



Research article

Do technological knowledge and game-based learning promote students achievement: lesson from Indonesia

Cipto Wardoyo^{a,*}, Yogi Dwi Satrio^a, Bagus Shandy Narmaditya^a, Agus Wibowo^b^a Faculty of Economics, Universitas Negeri Malang, Indonesia^b Faculty of Economics, Universitas Negeri Jakarta, Indonesia

ARTICLE INFO

Keywords:

Technological adoption
Educational competences
Computer skills
Game-based learning
Students' accomplishment

ABSTRACT

Continuous managing the quality of education in the Covid-19 pandemic has been a unique challenge, and the government has acknowledged to shift from conventional to screen adopting technology. This research attempts to examine the relationship between technological understanding, game-based learning, and students' achievements. This work engaged a quantitative approach with SEM-PLS to gain a deeper understanding of the connectivity among variables. The participants were senior high school students from several places in East Java of Indonesia. The findings indicate that technological knowledge, educational competence, computer skills play an essential role in supporting technology-based learning. However, this study notes that game-based learning in distance learning cannot act as a mediator in enhancing the students' achievement. This study offers policy-makers the use of game-based learning in the learning process during synchronous learning using technology.

1. Introduction

The Covid-19 pandemic has driven challenges and opportunities in the educational sector. Since the enactment of health distancing for reducing the virus outbreak, it has been forced to conduct learning activities from home by adopting technology (Qazi et al., 2020; Morgan, 2020). Consequently, the students and teachers need to be familiar with educational technology as a primary medium in providing teaching and learning activities. Unfortunately, these rapid changes from conventional to online-based learning have led unpreparedness for both teachers and students in learning activities (Tomasik et al., 2020; Bahasoan et al., 2020). Several recent works also mentioned that the challenge of the implementation of distance learning is connectivity problems and facilities (Rulandari, 2020; Narmaditya et al., 2020).

The implementation of distance learning with a synchronous or asynchronous approach also offers an opportunity for scholarly society to use technology that can help students' competencies for the 21st century (Dakhi et al., 2020). In detail, Karatas and Zeybek (2020) noted that self-directed instruction or independent enlightenment are essential for students as an output of educational process (Karatas and Zeybek, 2020). The Covid-19 pandemic can train students along particular online courses that learners attend. Also, learners can involve in workgroup to address learning issues that often occurs in the students' circumstance

(Gaber et al., 2020). To support this program, students should master new literacy, including technological literacy, data literacy, and human literacy (Yamin and Syahrir, 2020).

In addition to continuously manage educational quality, the implementation of distance learning should have the same benefit as face-to-face learning (Graham, 2019; Lazarevic and Bentz, 2020). For this reason, the teachers or lecturers need to be creative in creating a learning situation employing various learning methods or models (Emerson et al., 2020). Game-based learning can be an alternative distance learning media that is attractive and motivates students to learn independently (Chang et al., 2017, 2020; Yang and Chen, 2020). Additionally, some scholars believe that this model's use effectively improves student learning outcomes (Putz et al., 2020; Setiawan and Phillipson, 2020). A preliminary study by Perini et al. (2018) noted that the use game-based learning has successfully in promoting a higher performance of procedural knowledge.

Despite the escalating studies on managing quality in the Covid-19 pandemic, the technology adoption and game-based have been overlooked by scholars. The major theme in this pandemic era focuses on implementing problem-based learning and project-based learning as an attempt to enhance learning achievement (Yustina et al., 2020; Ardhyantama et al., 2021). Furthermore, many scholars are concerned about adopting m-learning or e-learning (Qazi et al., 2020; Pratama and

* Corresponding author.

E-mail address: cipto.wardoyo.fe@um.ac.id (C. Wardoyo).

Scarlatos, 2020; Al Emran et al., 2020). Meanwhile, this study elaborates some predictive variables, including technological knowledge, educational competencies, and computer skills, in relation to game-based learning as well as learning achievement.

This study provides three main contributions. First, it contributes to the literature on how to manage educational quality during the Covid-19 pandemic by involving game-based-learning, students' achievement, and factors affecting that are missing in the prior studies. Second, this is the first study that elaborates technological perception, game-based learning "e-crowd", and students' learning accomplishment. Third, Indonesia's focus study is unique as it issues the lack of facilities, infrastructures, and the situation with thousands of islands. Also, the Indonesian government has provided a program, "Freedom to Learn" as an effort to enhance the quality of education. This study offers policy research on what factors affect technological adoption in learning and the adoption of game-based learning to motivate and enhance academic achievement.

The overall structure of this paper takes form of seven sections. Section 1 of this paper begins with the recent issues of adopting technology and game in education. Section 2 focuses on the underpinning theory involved in this study and followed the detail of method adopted in Section 3. Section 4 provides the statistical calculation and followed by a comprehensive discussion in Section 5. Finally, the conclusion, limitations and suggestions are provided in Section 6 and Section 7.

2. Literature review

2.1. Technology knowledge and learning

The involvement of technology in education has attracted attention among scholars in the last decade as its role in promoting a better learning achievement (Fauth et al., 2019; Siron et al., 2020; Al-Hariri and Al-Hattami, 2017). The pattern of learning in the world has integrated learning strategies combining scientific skills, social humanities with computational technology skills. The role of technological knowledge is not only seen as an instrument to facilitate the teaching and learning process, but it has shifted to a necessity and mandatory knowledge for every individual (Chua and Jamil, 2012). The underlying rationale is that technological knowledge will affect individual skills in further education and the world of work. The integration of technology and education can be explained by the TPACK model by Mishra (2006).

TPACK focuses on the combination of the seven dimensions of TPACK owned by individuals, including Technology knowledge (TK), Pedagogy Knowledge (PK), Content Knowledge (CK), Technology Pedagogy Knowledge (TPK), Technology Content Knowledge (TCK), Pedagogy Content Knowledge (PCK), and Technology Pedagogy Content Knowledge (TPACK) (Mouza et al., 2014; Schmid et al., 2020). From the TPACK, the adoption of technological in learning can be translated into how the technology can shape students' skills and learning achievement (Niess, 2011). This implies that the role of teacher (teacher competences) also relates to students' accomplishment. The fundamental rationale is that teachers make decisions in terms of how to select, adapt, and apply appropriate materials, pedagogies and technologies that can add meaningful value to learning with technology in the classroom, leading to student-centered learning. Recent scholars believe TPACK can be provided as educators' knowledge of when, where, and how to adopt technology in assisting students to enhance their awareness and skills in a certain subject (Baran et al., 2019; Schmid et al., 2020).

The "freedom to learn" is the central concept of education in Indonesia. The freedom to learn policy covers student exchange, practical work, teaching assistance, research, humanitarian projects, entrepreneurial activities, independent learning, and village development. This program aims to provide students with opportunities to learn according to their potential and interest (Abidah et al., 2020). Additionally, Saleh (2020) remarked that the form of implementation of "freedom to learn" is creating fun learning activities so that it can encourage students' positive attitudes to respond to lessons. Indirectly, the Covid-19 pandemic

supports this program's implementation because students can study independently anywhere and anytime using technology.

Dealing with the distance learning and freedom to learn, the facilities and environment are entirely needed. Also, students need to have the technological knowledge to follow the distance learning model adopting the learning technology (Al-Hariri and Al-Hattami, 2017). Similarly, Incantalupo et al. (2013) noted that technology not only makes it easier for students to access various learning resources but also supports them to take responsibility, skills, and lifelong learning processes. The positive and significant influence technology knowledge on students' positive attitudes using integrated technology as a learning tool has been demonstrated by Ross et al. (2010). In fact, technology knowledge also enhances students' higher-order thinking, writing, and solving problems they face in learning. Ross et al. (2010) also emphasized that attainment in the 21st century requisites mastery of technology starting from technology knowledge and found that technology could increase student achievement and proficiency.

An earlier study by Incantalupo et al. (2013) found that technology knowledge played a pivotal role in teaching-learning activities based on technology and concluded that technology positively impacts students' activities with e-learning. Indeed, Andyani et al. (2020) found that technology knowledge is an ability that students and teachers must have in online learning activities. We measure Technology knowledge with indicators developed by Chai et al. (2011), including (1) knowledge about the use of technology in building learning innovations, (2) knowledge about using information technology media for learning, knowledge about choosing the right learning media (3) technological knowledge in measurement and evaluation, and (4) simplifying the assessment and evaluation process.

2.2. Educational competences

A professional teacher provides materials for students and attempts to enhance their learning progress (Fauth et al., 2019). Some preliminary studies remarked that educators take an essential role for students' internalization and enhancement in the learning process (Hattie, 2009). Teacher competence is described as a configuration that present particular personal qualities that educators requisite to accomplish the high demands of their profession. For instance, a good education should have in-depth knowledge of learning tasks and approaches to boost students' conceptual, such as knowledge of pedagogical content. Teachers need also to demonstrate a particular level of motivation in facing the challenges of the daily learning activities (Keller et al., 2014).

The growing body of literature found that competent teachers influence classroom learning activities, growth and development, and student learning outcomes (Baumert et al., 2020; Fauth et al., 2019). In more detail, the personal competence of teachers might promote students' interaction during teaching and learning process. Additionally, educator competence may serve as a significant lever with which to enhance the quality of teaching and student accomplishment, such as in professional enhancement programs. Similar to Kunter et al. (2008), we assume that teacher competence has a positive effect on the quality of learning, which in turn affects student learning outcomes.

We measure teacher educational competence (EC) referring to the indicator developed by Fauth et al. (2019), including (1) actively participating in learning activities; (2) develop student potential; (3) motivating students' willingness to learn; (4) ensure the level of understanding and adapt learning activities; (5) continue to improve teaching methods; (6) pay attention to learning objectives; (7) teaching in accordance with the learning objectives and life context; (8) increase student motivation; (9) providing opportunities for students to ask questions, and (10) analyzing the results of student evaluations.

2.3. Computer skills

Technology-based learning models will not be effective if students do not have technological knowledge and computer skills (Incantalupo

et al., 2013). The antecedent study by Cheng et al. (2019) also found that technology knowledge and computer skills had a positive effect on technology-based learning outcomes. Therefore, to improve technology-based learning outcomes, these two variables need to receive critical attention. According to (Tondeur et al., 2008), the multi-dimensional relationship between the use of computers with pedagogical abilities and academic activities is enough to focus on this research. The focus of computer expertise that individuals want to know about the ability of students to prepare assignments in Microsoft office applications to the upload process on E-crowdwar learning applications that can be accessed on computers and android applications.

Teachers, schools, and stakeholders need to ensure these two things are owned by students, before issuing technology-based learning policies. Computer skills are measured by being proficient at installing applications, understanding shortcut keys on the keyboard, understanding how to screenshot, and understanding the Microsoft formula (Incantalupo et al., 2013). Proficiency in computational skills analyzed in this research is a significant need because it relates to the working mechanism of the web and android-based E-crowdwar applications used by all research respondents. E-crowdwar is a game-based learning application that guides students to do independent learning and explore information in an environment that has been determined by the teacher by mapping via the global positioning system. During the pandemic, the area is determined to be around the school or sector adjacent to the student's house. The application contains material on economic events that exist around students. After heading to the intended area, students can choose a work scheme and collect multiple choice and essay model assignments selected via application shortcuts. This application runs side by side with other applications in the implementation of learning, one of the applications that must be installed on students' cellphones and computers are the Quizizz application and Microsoft office work applications. Unfortunately, in the development of this application, the work sequence guide or product introduction is not implicitly notified in the application. Students who do not adequately understand the operating system and working mechanisms of gadgets cannot optimize this game properly.

This learning tool provides additional resources for expanding knowledge, increasing interaction between students and teachers, as well as, assisting teachers with effective methods for assessing students. On the other hand, different cultures and conditions from various countries, which have different resources, capabilities, and perspectives in learning technology, respond to the readiness of learning in the network (Venkatesh, 2000). This situation requires researchers to understand the condition of students and need to know the essential readiness of students about computer and technology operations before applying game-based learning in a lesson. The discussion of planned behavior theory states that an attitude can impact habits (Ajzen, 1985). The development of the theory of planned behavior was developed in the theory of technology acceptance model, which integrates compatibility in attitude instruments (Taylor and Todd, 1995), and researchers include learning achievement as a measure of measurable behavioral usage with the fundamental reason that improving students' abilities depends on students' essential competencies in using computers and technology throughout the process of this learning strategy journey (Blignaut et al., 2010).

2.4. Mobile learning dan game-based learning

Screen time learning using internet technology has a wider scope than the face-to-face learning method. The primary advantage of internet-based learning is the emergence of new information and experience from the user engagement. In this term, each student can promote their potential and incline students' professionalism profile effectively by incorporating the internet. A prior study on blended learning also provided that the combination of learning with technology mediation (Computerize instruction) is able to increase active learning and bring better learning experiences and skills to students (Bonk and Graham,

2006). Some consensus also believes that the adoption of smartphones enables dynamic learning activities in which students can coordinate and collaborate with various sources and peers (Lin et al., 2017). Additionally, Al-Emran et al. (2016) remarked that mobile phones can be used for enlarging pedagogical dimensions. For this reason, an incline in readiness and independence in the educational process, the cognitive dimension can also be performed (Bakhsh et al., 2017).

Therefore, the use of smartphones as learning media will increase the dynamics in the teaching and learning process. The use of smartphones as learning media has various dimensions. To create fun learning, smartphones are used for the application of game-based learning. In this case, Chang et al. (2017) proved that game-based learning provides a greater students' experience instead of non-game-based learning. In this research, game-based learning adopted is E-crowdwar that can be accessed from android dan computer. Similarly, Chen and Law (2016); Satrio et al. (2020) recognized that the use of game-based learning will provide a more learning experience when it can collaborate with learning that provides instruction or guidance to students. Therefore, in this study, conventional learning collaboration (face-to-face in class) will be carried out by using games as a learning medium. According to these explanations, the hypotheses of this study are provided as follow:

- H1. Technology knowledge positively influences game-based learning tools
- H2. Technology knowledge positively influences learning achievement
- H3. Educational competences positively influences game-based learning tools
- H4. Educational competences positively influences learning achievement
- H5. Computer skills positively influences game-based learning tools
- H6. Computer skills positively influences learning achievement
- H7. Game-based learning tools positively influences learning achievement
- H8. Game-based learning tools mediates the influence of technology knowledge and learning achievement

3. Method and materials

3.1. Research design

This study was conducted using a quantitative method with a cross-sectional survey. The advantage of adopting this method enables for wide quantities of data from a subject, which also relevant during the Covid-19 pandemic. Furthermore, the output from quantitative studies can be incorporated to the target population, which is in line with this research purposes. The exogenous variables in this study are Technology Knowledge (TK), Educational competencies (EC), and Computer skills (CS). The intervening is Game-based learning tools (GBL). The research framework can be seen in Figure 1.

3.2. Sample and data collection

The participants of this study were 945 senior high school students who took game-based learning in economic learning, which was applied in selected regions in East Java of Indonesia. Data were collected using cluster sampling method which divided the sample based on three characteristics of coverage and the strength and weakness of the internet signal in three areas of East Java, including Blitar, Tulungagung, and Kediri. The data were collected using a survey method where questionnaires were distributed by providing an online questionnaire to various senior high school students through WhatsApp. The closed questionnaires with five Likert scale choices were involved in this project. Respondents in this paper were voluntary, and students incorporated in the

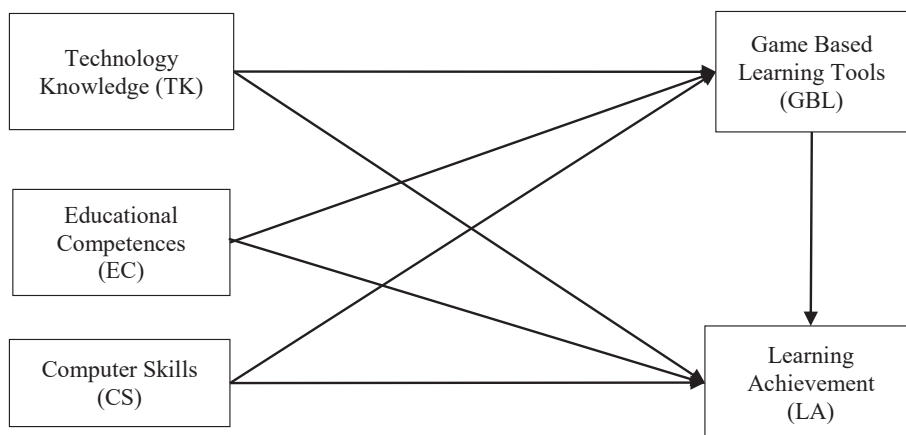


Figure 1. Theoretical framework.

research were informed for their anonymity. Ethical approval was obtained from the Universitas Negeri Malang Institutional Research Committee for all aspects of this research.

The demographic statistics of the participants are provided in Table 1. The female respondents represented 75.13%, while male participants were 24.87%. The respondents in this study came from three main areas in East Java of Indonesia, including Kediri (43.49%), Blitar (24.13%), and Tulungagung (32.38%). In terms of age distribution, most respondents were senior high school students in the age of 16 years, representing 33.40%, and the age of 17 and 18 years with the percentage of 24.34% and 25.82%, respectively.

3.3. Instrument development and data analysis

To measure technology knowledge (TK) variables, we adapted the four indicators developed by Chai et al. (2011), while to calculate teacher educational competence (EC), we adapted ten indicators from Fauth et al. (2019). We also involved six indicators for measuring computer skills (CS) from Incantalupo et al. (2013). Meanwhile, to measure Game-Based Learning (GBL), we have adapted six indicators from the Chen and Law study (2016). As for testing the effectiveness of the game-based learning method applied by the teacher, we tested student learning outcomes before participating in the learning method and following the learning method in the economic field using the pre-test and post-test.

Furthermore, each variable construct was calculated through a five-point Likert scale composed of “strongly disagree” (1) and “strongly agree” (5). Data were calculated using the Partial Least Square Structural Equation Modeling (PLS-SEM) with Smart PLS version 3.0. The data analysis in this study followed the criteria from Hair et al. (2013), which

Table 1. Demographic statistics of participants.

S/No.	Item	Frequency	%
1.	Age	945	100
	15 years old	155	16.40
	16 years old	316	33.44
	17 years old	230	24.34
	18 years old	244	25.82
2.	Sex	945	100
	Female	710	75.13
	Male	230	24.87
3.	Area	945	100
	Blitar	228	24.13
	Tulungagung	306	32.38
	Kediri	411	43.49

covers several stages of test, including inner model estimation, outer model calculation, Goodness of fit (Gof), and hypothesis testing.

4. Results and discussion

4.1. Assessment of outer model

In the outer model calculation, Hair et al. (2013) suggested that variables achieve the convergent validity when the loading factor (λ) is higher than 0.70. As provided in Table 2, the loading factor of TK, EC, CS, GBL, and LA has loading factors ranging between 0.728 to 0.848, indicating to meet the convergent validity indicator. In addition, the model achieves the discriminant variable when the value of cross-loading is more significant than 0.70. Table 3 illustrates that all variables involved in this study are higher than 0.70, implicating to fulfil the discriminant validity. This study also followed the discriminant validity using heterotrait-monotrait (HTMT) proposed by Henseler and Schuberth (2020). From the estimation, each variable has a ratio less than 0.90 to achieve the discriminant validity criteria (See Table 4).

Table 2. Results of outer model.

Variable	Indicator	λ	α	CR	AVE
Technology Knowledge (TK)	TK1	0.848	0.855	0.901	0.696
	TK2	0.825			
	TK3	0.839			
	TK4	0.824			
Educational Competences (EC)	EC10	0.728	0.901	0.917	0.580
	EC2	0.739			
	EC3	0.797			
	EC4	0.762			
	EC5	0.798			
	EC6	0.740			
	EC7	0.768			
	EC8	0.757			
Computer Skills (CS)	CS1	0.882	0.844	0.894	0.678
	CS2	0.825			
	CS3	0.780			
	CS4	0.802			
Game Based Learning (GBL)	GBL1	0.777	0.820	0.881	0.650
	GBL2	0.802			
	GBL5	0.803			
	GBL4	0.843			
Learning Achievement (LA)	LA	1.000	1.000	1.000	1.000

Source: Authors (2021).

Table 3. Discriminant Validity using Fornell-Larcker.

Variable	CS	EC	GBL	LA	TK
CS	0.823				
EC	0.643	0.761			
GBL	0.747	0.804	0.806		
LA	0.889	0.805	0.710	1.000	
TK	0.716	0.687	0.740	0.798	0.834

Source: Authors (2021).

4.2. Assessment of inner model

This study adopted a procedure from Hair et al. (2013) to estimate the inner model, which consists of several tests, including collinearity test, R-squared (R²), F-Squared (f²), and Q-squared (Q²). The collinearity test can be achieved when the VIF is lower than 5.00. The statistical calculation shows that the TK, CS, EC, GBL and LA variable is less than 5.00 to achieve the collinearity test, meaning that the construct can be used for further analysis (See Table 5). The R² test in this study notes that the variable of GBL can be explained moderately (36.7%) by TK, CS and EC, while the variable of LA can be explained by TK, CS, EC, and GBL which represented 12%.

The f² test in this study shows that TK, CS, and EC influences GBL with a level of 0.077. Indeed, TK, CS, EC, and GBL can explain LA with a level of 0.088. Furthermore, Q² calculation of variable TK, CS, EC, GBL and LA is greater than 0, meaning that the model has predictive relevance. Lastly, the GoF can be accomplished when Cronbach's Alpha (α) > 0.70, composite reliability (CR) > 0.70, and AVE >0.50. As illustrated in Table 6, the value of α, CR, and AVE have met the GoF criteria.

Furthermore, the hypothesis testing in this research using resampling bootstrap method and comparing t-test (t-count ≥ 1.645) and (p < 0.050). Table 7 informs that the hypothesis provided in this study ranges from 1.868- 12.810 (≥1.645) and p 0.000–0.031 (<0.050) to meet the criteria. To estimate the mediating variable, we adopted bootstrapping analysis by Preacher and Hayes (2008). The bootstrapping analysis indicates that it is insignificant with β = -0.002 and t-values of 0.578 < 1.645. The indirect effects 95% Boot CI Bias Corrected: [LL = -0.007, UL = 0.002], did straddle a 0 in between, therefore there is no mediation impact in this model. Therefore, H8 is rejected, meaning that GBL cannot mediate the relationship between TK and LA.

4.3. Discussion

The Covid-19 pandemic has affected activities in the world of Indonesian education. Indirectly, this condition supports the “Freedom to learn” program by the Indonesian government. The program provides many opportunities for students to obtain various information with fun learning concepts so as to encourage positive attitudes of students to continue learning and understand the essence of learning. The quality of learning is an aspect that plays an important role, especially for the current learning model. This study has measured student learning outcomes in terms of technology knowledge, educational competence, computer skills, and game-based learning to mediate in measuring

Table 4. Discriminant Validity using HTMT.

Variable	CS	EC	GBL	LA	TK
CS					
EC	0.275				
GBL	0.283	0.046			
LA	0.094	0.095	0.022		
TK	0.262	0.792	0.068	0.104	

Source: Authors (2021).

Table 5. Variance inflation factor (VIF).

	CS	EC	GBL	LA	TK
CS			1.068	1.141	
EC			1.927	1.939	
GBL				1.072	
LA					
TK			1.903	1.906	

Source: Authors (2021).

Table 6. Goodness of fit.

Variable	α	CR	AVE
Technology Knowledge (TK)	0.855	0.901	0.696
Educational Competences (EC)	0.901	0.917	0.580
Computer Skills (CS)	0.844	0.894	0.678
Game Based Learning (GBL)	0.820	0.881	0.650
Learning Achievement (LA)	1.000	1.000	1.000

Source: Authors (2021).

learning outcomes. The current condition makes technology a bridge to transmit information and knowledge to students. No matter how good the design of the online learning model is, if it is not followed by a good understanding of technology by students, the design will be useless.

Meanwhile, the findings of this study indicate that the learning model with game-based learning is explained by technology knowledge, educational competence, and computer skills. These results show that students' technology knowledge has a positive and significant effect on game-based learning. This measurement model is in line with the results of previous works Satrio et al. (2020); Incantalupo et al. (2013). The fundamental rationale is that when students' understanding is supported by the ability to use technology when learning to use smartphones, effective learning is created, and of course, students will feel comfortable when receiving it (Lin et al., 2017; de Witt and Gloerfeld, 2018). Since students understand the use of certain technologies appropriately, it can affect their learning behavior and, at the same time, increase their understanding.

This study's finding is relevant to prior studies that remarked that educators are expected to provide creative, active, and fun learning for students (Al-Emran et al., 2016; Lin et al., 2017). Therefore, educators' competence is also required to continue to develop and innovate, not only for conventional learning models but also for online learning. When educators can create good online learning, educators have shown a professional attitude towards their profession by choosing the right platform. Our findings are in line with previous studies (Baumert et al., 2020; Fauth et al., 2019) that competence affects learning activities, which used game-based learning in this study. This shows that educators who have useful competence will seriously produce a creative and easy-to-understand learning media to help students face online learning challenges. Whereas our findings have shown that the better educators' competence, the more likely it is to improve student learning outcomes, although not significantly.

Technology-based learning models need skills, namely computer skills. Students and educators should have this ability. How can online learning be effective if not followed by qualified skills? While the current conditions limit conventional learning and force-distance learning to take place. Our findings suggest that computer skills have a positive and significant effect on games-based learning. This means that a game-based learning model will be better if it is supported by computer skills. For example, educators create learning that utilizes a certain platform, for students who can operate it, of course, they can easily follow the instructor's instructions. Otherwise, students will be left with much

Table 7. The summary of hypothesis testing results.

Hypothesis	Relationship	β	SE	T-value	Confidence Interval (BC)		Support
					LL	UL	
H ₁	TK → GBL	0.361	0.036	6.305	0.016	0.136	Yes
H ₂	TK → LA	0.045	0.047	1.969	0.028	0.118	Yes
H ₃	EC → GBL	0.107	0.050	2.165	0.029	0.190	Yes
H ₄	EC → LA	0.056	0.044	1.868	0.001	0.136	Yes
H ₅	CS → GBL	0.261	0.036	7.305	0.207	0.321	Yes
H ₆	CS → LA	0.073	0.034	2.167	0.019	0.128	Yes
H ₇	GBL → LA	0.029	0.035	2.828	0.084	0.134	Yes
Indirect Effects							
H ₈	TK → GBL → LA	-0.002	0.003	0.578	-0.007	0.002	No

Source: Authors (2021).

Note: t-value > 1.645, $p < 0.05$, BC = bias corrected, UL = upper level, LL = lower level, SE - standard error, β = path coefficient, TK = Technology knowledge, EC = Educational competences, CS = Computer skills, GBL = Game-based learning, LA = learning achievement.

material if they cannot operate it. Furthermore, our findings have shown that the better the computer skills, the more likely it is to improve student learning outcomes. Because online learning is inseparable from technology, like it or not, students who want to obtain better results must master the platform used.

Referring to the research findings with a low R-level, it shows a small correlational relationship between game-based learning and student learning outcomes. This is reasonable because the use of new game-based learning applications is fully used in the midst of the covid-19 pandemic to address student boredom in dominant learning with lectures and assignments with media learning management systems. The low contribution of technology knowledge and educational knowledge to online-based learning and learning outcomes is allegedly due to the transition of learning models that previously used classical learning. In addition, the condition of the signal, which is quite dynamic among students, is allegedly causing this learning to not run optimally. The use of smartphones as learning media has a variety of functions in supporting technology-based learning. There are various types of services available on the platform on smartphones, depending on which platform is needed for learning, is it synchronous or asynchronous. Thus, educators' choice of platform needs to be considered by educators, not only in terms of costs but also to pay attention to convenience and usefulness for its users. Our findings are precisely the game-based learning model that can reduce learning outcomes, although the decrease is not significant. It is assumed that other factors not mentioned in this study may have a positive effect. Based on our findings, technology knowledge, educational competence, computer skills through game-based learning partially show a negative and insignificant effect on student learning outcomes. The more effective game-based learning media is, it can reduce student learning outcomes, although the decrease is not significant.

5. Conclusion

This research has shown that student learning outcomes are the primary reasons and determinants of the success of education in the Covid-19 pandemic. Referring to the presentation of the results and previous discussions, technology knowledge, educational competence, computer skills play an essential role in supporting technology-based learning. The challenges shown during online learning with uncertain conditions make actors in the world of education more responsive and responsive to situations and conditions. Referring to this, through its policies, educational institutions and the government must work together so that teaching and learning matters can run properly and do not reduce the essence of learning. Therefore, further research is expected to further examine the factors not mentioned in this study.

6. Limitations

As other studies, this research lies some limitations. First, although the data of this research describe field conditions, however, the data of three respondent areas with signal coverage characteristics of the medium and low-level categories is allegedly causing the application of technology to be not so intensively implemented. Second, the application of TPACK is only limited to the results of learning strategies perceived by students. This case only covers aspects of understanding technology, understanding the learning process, ability to use computer applications, and student responses to the use of game-based learning applications without observing how the level of understanding of teachers in using TPACK learning strategy integrated with game-based learning.

Declarations

Author contribution statement

Cipto Wardoyo and Yogi Dwi Satrio: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Bagus Shandy Narmaditya and Agus Wibowo: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Appendix

1. Indicator of Each Variable

	Variable	Source
1	Technology Knowledge (TK)	Chai et al. (2011)
Tk1	I have the technical skills to use technology	
Tk2	I can Learn technology easily	
Tk3	I am able to integrate e-crowdwar for study	
Tk4	I can use multiple technology to studying my learning subject	
2	Educational Competences (EC)	Fauth et al. (2019).
Ec1	Actively participating in learning activities	
Ec2	Develop student potential	
Ec 3	Motivating students' willingness to learn	
Ec 4	Ensure the level of understanding and adapt learning activities	
Ec 5	Continue to improve teaching methods	
Ec 6	Pay attention to learning objectives	
Ec 7	Teaching in accordance with the learning objectives and life context	
Ec 8	Increase student motivation	
Ec 9	Providing opportunities for students to ask questions	
3	Computer Skills (CS)	Incantalupo et al. (2013)
Cs1	installing applications,	
Cs.2	understanding shortcut keys on the keyboard,	
Cs.3	understanding how to screenshot	
Cs4	understanding the Microsoft formula	
4	Game Based Learning (GBL)	Chen and Law (2016).
Gbl1	ECrowd War provides interactive features between users and system.	
Gbl2	ECrowd War is user-friendly	
Gbl3	ECrowd War provides high availability	
Gbl4	ECrowd War is easy to use	

References

- Abidah, A., Hidaayatullaah, H.N., Simamora, R.M., Fehabutar, D., Mutakinati, L., 2020. The impact of covid-19 to indonesian education and its relation to the philosophy of "merdeka belajar". *Stud. Philosophy Sci. Educ.* 1 (1), 38–49.
- Ajzen, I., 1985. From intentions to actions: A theory of planned behavior. In: *Action control*. Springer, Berlin, Heidelberg, pp. 11–39.
- Al-Emran, M., Elsherif, H.M., Shaalan, K., 2016. Investigating attitudes towards the use of mobile learning in higher education. *Comput. Human Behav.* 56, 93–102.
- Al-Emran, M., Mezhyuev, V., Kamaludin, A., 2020. Is M-learning acceptance influenced by knowledge acquisition and knowledge sharing in developing countries? *Educ. Inf. Technol.* 1–22.
- Al-Hariri, M.T., Al-Hattami, A.A., 2017. Impact of students' use of technology on their learning achievements in physiology courses at the University of Dammam. *J. Taibah Univ. Med. Sci.* 12 (1), 82–85.
- Andyani, H., Setyosari, P., Wiyono, B., Djatmika, E., 2020. Does technological pedagogical content knowledge impact on the use of ICT in Pedagogy? *Int. J. Emerg. Technol. Learn. (iJET)* 15 (3), 126–139.
- Ardhyantama, V., Apriyanti, C., Erviana, L., 2021. Project-based learning as the alternative for distance learning in COVID-19 outbreak. *Indo. J. Prim. Educ.* 4 (2), 18–28.
- Bahasoan, A.N., Ayuandiani, W., Mukhran, M., Rahmat, A., 2020. Effectiveness of online learning in pandemic COVID-19. *Int. J. Serv. Technol. Manag.* 1 (2), 100–106.
- Baran, E., Canbazoglu Bilici, S., Albayrak Sari, A., Tondeur, J., 2019. Investigating the impact of teacher education strategies on preservice teachers' TPACK. *Br. J. Educ. Technol.* 50 (1), 357–370.
- Baumert, J., Fleckenstein, J., Leucht, M., Köller, O., Möller, J., 2020. The long-term proficiency of early, middle, and late starters learning english as a foreign language at school: a narrative review and empirical Study. *Lang. Learn.* 70 (4), 1091–1135.
- Bakhsh, M., Mahmood, A., Sangi, N.A., 2017. Examination of factors influencing students and faculty behavior towards m-learning acceptance: An empirical study. *Int. J. Inform. Learn. Technol.* 34 (3), 166–188.
- Blignaut, A.S., Hinostroza, J.E., Els, C.J., Brun, M., 2010. ICT in education policy and practice in developing countries: South Africa and Chile compared through SITES 2006. *Comput. Educ.* 55 (4), 1552–1563.
- Bonk, C.J., Graham, C.R., 2006. *The Handbook of Blended Learning: Global Perspective, Local Designs*. Wiley.
- Chai, C.S., Koh, J.H.L., Tsai, C.C., Tan, L.L.W., 2011. Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Comput. Educ.* 57 (1), 1184–1193.
- Chang, Y.H., Hwang, J.H., Fang, R.J., Lu, Y.T., 2017. A Kinect-and game-based interactive learning system. *Eurasia J. Math. Sci. Technol. Educ.* 13 (8), 4897–4914.
- Chang, C.S., Chung, C.H., Chang, J.A., 2020. Influence of problem-based learning games on effective computer programming learning in higher education. *Educ. Technol. Res. Dev.* 68 (5), 2615–2634.
- Chen, C.H., Law, V., 2016. Scaffolding individual and collaborative game-based learning in learning performance and intrinsic motivation. *Comput. Human Behav.* 55, 1201–1212.
- Cheng, L., Ritzhaupt, A.D., Antonenko, P., 2019. Effects of the flipped classroom instructional strategy on students' learning outcomes: a meta-analysis. *Educ. Technol. Res. Dev.* 67 (4), 793–824.
- Chua, J.H., Jamil, H., 2012. Factors influencing the technological pedagogical content knowledge (TPACK) among TVET instructors in Malaysian TVET institution. *Procedia-Soc. Behav. Sci.* 69, 1539–1547.
- Dakhi, O., Jama, J., Irfan, D., 2020. Blended learning: a 21st century learning model at college. *Int. J. Multi Sci.* 1 (8), 50–65.
- de Witt, C., Gloerfeld, C., 2018. Mobile learning and higher education. In: *The digital turn in higher education*. Springer VS, Wiesbaden, pp. 61–79.
- Emerson, A., Cloude, E.B., Azevedo, R., Lester, J., 2020. Multimodal learning analytics for game-based learning. *Br. J. Educ. Technol.* 51 (5), 1505–1526.
- Fauth, B., Decristan, J., Decker, A.-T., Büttner, G., Hardy, I., Klieme, E., Kunter, M., 2019. The effects of teacher competence on student outcomes in elementary science education: the mediating role of teaching quality. *Teach. Teach. Educ.* 86, 102882.
- Gaber, D.A., Shehata, M.H., Amin, H.A., 2020. Online team-based learning sessions as interactive methodologies during the pandemic. *Med. Educ.* 54 (7), 666–667.
- Graham, A., 2019. Benefits of online teaching for face-to-face teaching at historically black colleges and universities. *Online Learn.* 23 (1), 144–163.
- Hattie, J., 2009. The black box of tertiary assessment: An impending revolution, 259. *Tertiary Assessment & Higher Education Student Outcomes: Policy, Practice & Research*, p. 275.
- Hair, J.F., Ringle, C.M., Sarstedt, M., 2013. Partial least squares structural equation modeling: rigorous applications, better results and higher acceptance. *Long. Range Plan.* 46 (1–2), 1–12.
- Incantalupo, L., Treagust, D.F., Koul, R., 2013. Measuring student attitude and knowledge in technology-rich biology classrooms. *J. Sci. Educ. Technol.* 23 (1), 98–107.
- Karatas, K., Zeybek, G., 2020. The role of the academic field in the relationship between self-directed learning and 21st century skills. *Bull. Educ. Res.* 42 (2), 33.
- Keller, M.M., Chang, M.L., Becker, E.S., Goetz, T., Frenzel, A.C., 2014. Teachers' emotional experiences and exhaustion as predictors of emotional labor in the classroom: An experience sampling study. *Front. Psychol.* 5, 1442.
- Kunter, M., Tsai, Y.M., Klusmann, U., Brunner, M., Krauss, S., Baumert, J., 2008. Students' and mathematics teachers' perceptions of teacher enthusiasm and instruction. *Learn. Instruct.* 18 (5), 468–482.

- Lazarevic, B., Bentz, D., 2020. Student perception of stress in online and face-to-face learning: the exploration of stress determinants. *Am. J. Dist. Educ.* 1–14.
- Lin, M.H., Chen, H.G., Liu, K., 2017. A study of the effects of digital learning on learning motivation and learning outcome. *Eurasia J. Mathemat. Sci. Technol. Educ.* 13 (7), 3553–3564.
- Mouza, C., Karchmer-Klein, R., Nandakumar, R., Ozden, S.Y., Hu, L., 2014. Investigating the impact of an integrated approach to the development of preservice teachers' technological pedagogical content knowledge (TPACK). *Comput. Educ.* 71, 206–221.
- Morgan, H., 2020. Best practices for implementing remote learning during a pandemic. *Clear. House A J. Educ. Strategies, Issues Ideas* 93 (3), 135–141.
- Narmaditya, B.S., Prayitno, P.H., Wibowo, A., Agustina, Y., 2020. Blended synchronous learning and students' critical thinking ability: lesson from Covid-19. *JPBM (Jurnal Pendidikan Bisnis Dan Manajemen)* 6 (3), 112–119.
- Niess, M.L., 2011. Investigating TPACK: knowledge growth in teaching with technology. *J. Educ. Comput. Res.* 44 (3), 299–317.
- Perini, S., Luglietti, R., Margoudi, M., Oliveira, M., Taisch, M., 2018. Learning and motivational effects of digital game-based learning (DGBL) for manufacturing education—The Life Cycle Assessment (LCA) game. *Comput. Ind.* 102, 40–49.
- Pratama, A.R., Scarlatos, L.L., 2020. The roles of device ownership and infrastructure in promoting E-learning and M-learning in Indonesia. *Int. J. Mob. Blended Learn. (IJMBL)* 12 (4), 1–16.
- Preacher, K.J., Hayes, A.F., 2008. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behav. Res. Methods* 40 (3), 879–891.
- Putz, L.M., Hofbauer, F., Treiblmaier, H., 2020. Can gamification help to improve education? findings from a longitudinal study. *Comput. Human Behav.* 110, 106392.
- Qazi, A., Naseer, K., Qazi, J., AlSalman, H., Naseem, U., Yang, S., Gumaiei, A., 2020. Conventional to online education during COVID-19 pandemic: do develop and underdeveloped nations cope alike. *Child. Youth Serv. Rev.* 119, 105582.
- Ross, M., Morrison, G.R., Lowther, D., 2010. Educational technology research past and present: balancing rigor and relevance to impact school learning. *Contemp. Educ. Technol.* 1 (1), 17–35.
- Rulandari, N., 2020. The impact of the covid-19 pandemic on the world of education in Indonesia. *Ilomata Int. J. Soc. Sci.* 1 (4), 242–250.
- Saleh, M., 2020, May. Merdeka belajar di tengah pandemi Covid-19. In: *Prosiding Seminar Nasional Hardiknas*, 1, pp. 51–56.
- Satrio, Y.D., Handayani, S., Abbas, M.H.I., Kustiandi, J., 2020. Studi komparasi metode pembelajaran dalam meningkatkan literasi keuangan di Masa pandemi covid-19. *J. Pend. Ekon. Undiksha* 12 (1), 29.
- Setiawan, H., Phillipson, S., 2020. The correlation between social media usage in academic context and self-efficacy towards tpack of prospective science teachers in Indonesia. *J. Sci. Learn.* 3 (2), 106–116.
- Schmid, M., Brianza, E., Petko, D., 2020. Developing a short assessment instrument for Technological Pedagogical Content Knowledge (TPACK. xs) and comparing the factor structure of an integrative and a transformative model. *Comput. Educ.* 157, 103967.
- Siron, Y., Wibowo, A., Narmaditya, B.S., 2020. Factors affecting the adoption of e-learning in Indonesia: Lesson from Covid-19. *JOTSE: J. Technol. Sci. Educ.* 10 (2), 282–295.
- Taylor, S., Todd, P., 1995. Assessing IT usage: The role of prior experience. *MIS Q.* 561–570.
- Tondeur, J., Valcke, M., Van Braak, J., 2008. A multidimensional approach to determinants of computer use in primary education: Teacher and school characteristics. *J. Comput. Assist. Learn.* 24 (6), 494–506.
- Tomasik, M.J., Helbling, L.A., Moser, U., 2020. Educational gains of in-person vs. distance learning in primary and secondary schools: a natural experiment during the COVID-19 pandemic school closures in Switzerland. *Int. J. Psychol. Organ. Behav. Hum. Decis. Process.* 83 (1), 33–60.
- Venkatesh, V., Morris, M.G., Ackerman, P.L., 2000. A longitudinal field investigation of gender differences in individual technology adoption decision-making processes. *Organ. Behav. Hum. Decis. Process.* 83 (1), 33–60.
- Yamin, M., Syahrir, S., 2020. Pembangunan pendidikan merdeka belajar (telaah metode pembelajaran). *J. Ilmiah Mand. Educ.* 6 (1).
- Yang, J.C., Chen, S.Y., 2020. An investigation of game behavior in the context of digital game-based learning: an individual difference perspective. *Comput. Hum. Behav.* 112, 106432.
- Yustina, Y., Syafii, W., Vebrianto, R., 2020. The effects of blended learning and project-based learning on pre-service biology teachers' creative thinking skills through online learning in the covid-19 pandemic. *J. Pend. IPA Indo.* 9 (3), 408–420.