties, expressing the meaning of a technology solution, which is a reliable basis for choosing the solution of digital game-based learning. From a feasible perspective, to identify the solution using digital game-based learning in the usable range, our research considers the formation of learning skills through the use of typical digital games in learning. From an efficiency perspective, it is necessary to consider all possible options that meet the efficiency criteria set from low to high. Therefore, to build these effective criteria, we will re-evaluate international studies on effectiveness of teaching using digital games, and then select typical efficiency criteria, build a set of criteria to evaluate the effectiveness of teaching plans using digital games.

2.3 The efficiency criteria of digital game-based instructional technology

According to Marc Prensky, neuroscientists C. Shawn Green and Daphne Bavelier of the University of Rochester have had studies showing that playing "action" videos and computer games have a positive effect on increasing students' attention. However, that finding is only a small part of the more important message that all parents and educators need to understand: Video games are not enemies, but good opportunities which can be created for learners to engage in real learning if used correctly. [in 5]

Another prominent researcher, James Paul Gee (2003), focuses on principles of video game-assisted learning and how these principles can be applied in the classroom. Video games can be used as a tool to challenge players while learning. They motivate players to persevere and at the same time teach players how to play. These games provide an overview of new ways for learning in school, community and at work. [26]

Authors - both experienced educators and gamers - assume that 21st century students learn differently from previous generations. By incorporating digital games into the lessons, students' learning experience can be more realistic, more attractive and better prepared for apprenticeship. [27]

In recent years, the use of games has proven to be successful in encouraging learners' participation and sustaining learners' contribution. The developments in video games, serious computer games and game-based learning are becoming important to virtual learning environments [in 28]. Early exposure to technology has changed the way in which young people think and use technology. Prensky (2001) describes a clear distinction between 'digital natives', a term commonly used to describe people

born and living in the digital age, with other names such as Generation Z, Generation Alpha ... they are the ones who grew up with computer games, television and other media, and used them to instinctively learn and older learners, whose collaboration with these types of technologies must be done through conscious effort. He argued that the generation of adults raised in the computer world (most of the current student generation) was cognitively different from previous generations, and that immersion in technology fundamentally changed the way that people obtain and assimilate information.

Digital games can provide a virtual environment where students are not limited by physical space or have direct access to material (Busch, Conrad, & Steinickie, 2013) [29]. Participation in Digital Games allows for active accumulation of knowledge. Complex situations in digital games create opportunities for users to take on roles and participate in critical thinking activities (Sardone & Devlin-Scherer, 2010) [30]. Digital games can have a positive impact on a user's understanding of real-world situations (Ibrahim, 2010), and immediate digital feedback can allow for in-depth processing of embedded content [31]. Digital games are an effective and motivating approach to encourage students to create knowledge (Papastergiou, 2009) [32]. Digital games can significantly improve knowledge about embedded topics and increase students' interest and motivation for the content (Papastergiou, 2009). Students, both boys and girls, are equally motivated to participate in digital games (Papastergiou, 2009).

Studies in the world have confirmed many advantages when implementing digital game-based learning, but according to qualitative research in Cavus's Web of Science database, the application of games alone in developing strategy management skills, namely Business Strategy Games (BSG) and Learning Strategy Management still shows many limitations, so it is affirmed that there is a need to do more research on deploying business strategy game and learning strategy management [33].

A study in Vietnam on digital game-based learning has mentioned the level of development and attitudes about this issue. Huyen, P.T.T have affirmed, gamification has begun to play a certain role in learning English both inside and outside the classroom in the context of the author's research. Students are technologically well-prepared for online games and maintain a positive attitude toward game learning. However, online games are mainly used to aid vocabulary learning [34].

Other studies have also given some criteria as a measure of the quality of digital game-based learning (perception, technology application, attitudes, personal characteristics...). In Baig's (2020) study, results indicate that video games based on the Math curriculum have a positive impact on student performance based on their average scores in standard tests, when compared with traditional learning methods [35]. Also applied to math teaching, it is confirmed by Wahidah et al. that using digital games to design multimedia confirmed not only helps learners remember and read, but also helps learners participate in the process of finding concepts. The learning process is fun and interactive [36]. An area related to language teaching has also produced positive results using digital games, such as research report of Backman et al., based on computer game technology as well as in dialogue education theory and debate theory, the effectiveness of dialogue interventions to develop communication for

people with aphasia has been improved [37]. In Yamani's methodological research, in-depth discussion on the differences between Digital Games, game-based learning and games was discussed. The findings suggest a conceptual framework for integrating gamification in eLearning systems based on the Instructional Design Model. Gamification has been incorporated into the general phases of the instructional design model, which are analysis, design, development, implementation, and evaluation. The findings help decision-makers and stakeholders in higher education institutions differentiate between games, game-based learning, and integrate gamification into education, and identify appropriate instructional design models as conceptual frameworks to systematically deliver learning content through gamification [38].

In short, the effective criteria for teaching using digital games mentioned by international publications revolve around the following basic contents:

- Digital game-based learning is an appropriate teaching method.
- Digital game-based learning makes the learning process easy and interesting.
- Digital game-based learning helps learners apply knowledge learned in games into real life.
- Digital game-based learning can be used to improve learning outcomes.
- Digital game-based learning helps students learn through practical situations simulated in a game.

Based on these conclusions, our research will propose survey criteria in research design to evaluate the feasibility and effectiveness of digital game-based instructional technology.

3 Methods and results

3.1 Research design

Stemming from the characteristics of Vietnamese young people, especially students, who are very connoisseurs of technology and most of them experience digital games as analyzed above, the respondents of the article will be students who are studying at HUST. Therefore, within the scope of the paper, our research shows students' perceptions of the feasibility of developing learning skills from the seven popular types of digital games and to evaluate the impact of digital games on the learning process of students at HUST.

Based on the research objective of the feasibility and effectiveness of digital game-based instructional technology at higher education institutions (section 2.2), based on the effects brought about by digital game-based instructional technology through different research projects in the world in section 2.3, the authors built 15 survey criteria divided into 2 groups as follows:

Criterion group 1 (feasibility): Learning skills can be formed when participating in digital games (see Table 1).

Criterion group 2 (effectiveness): The level of effectiveness of a digital game on the learning process (see Table 2).

Table 1. Learning skills

Item#	Types of learning skills	Item#	Types of learning skills
F1.	Facts recalling	F6.	Decision making skills
F2.	Thought and thinking practice	F7.	Negotiation skills
F3.	Problem solving skills	F8.	System management skills
F4.	Planning and strategy planning	F9.	Hand and eye coordination
F5.	Cooperation and teamwork skills	F10.	Ingenuity practice

Table 2. Effects of digital game in learning process

Item#	Effectiveness of teaching using digital games
E1.	An appropriate teaching method in higher education
E2.	Makes the learning process easy and interesting
E3.	Helps students apply knowledge learned in games into real life
E4.	Can be used to improve student learning outcomes
E5.	Helps students learn through practical situations simulated in a game

Therefore, the model of digital game-based instructional technology is designed according to feasibility and effectiveness that was described as seen in Fig.1.

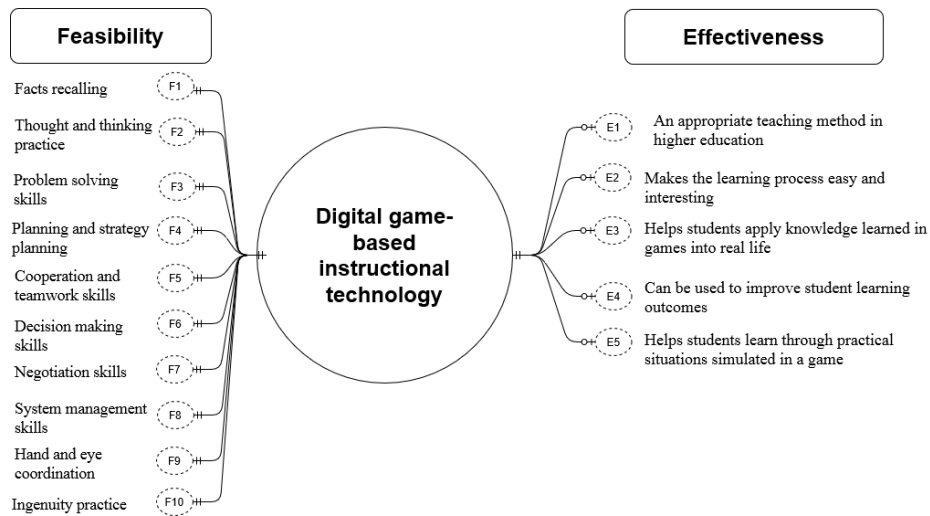


Fig. 1. Evaluation model of digital game-based instructional technology

3.2 The population and sampling of survey

The survey was conducted on students of HUST in the first semester of the 2020-2021 school year with a total population of about 35,000 students.

Survey sampling was selected based on three parameters according to the Yamane formula (1967) in [39].

The level of precision, sometimes called sampling error (e): is the range in which the true value of the population is estimated to be.

The Confidence level or risk level is the true population value within the range of precision specified earlier.

The degree of variability (p) in the attributes being measured to the distribution of attributes in the population. The less variable (more homogeneous) a population, the smaller the sample size and vice versa.

Table 3. Sample size for $\pm 3\%$, $\pm 5\%$, $\pm 7\%$ and $\pm 10\%$ Precision Levels Where Confidence Level is 95% and $P=0.5$

Size of Population	Sample Size (n) for Precision (e) of			
	$\pm 3\%$	$\pm 5\%$	$\pm 7\%$	$\pm 10\%$
15,000	1,034	390	201	99
20,000	1,053	392	204	100
25,000	1,064	394	204	100
50,000	1,087	397	204	100
100,000	1,099	398	204	100
>100,000	1,111	400	204	100

From the Yamane formula (1967)

With size of population is approximately 35.000, the level of precision (e) of $\pm 7\%$ where confidence level 95% and the degree of variability $P=0.5$, look up the table 1, the minimum of sample size is 204. In this survey, we have received 206 records from 206 students participating in the survey, ensuring the level of precision (e) of $\pm 7\%$ where confidence level 95% and the degree of variability $P=0.5$.

3.3 Data collection

The survey research method based on the questionnaire survey is mainly used in the study. We use questionnaires containing 15 criteria in 2 groups of feasibility and effectiveness proposed in section 3.1 to systematically collect research-related data from students of HUST. The questionnaires are designed on Google Forms and data collection is organized online. The link of the questionnaire is: <https://forms.gle/zPkmV978hKWJMAcr9>

3.4 Data description tool

The process of data description in research uses univariate descriptive statistics such as frequency distribution to aggregate the frequency of individual values or the range of values of a research variable; arithmetic mean (Mean) to estimate the center when distributing values; standard deviation is one measure of dispersion or values positioned around central tendency through how close or distant each value is from the mean of the distribution.

In the survey of this study, questions containing scales are used. With the Likert 5-level scale: (1) Totally disagree; (2) disagree; (3) Partially agree; (4) Absolutely

agree; (5) Totally agree. In which, the Mean is the average value that has many meanings, namely the level 3 is the intermediate, if it is inclined to 3-5, it means that the respondents agree with the view of the variable given. Conversely, if it is biased to 1-3, respondents disagree with the opinion of the variable. About Std. Deviation, smaller the standard deviation of the variable shows that the respondents answering the number of answers does not differ much. On the contrary, if this value is high, it shows that the respondents have many different views with that variable, so the difference is quite high.

In addition, the research also discusses the comparison of two groups through the t-test statistical test method. Does the T-test look at whether the mean values of the two groups are statistically different?

3.5 Survey results

Learning skills are formed through digital games. The survey results show that 64.29% of students' opinion agree that digital games can form thought and thinking practice skill (F2), accounting for the largest proportion. Next, ranked second is the hand-to-eye coordination skill (F9) with a 58.39% agreement rate. Decision-making skill (F6) is ranked third with the student's consent rate of 58.32%. Accounting approximately 50% of consent rate are problem-solving skills (F3, 55.34%), planning and strategy planning skills (F4, 52.08%), ingenuity practice skill (F10, 51.94%). In contrast, the most difficult skill to be formed in teaching using digital games is negotiation (F7, only 21.78% of respondents agree), followed by system management skills (F8, the rate of agreement is only 27.46. %) (see more in table 4)

Table 4. Hierarchy of types of learning skills formed through digital games

No#	Type of learning skills	Percentage (%)	Order of choice
1	F1	44.17	7
2	F2	64.29	1
3	F3	55.34	4
4	F4	52.08	5
5	F5	43.13	8
6	F6	58.32	3
7	F7	21.78	10
8	F8	27.46	9
9	F9	58.39	2
10	F10	51.94	6

Effectiveness of using digital games in learning process at HUST. The criteria on the table 5 with the mean value in the range of 4 show that the students participating in the survey agree, in other words, the students will enjoy this new teaching method (E2, mean = 4.0728) and realize that this is a learning method that allows learners to experience a lot (E5, mean = 3.9320) as well as apply knowledge to solve practical situations (E3, Mean = 3.9078).

Table 5. Mean values of criteria describing the effectiveness of digital game-based instructional technology

Criteria	N	Minimum	Maximum	Mean	Std. Deviation
E1	206	1.00	5.00	3.7913	.92664
E2	206	1.00	5.00	4.0728	.88870
E3	206	1.00	5.00	3.9078	.90862
E4	206	1.00	5.00	3.6602	.96831
E5	206	1.00	5.00	3.9320	.91345
Valid N (listwise)	206				

Compare the evaluation about the effectiveness of digital game-based instructional technology by gender. To comparing these evaluations by gender, the research uses the results of t-test in table 6.

Table 6. Results of t-test comparing the effectiveness of digital game-based instructional technology by gender

Criteria	Gender	N	Mean	Std. Deviation	Std. Error Mean
E1	Male	153	3.7647	.95810	.07746
	Female	53	3.8679	.83292	.11441
E2	Male	153	4.0065	.93539	.07562
	Female	53	4.2642	.71120	.09769
E3	Male	153	3.8693	.95071	.07686
	Female	53	4.0189	.77187	.10603
E4	Male	153	3.6405	.99746	.08064
	Female	53	3.7170	.88529	.12160
E5	Male	153	3.8758	.94117	.07609
	Female	53	4.0943	.81487	.11193

Criteria	Independent Samples Test					
		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
E1	Equal variances assumed	3.551	0.061	-0.698	204	0.486
	Equal variances not assumed			-0.747	103.177	0.457
E2	Equal variances assumed	0.717	0.398	-1.829	204	0.069
	Equal variances not assumed			-2.085	118.441	0.039
E3	Equal variances assumed	2.939	0.088	-1.033	204	0.303
	Equal variances not assumed			-1.142	110.568	0.256
E4	Equal variances assumed	0.593	0.442	-0.494	204	0.621
	Equal variances not assumed			-0.524	101.101	0.601
E5	Equal variances assumed	1.075	0.301	-1.506	204	0.134
	Equal variances not assumed			-1.615	103.596	0.109

In table 6, the values of Levene's Test for Equality of Variances have sig > 0.05 and sig at t-test > 0.05 (Equal variances assumed), so it should be concluded that there is no difference between the two groups of male and female students in terms of mean values describing the effects of digital games in studying at HUST.

Compare the evaluation about the effectiveness of digital game-based instructional technology by groups of discipline. The research team divided the number of students participating in the survey into two groups of disciplines: those not related to information technology (Non-IT) and groups related to information technology (IT).

Based on Levene's Test for Equality of Variances with sig > 0.05 and sig at t-test > 0.05 (Equal variances assumed) (see in Table 7), we conclude that there is no difference in choice between two groups of disciplines, IT and non-IT.

Table 7. Results of t-test comparing the effectiveness of digital game-based instructional technology by groups of discipline

Criteria	Discipline	N	Mean	Std. Deviation	Std. Error Mean
E1	Non-IT	132	3.7652	.98740	.08594
	IT	74	3.8378	.81134	.09432
E2	Non-IT	132	4.0606	.90594	.07885
	IT	74	4.0946	.86276	.10029
E3	Non-IT	132	3.9091	.92839	.08081
	IT	74	3.9054	.87849	.10212
E4	Non-IT	132	3.6288	.94429	.08219
	IT	74	3.7162	1.01388	.11786
E5	Non-IT	132	3.9091	.97648	.08499
	IT	74	3.9730	.79335	.09222

Criteria	Independent Samples Test					
		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
E1	Equal variances assumed	6.626	0.011	-0.539	204	0.59
	Equal variances not assumed			-0.57	176.677	0.57
E2	Equal variances assumed	0.072	0.789	-0.263	204	0.793
	Equal variances not assumed			-0.266	157.586	0.79
E3	Equal variances assumed	0.127	0.722	0.028	204	0.978
	Equal variances not assumed			0.028	158.42	0.977
E4	Equal variances assumed	0.015	0.903	-0.621	204	0.535
	Equal variances not assumed			-0.608	142.485	0.544
E5	Equal variances assumed	4.215	0.041	-0.481	204	0.631
	Equal variances not assumed			-0.509	178.075	0.611

Compare the evaluation about the effectiveness of digital game-based instructional technology by groups of students in different courses. Surveying the differences between groups of students by course, the research found the difference be-

tween the second and third year students in two criteria: (1) Teaching using digital games makes the learning process easy and interesting (E2) with Levene's Test for Equality of Variances with sig = 0.858 > 0.05 and sig at t-test = 0.014 < 0.05 (Equal variances assumed) and (2) Teaching using digital games helps learners apply knowledge learned in games into real life (E3) with Levene's Test for Equality of Variances with sig = 0.949 > 0.05 and sig at t-test = 0.044 < 0.05 (Equal variances assumed) (see Table 8).

Table 8. Results of t-test comparing the effectiveness of digital game-based instructional technology by groups of students in different courses

Group Statistics					
	Course	N	Mean	Std. Deviation	Std. Error Mean
E1	Second year	58	3.8793	1.01008	.13263
	Third year	88	3.6364	.91201	.09722
E2	Second year	58	4.2241	.89918	.11807
	Third year	88	3.8523	.87808	.09360
E3	Second year	58	4.0862	.86419	.11347
	Third year	88	3.7841	.88990	.09486
E4	Second year	58	3.5517	.99424	.13055
	Third year	88	3.6023	.91651	.09770
E5	Second year	58	3.9310	1.00633	.13214
	Third year	88	3.7955	.93660	.09984

Criteria	Independent Samples Test					
		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
E1	Equal variances assumed	0.059	0.809	1.509	144	0.134
	Equal variances not assumed			1.477	113.283	0.142
E2	Equal variances assumed	0.032	0.858	2.48	144	0.014
	Equal variances not assumed			2.468	120.088	0.015
E3	Equal variances assumed	0.004	0.949	2.03	144	0.044
	Equal variances not assumed			2.043	124.631	0.043
E4	Equal variances assumed	1.386	0.241	-0.315	144	0.753
	Equal variances not assumed			-0.31	115.078	0.757
E5	Equal variances assumed	0.044	0.835	0.831	144	0.407
	Equal variances not assumed			0.819	115.91	0.415

4 Discussion and conclusion

This study has evaluated the feasibility and effectiveness of teaching technology using digital games by consulting HUST's students in the common age of using technology and participating in digital games. In terms of feasibility, it is ensured that the successful implementation of digital game-based instructional technology. This feasibility is judged thanks to the learning skills which the games will help learners develop (which is the goal of teaching process). The efficiency aspect is assessed on the

positive impact brought about in learning activities when applying digital games in the teaching process.

Among the ten types of learning skills formed by using seven typical types of digital games in the teaching process, the results from the survey (Table 4) showed that six types of learning skills were selected with the rate of over 50%, such as Skills of thought and thinking practice (64.29%); Hand and eye coordination (58.39%); Decision making (58.32%); Problem solving (55.34%); Planning and strategy (52.08%); Ingenuity training (51.94%). These are all complex learning skills required to be applied and experienced by learners. In a digital game-based learning environment, challenges, competitions, and attractive elements of interactive multimedia can be integrated into learning contexts, so learning engagement is enhanced. Learners can persevere to gain more complex skills than in traditional learning environments. This result is similar to those found in Duplantis (2002) [40], Facer (2004) [41], Virvou (2005) [42], Papastergiou (2008), Wahidah (2020), Yamani (2021), which show that digital games can deliver complex, diverse learning abilities and goals. Thus, the feasibility of forming complex learning skills by using digital games opens many opportunities to apply digital games in the modern teaching process at HUST.

Concerning gender differences in assessing the effectiveness of digital games in teaching, boys play video games more frequently than girls. However, research suggests there are no differences between males and females in evaluating the effectiveness of digital games in HUST. This is similar to the studies of Papastergiou (2008), Ke & Grabowski (2007) [43], which do not find gender difference when studying the effectiveness and motivation of learning under the impact of games.

Although IT students have many opportunities to be exposed to digital technology and digital games, a review of research on the effectiveness of teaching using digital games shows that both groups of students, IT and non-IT students have the same opinion. Thus, when applied in learning, digital games are evaluated to be equally effective regardless of whether the learners have experience in using digital technology in learning and research.

However, there is a difference in the perspective of teaching using digital games in two groups of students, the second-year students who study in general knowledge and the third-year students starting to study specialized subjects. Research shows a difference between them in emphasizing that teaching using digital games makes the learning process easy and exciting and teaching using digital games helps learners apply knowledge learned in games into real life. In particular, the group of students who are still studying general subjects has a higher appreciation of the effectiveness of teaching using digital games. This result can be explained that delivering in-depth knowledge and experience by using digital games is not enough; specialized students also need to combine with practical learning activities to form workmanship (not just pure virtual environments). The results of this study will guide future research to develop teaching solutions using digital games in blended learning environments, to promote the effectiveness of both real and virtual environments in higher education, especially the engineering education field, in later studies.

5 Acknowledgement

This research was funded by the Ministry of Education and Training in Viet Nam under grant Number: CT2020.02.BKA.07

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Article submitted 2021-05-08. Resubmitted 2021-06-13. Final acceptance 2021-06-14. Final version published as submitted by the authors.