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Research Article

University students' acceptance of video-conferencing for learning of mathematics in the post-COVID-19 era

Mailizar Mailizar [1*]
0000-0003-4084-311X

Ega Gradini [2]
0000-0002-4183-527X

Tommy Tanu Wijaya [3]
0000-0001-6840-3875

Abdulsalam Al-Manthari [4]
0000-0001-6861-5974

[1] Department of Mathematics Education, Universitas Syiah Kuala, Banda Aceh, INDONESIA
[2] Department of Mathematics Education, IAIN Takengon, Takengon, INDONESIA
[3] School of Mathematical Sciences, Beijing Normal University, Beijing, CHINA
[4] Department of Curriculum Development, University of Technology and Applied Sciences–Ibri, Ibri, OMAN
[*] Corresponding author: mailizar@unsyiah.ac.id

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ABSTRACT

This study aims to examine the factors that influence university students' behavioral intention in accepting video-conferencing for learning mathematics in the post-COVID-19 era. Video-conferencing as a learning tool has been widely used to establish effective communication among learners, teachers, and peers. This is particularly valuable in situations where face-to-face communication is not possible, such as during the COVID-19 pandemic. As the pandemic comes to an end, it is unclear whether video-conferencing will continue to be widely used as a teaching and learning tool. This study extends the technology acceptance model (TAM) by adding digital literacy (critical use, technology focused, and digital reading) and social presence (SC) as external factors. Extended TAM with digital literacy and SC as factors provide understanding on how university students' digital literacy level and their connection and engagement with others influences their acceptance of video-conferencing for learning. The participants include 238 students from six universities in Indonesia (three public universities and three private universities), who enrolled in bachelor's degree of mathematics and mathematics education. The questionnaire consisted of 40 items administered online to students selected by random sampling. A partial least square-structural equation modelling approach was used to analyze the measurement model, test the path, and draw conclusions. The findings of this study shows that attitude is the most important factor that has influenced the intention to employ video-conferencing after a pandemic situation. In addition, SC is considered the most significant factor in students' attitudes towards the use of video-conferencing in the post-COVID-19 era.

Keywords: TAM, video conferencing acceptance, post-COVID-19, university student

INTRODUCTION

By mid-2020, higher education institutions (HEIs) worldwide replaced traditional face-to-face teaching during the pandemic with online instruction, video learning, MOOCs and various online learning approaches. One of the most dominant adopted online learning approaches during the pandemic was the synchronous learning approach. According to Phelps and Vlachopoulos (2020), synchronous learning is a relatively new approach to online education that provides a wide range of digital tools that enhance dialogue and learners' autonomy. Through interactive platforms and tools, it can shorten the distance experienced between teachers, learners, and their peers.

The pandemic has created an online learning experience for most educational institutions, including HEIs. Studies show that during the pandemic, video-conferencing was one of the main methods used by educators (other methods were SPOC, MOOC, and micro lecture videos). During the pandemic, video-conferencing platforms, such as Zoom, Google Meet, and Microsoft Teams, significantly assisted teaching and learning. Video-conferencing uses synchronous audio and video to connect virtually people separated physically. This technology was used even before the pandemic for facilitating learners' self-directed learning.

Zoom was launched almost ten years ago, but most people only became familiar with it during the pandemic (Chen et al., 2021a). During this time, the software quickly became a reliable tool for distance learning, making it a key part of educational technology (Bonk, 2020). Hersh (2020) claims that Zoom helped create new kinds of real-time communities and suggests that using Zoom and other similar tools for teaching might become common

The pandemic resulted in a shift in teaching methods from traditional to online learning, particularly synchronous learning (e.g., Bonk, 2020). HEIs around the globe have started re-opening their classrooms with the end of the pandemic.

There is lack of studies focusing on factors affecting students' continued acceptance of video-conferencing after the pandemic for learning mathematics. It is necessary to understand whether university students are still willing to use video-conferencing post-pandemic. This is especially applicable in mathematics learning, as it is a technical subject with unique challenges not easily delivered online (Harman & Dorman, 1998).

Our study aims to investigate university students' acceptance of video-conferencing as a synchronous learning tool for learning mathematics in the post-pandemic era. We extended the technology acceptance model (TAM) (Davis, 1989) with external factors of digital literacy and social presence (SC). The research provides an in-depth investigation at the sustainability of synchronous online learning and blended learning, especially using video-conferencing tools.

In this paper, the literature review and conceptual framework sections explain video-conferencing in mathematics lessons and the TAM model. Next, it explains the initial model and the initial hypothesis. The third part describes the research design, participants, data collection approach, and data processing used to draw conclusions. Finally, the discussion section describes the validity and reliability of the model, explaining the study results in detail. Several practical and theoretical implications were drawn from the findings.

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

COVID-19 and Synchronous Technology Use in Higher Education

Distance learning became a solution to keep teaching and learning going during the pandemic. The shift to online teaching for higher education instructors brought different experiences, preferences, and challenges, especially with live, real-time classes (Bonk, 2020). The pandemic also pushed most higher education instructors to learn and use tools like Webex, Zoom, Kaltura, Microsoft Teams, and Google Meet for synchronous instruction.

Zoom has emerged as a popular tool for real-time class sessions, feedback meetings, and mentoring students (Beriswill, 2018). It stands out for its strong connectivity, reliability, and user-friendly interface (Beriswill, 2018). As a result, Zoom gained significant attention (Bonk, 2020) and played a crucial role in keeping many academic programs running during the pandemic (Bonk, 2020). It also helped numerous students continue their education (Bonk, 2020). By using Zoom, new forms of real-time communities were established (Hersh, 2020), Even though there are various other remote learning tools, Zoom has firmly positioned itself in the field of educational technology (Bonk, 2020).

Web-Based Video Conferencing for Learning Mathematics

One of the most important objectives of any learning system is delivering and attaining high-quality educational programs. Alelaiwi et al. (2015) suggested assembling e-learning in a smart setting to support the

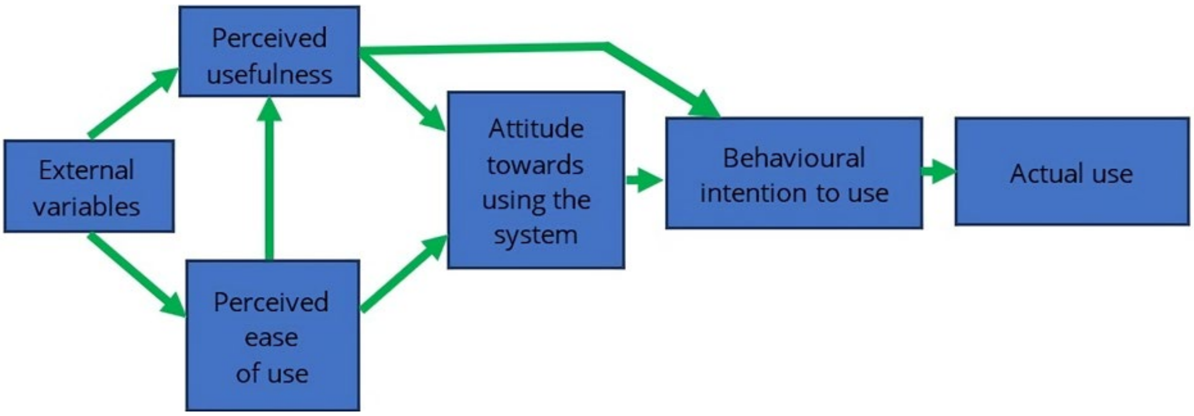

Figure 1. TAM (Davis, 1989)

value of expanded e-learning, although most educators oppose the idea of student annotation. In this study, smart setting referred to an environment where the classroom transformed into an advanced technological learning classroom. This study found that using a smart class environment and increasing students' engagement improved students' learning outcome. The result also showed that their high satisfaction with the technology enhances their learning experience. Thus, teaching and learning during the pandemic need to assemble with

(1) synchronous and asynchronous instructional modes and

(2) online learning tools such as video conferencing (Taylor & Hwang, 2021).

In online mathematics learning, students self-regulate their learning processes and retain their motivation to attain their learning objectives. However, a better learning system is required for favorable recognition in mathematics online learning since it involve the use of formulas and concepts that require strong explanations.

Web-based learning has its limitations to mathematical expressions and students' understanding (Miyazaki et al., 2017). Video-based learning has been recognized as a practical learning tool to enhance student learning outcomes and knowledge (Kay & Kletskin, 2012; Wells et al., 2012), practical skills (Donkor, 2010), and enabling spatial flexibility (Estriegana et al., 2019). Lakhal et al.'s (2013) found that students tend to perform better academically in video conferencing settings compared to traditional, face-to-face classes. To support this, teachers need to establish a learning environment that keeps students engaged in online mathematics education, both during and after the COVID-19 pandemic (Galanti et al., 2021).

Web-Based Video Conferencing: TAM Perspective

TAM (Davis, 1989) has been extensively used to analyze how users adopt and accept new technologies (Cigdem & Topcu, 2015) (**Figure 1**). The model is a well-known model to measure user acceptance of technology and its use by deploying three main factors; perceived usefulness (PU), perceived ease of use (PEOU), and attitude toward using it. A meta-analysis study on TAM in an educational context revealed that TAM is robust that hypothesized teacher acceptance of technology (Scherer et al., 2019).

This study examines students' intention to use web-based video conferencing by assessing their PU and attitudes towards the technology in the post-COVID-19 period. PU refers to how much students believe that web-based video conferencing can improve their performance in learning mathematics. PEOU is defined as the extent to which students find the technology easy and straightforward to use. Previous research suggests that students are more likely to adopt new technology if they consider it simple to use (Saadé & Bahli, 2004). Students' attitude towards video conferencing use is described as the degree of the evaluative effect of web-based video conferencing in their learning. Both PEOU and PU are related to attitude towards using it. However, Shih (2004) found that PEOU is more likely to affect the attitude than PU. Research on TAM found that PEOU significantly affects PU (Venkatesh & Davis, 1996). We investigated this relationship by hypothesizing that students who perceived web-based video conferencing as easier to use would be more helpful.

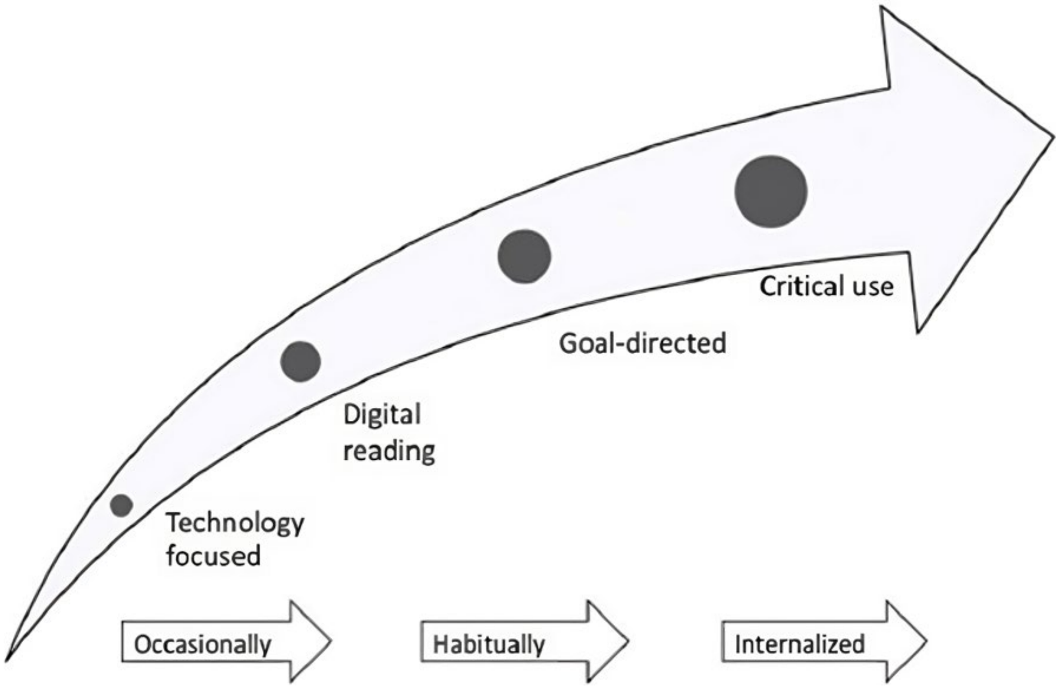

Figure 2. Framework of digital literacy (List et al., 2020)

According to TAM, a person's actual use of a system is influenced by their behavioral intention (BI). This intention, in turn, is shaped by two key factors: PU and their attitude toward the system (Davis, 1985, 1989). PEOU has a significant connection to intention, both directly and indirectly, by influencing PU (Venkatesh & Davis, 2000) and attitude towards using the system (Davis, 1985; Venkatesh & Davis, 1996). Students' BI is defined as their subjective probability, willingness, decision, conflict, and commitment to using web-based video conferencing in mathematics learning. This BI was used to predict the university students' actual use of web-based video conferencing in learning mathematics as supported by a systematic literature review that proposed BI likely correlated to the actual system (Turner et al., 2010). TAM has been extended with various external factors to better understand users' adoption of technology. In this study, we proposed two external factors of TAM: SC and digital literacy.

Social Presence and Online Learning

Video conferencing creates an online learning environment that strengthens the lecturer's presence, facilitates student group decision-making, and develops the learning community (Myers & Schiltz, 2012). Starr-Glass (2020) argued that video conferencing has greatly enhanced learners' appreciation, satisfaction, and overall engagement. Nevertheless, the sense of a learning community often disappears in online learning. Numerous studies on SC in online learning discovered that a feeling of community is essential in online learning. Becoming acquainted with peers in an online class by seeing and hearing them may be essential for a sense of community, and the feeling increases when the video is authentic (Koivula, 2018). SC in online learning refers to being together with peers as real-time social interaction among learners (Biocca et al., 2003) despite broader and more psychological terms (Biocca & Harms, 2002; Kehrwald, 2008; Lowenthal, 2010; Tu, 2000). Social context, online communication, and interactivity–all of these factors have emerged as crucial in fostering a feeling of community among online learners (Tu & McIsaac, 2002). Regarding this, we hypothesized SC significantly affects students' BI to use web-based video conferencing.

Digital Literacy

In this study, we adopt the OECD's (2015) definition of digital literacy (**Figure 2**), which describes it as the capability to assess information from various sources, determining its credibility and relevance based on self-established standards. It also involves the ability to handle tasks that require locating information in unfamiliar contexts, dealing with ambiguity, and navigating without clear instructions (OECD, 2015). Students' digital literacy intersects in three dimensions:

(1) the technical dimension, which refers to students' technical and operational skills in using information and communications technologies (ICTs) in learning (Ng, 2012),

(2) the cognitive dimension refers to students' skills in exploring, evaluating, and creating digital information, as well as their ability to critically analyze that information (List et al., 2020), and

(3) the socio-emotional dimension refers to students' ability to use ICTs for responsible communication, collaboration, and other social purposes related to learning (List et al., 2020).

In this study, we adopted the digital literacy framework from List et al. (2020).

According to List et al. (2020), technology focused (TF) refers to the knowledge or skill of certain technical tools (e.g., computer and the Internet use). Furthermore, digital reading (DR) is defined as the ability to adapt traditional print literacy skills to a digital setting. On the other hand, critical use (CU) involves viewing digital literacy as a reflective and evaluative process, where technology is utilized thoughtfully to accomplish intended objectives. Regarding digital literacy, Mailizar et al. (2022) showed that hat digital literacy has a significant impact on teachers' acceptance of online professional development. Other studies (Mohammadyari & Singh, 2015; Prior et al., 2016) also showed positive impacts of digital literacy on students' use of e-learning. However, those studies do not focus on the context of mathematics learning and look at online learning in general. Thus, the present study focuses on learning mathematics with a specific online learning system: video conferencing.

Issues of Online Learning Technology and Digital Literacy

Online learning technology has become increasingly critical in the education sector, particularly with the shift to remote and hybrid learning models accelerated by the COVID-19 pandemic. The integration of digital tools, online platforms, and virtual classrooms has enabled continued access to education despite physical constraints, significantly influencing teaching and learning processes (Dhawan, 2020). However, the effectiveness of these technologies is heavily dependent on the digital literacy of both educators and students.

Digital literacy, which includes the ability to navigate, evaluate, and create information using digital technologies, is increasingly recognized as a fundamental skill for success in online education. It involves not only technical proficiency but also the ability to critically assess digital content and communicate effectively in a digital context (van Laar et al., 2020). Studies have shown that students with higher levels of digital literacy are better equipped to engage with online learning platforms, leading to improved academic performance. On the other hand, students who lack these skills often face significant challenges, including difficulty in navigating online platforms and lower educational outcomes (Helsper, 2021).

The rapid transition to online learning has also highlighted disparities in digital literacy, often linked to the digital divide. This divide, characterized by unequal access to technology and digital literacy education, is particularly obvious among students from lower socioeconomic backgrounds. The digital divide worsens existing educational inequalities, as students without adequate access to technology or digital literacy skills are at a disadvantage in online learning settings. Addressing these disparities is critical for ensuring that all students can benefit equally from the opportunities provided by digital learning technologies (Robinson et al., 2020).

Educators play a crucial role in addressing the digital literacy gap by integrating digital tools into their teaching practices and enhancing their own digital competencies (Kimmons & Hall, 2016). Professional development programs that focus on improving educators' digital literacy are essential for equipping teachers with the skills necessary to support student learning in online environments (Hennessy et al., 2022). Research has shown that when educators are confident in their digital literacy skills, they are better able to create engaging and interactive online learning experiences, which positively impact student outcomes (Bond, 2021).

In addition to supporting educators, it is also important to equip students with digital literacy skills. Educational institutions should implement programs that address both foundational and advanced digital skills, preparing students to succeed in increasingly digital learning environments (Hargittai, 2020). Developing these competencies can help students become more independent learners and better prepare them for success in a technology-driven educational landscape (Pangrazio & Selwyn, 2021).

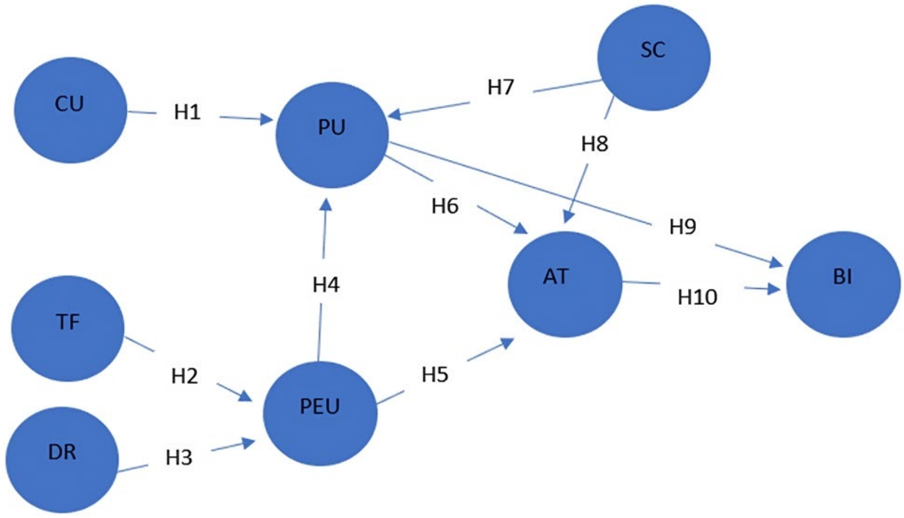

Figure 3. Proposed model (The authors' own work)

Research Model and Hypotheses

Regarding the literature review discussed above, the present study proposes two external factors of TAM: digital literacy and SC. As a result, we proposed the following initial structural model and hypotheses (**Figure 3**).

H1: CU positively and significantly affects PU of video conferencing.

H2: TF positively and significantly affects PEOU of video conferencing.

H3: DR positively and significantly affects PEOU of video conferencing.

H4: PEOU positively and significantly affect PU of video conferencing.

H5: PEOU positively and significantly affects attitude (AT) toward video conferencing.

H6: PU positively and significantly affects AT toward video conferencing.

H7: SC positively and significantly affects PU of video conferencing.

H8: SC positively and significantly affects attitude (AT) toward video conferencing.

H9: PU positively and significantly affects BI to use video conferencing.

H10: AT positively and significantly affects BI to use video conferencing.

The literature indicates that web-based video conferencing was crucial in the teaching and learning of mathematics in higher education during the COVID-19 pandemic. Additionally, it has been found that the TAM has been extensively applied to understand users' adoption of technology. In addition, digital literacy is considered as an important ability that students need in this digital ages. Therefore, it is necessary to extend the TAM model with external factor of digital literacy in order to understand university students' use of web-based video conferencing in learning of mathematics in higher education.

METHOD

Research Design and Participants

This study used a quantitative approach with a survey design, employing partial least square-structural equation modeling (PLS-SEM) to analyze and interpret the relationships between variables and to evaluate the model fit. This method was appropriate for assessing the proposed model.

The participants of this study were students from six universities in Indonesia (three public universities and three private universities), who enrolled in mathematics and mathematics education undergraduate programs. The study population was students who enrolled in mathematics or mathematics education programs at those universities, totaling approximately 1,100 students. In this study, we received responses from 238 students.

Table 1. The indicators after face and content validity

No	Construct	Indicators	Number of items
1	Critical use (CU)	CU1, CU2, CU3, CU4, CU5	5
2	Technology focused (TF)	TF1, TF2, TF3, TF4, TF5, TF6	6
3	Digital reading (DR)	DR1, DR2, DR3, DR4	4
4	Perceived usefulness (PU)	PU1, PU2, PU3, PU4	4
5	Perceived ease of use (PEOU)	PEOU1, PEOU2, PEOU3, PEOU4, PEOU5	5
6	Attitude (AT)	AT1, AT2, AT3, AT4	4
7	Social presence (SC)	SC1, SC2, SC3, SC4, SC5, SC6	6
8	Behavioral intention (BI)	BI1, BI2, BI3, BI4, BI5, BI6	6

Instrumentation

According to Hair et al. (2016), a literature review helps a researcher develop a conceptual framework for the research and to determine appropriate research instruments. In this study, we adapted and developed survey items from previous related research; Zoom and TAM (Alfadda & Mahdi, 2021), digital literacy (List et al., 2020), and SC (Smith & Sivo, 2012). Furthermore, we examined face validity. In total, our study generated forty-five items.

We involved four students and two lecturers in discussing the adapted questionnaire regarding face validity. We conducted a focus group discussion. In terms of content validity, we discussed the questionnaire with three experts in education technology. After face and content validity, we eliminated five items. Therefore, forty items remained for the further validation process (**Table 1**).

Data Collection

This study's target population was students enrolled in mathematics of mathematics education undergraduate programs. After completing face and content validity, we distributed questionnaires to university students. Through stratified random sampling (Creswell, 2012), we obtained data from six universities in Indonesia that have mathematics or mathematics education undergraduate programs at the faculty of education. The stratified random sampling process was conducted by first dividing the population into two primary strata: public and private universities. From these, we selected three public universities and three private universities, ensuring that both types were equally represented in the study. Within each selected university, random sampling was then employed to choose participants, ensuring that every individual had an equal chance of being included in the sample. This approach was designed to capture the diversity of experiences across both public and private institutions, thereby enhancing the representativeness of the sample. We distributed the online questionnaire to students in virtual groups at those universities. As a result, we received responses from 238 students. The response rate for the survey was 21.6%, calculated based on the 238 participants who completed the survey out of the total 1,100 individuals invited. Data collection was conducted over a two-month period, from January 2023 to February 2023, ensuring that participants had ample time to respond.

In terms of ethical considerations, all participants received informed consent forms prior to their involvement in the study. These forms detailed the research purpose, emphasized voluntary participation, and informed participants of their right to withdraw at any point. Additionally, measures were taken to ensure anonymity and confidentiality by assigning unique codes to responses and securely storing the data.

Data Analysis Procedure

Data were analyzed using SMART PLS 3.0. PLS-SEM was selected due to its suitability for exploring complex relationships between multiple variables, especially in cases where the research model includes both reflective and formative constructs. Additionally, PLS-SEM is particularly effective in handling smaller sample sizes, which were considerations in our study. To conduct data analysis, we did the following procedure. We employed the PLS algorithm to assess the reliability and validity of the constructs. We then evaluated the measurement model by examining reflective indicator loadings, internal consistency reliability, convergent validity, and discriminant validity. Additionally, we used bootstrapping to test the statistical significance of the proposed model. Finally, a blindfolding procedure was conducted to determine the Q^2 value of the latent variables.

Table 2. Outer loading, Cronbach's alpha, composite reliability, and AVE

Item	Outer loading	Cronbach's alpha	Composite reliability	AVE
AT1	0.904	0.916	0.941	0.799
AT2	0.859			
AT3	0.900			
AT4	0.913			
BI2	0.826	0.904	0.929	0.723
BI3	0.891			
BI4	0.871			
BI5	0.876			
BI6	0.783			
CU1	0.791	0.821	0.880	0.647
CU2	0.804			
CU3	0.797			
CU4	0.827			
DR1	0.769	0.827	0.885	0.659
DR2	0.796			
DR3	0.846			
DR4	0.834			
PEOU1	0.850	0.890	0.919	0.694
PEOU2	0.852			
PEOU3	0.829			
PEOU4	0.826			
PEOU5	0.810			
PU1	0.844	0.885	0.920	0.743
PU2	0.890			
PU3	0.867			
PU4	0.847			
SC1	0.884	0.957	0.966	0.824
SC2	0.923			
SC3	0.924			
SC4	0.897			
SC5	0.924			
SC6	0.893			
TF1	0.742	0.864	0.902	0.649
TF2	0.854			
TF3	0.806			
TF4	0.855			
TF5	0.766			

RESULTS

Measurement Models

The measurement model serves as an evaluation procedure to determine the validity and reliability of the instrument. Following the guidelines of Hair et al. (2016), this study assessed four key aspects: reflective indicator loading, internal consistency reliability, convergent validity, and discriminant validity.

Reflective indicator loadings

The reflective indicator results were reported using the PLS-SEM format. **Table 2** presents the final measurements for all eight constructs in the reflective model. The results indicate that three loadings were below the recommended threshold of 0.700, as outlined by Hair et al. (2016). Specifically, the indicators CU5 (0.691), TF6 (0.678), and BI1 (0.698) did not meet the required standard and were thus excluded from further analysis.

Internal consistency reliability

To assess the consistency of results across items, we evaluated internal consistency reliability by examining both Cronbach's alpha and composite reliability, following the guidelines of Hair et al. (2016). According to these standards, values for both measures should exceed 0.700.

Table 3. Cross-loading

	AT	BI	CU	DR	PEOU	PU	SC	TF
AT1	**0.904**	0.684	0.239	0.381	0.674	0.764	0.768	0.382
AT2	**0.859**	0.634	0.291	0.401	0.629	0.656	0.633	0.346
AT3	**0.900**	0.667	0.188	0.325	0.614	0.724	0.705	0.349
AT4	**0.913**	0.767	0.244	0.422	0.718	0.719	0.730	0.374
BI2	0.671	**0.826**	0.319	0.440	0.650	0.565	0.643	0.380
BI3	0.705	**0.891**	0.317	0.367	0.598	0.588	0.650	0.309
BI4	0.594	**0.871**	0.341	0.414	0.606	0.537	0.578	0.379
BI5	0.597	**0.876**	0.310	0.378	0.590	0.529	0.564	0.342
BI6	0.687	**0.783**	0.242	0.324	0.587	0.715	0.760	0.336
CU1	0.233	0.291	**0.791**	0.401	0.298	0.304	0.239	0.360
CU2	0.171	0.277	**0.804**	0.466	0.246	0.190	0.171	0.408
CU3	0.216	0.252	**0.797**	0.523	0.343	0.256	0.227	0.516
CU4	0.226	0.325	**0.827**	0.476	0.322	0.292	0.265	0.436
DR1	0.362	0.352	0.457	**0.769**	0.400	0.374	0.310	0.494
DR2	0.316	0.357	0.421	**0.796**	0.352	0.291	0.292	0.410
DR3	0.366	0.391	0.521	**0.846**	0.436	0.404	0.357	0.520
DR4	0.343	0.367	0.465	**0.834**	0.456	0.346	0.377	0.589
PEOU1	0.759	0.706	0.341	0.457	**0.850**	0.745	0.669	0.402
PEOU2	0.584	0.599	0.360	0.474	**0.852**	0.604	0.609	0.538
PEOU3	0.509	0.522	0.319	0.370	**0.829**	0.523	0.519	0.514
PEOU4	0.608	0.561	0.263	0.399	**0.826**	0.648	0.640	0.516
PEOU5	0.584	0.567	0.301	0.416	**0.810**	0.601	0.526	0.403
PU1	0.653	0.570	0.302	0.352	0.532	**0.844**	0.593	0.320
PU2	0.663	0.556	0.267	0.323	0.593	**0.890**	0.631	0.336
PU3	0.667	0.617	0.270	0.407	0.697	**0.867**	0.695	0.388
PU4	0.766	0.648	0.309	0.418	0.757	**0.847**	0.741	0.479
SC1	0.728	0.682	0.243	0.382	0.668	0.713	**0.884**	0.375
SC2	0.735	0.683	0.299	0.392	0.694	0.719	**0.923**	0.446
SC3	0.702	0.718	0.319	0.437	0.715	0.734	**0.924**	0.510
SC4	0.693	0.652	0.263	0.366	0.572	0.663	**0.897**	0.432
SC5	0.690	0.676	0.269	0.380	0.630	0.673	**0.924**	0.475
SC6	0.775	0.722	0.174	0.306	0.618	0.723	**0.893**	0.326
TF1	0.297	0.340	0.517	0.522	0.418	0.336	0.353	**0.742**
TF2	0.325	0.342	0.401	0.510	0.448	0.326	0.408	**0.854**
TF3	0.329	0.279	0.365	0.438	0.398	0.391	0.398	**0.806**
TF4	0.366	0.334	0.427	0.619	0.489	0.377	0.397	**0.855**
TF5	0.315	0.351	0.432	0.427	0.510	0.369	0.339	**0.766**

As shown in **Table 2**, the results indicate that all constructs met this criterion, with values of Cronbach's alpha and composite reliability above the threshold. Therefore, we concluded that the constructs demonstrated strong internal consistency reliability.

Convergent validity

Hair et al. (2016) state that the minimum acceptable value for the average variance extracted (AVE) is 0.500, which reflects that the constructs account for 50% of the variance in the items. As shown in **Table 2**, all constructs achieved AVE values exceeding 0.500, demonstrating that they possess strong convergent validity.

Discriminant validity

Discriminant validity indicates to what extent a construct is different from other constructs (Hair et al., 2016). Discriminant validity can be assessed by Fronell-Larcker criterion, cross-loading, and the heterotrait-monotrait (HTMT) ratio of correlations.

According to the Fornell-Larcker criterion, Hair et al. (2016) recommend that the shared variance among all constructs should be lower than their AVE values. **Table 3** illustrates that the outer loadings (in bold) for each construct are greater than the cross-loadings with other constructs, confirming discriminant validity. Moreover, discriminant validity can also be assessed using the HTMT ratio of correlations. As per Hair et al. (2016), HTMT values should be below 0.90.

Table 4. Fronell-Larcker criterion

	AT	BI	CU	DR	PEOU	PU	SC	TF
AT	**0.894**							
BI	0.772	**0.850**						
CU	0.268	0.359	**0.805**					
DR	0.428	0.452	0.577	**0.812**				
PEOU	0.738	0.715	0.381	0.510	**0.833**			
PU	0.802	0.697	0.333	0.438	0.756	**0.862**		
SC	0.795	0.760	0.287	0.415	0.717	0.777	**0.908**	
TF	0.406	0.411	0.532	0.626	0.567	0.447	0.470	**0.806**

Table 5. HTMT

	AT	BI	CU	DR	PEOU	PU	SC	TF
AT								
BI	0.839							
CU	0.304	0.414						
DR	0.490	0.523	0.700					
PEOU	0.807	0.789	0.438	0.587				
PU	0.884	0.768	0.378	0.505	0.835			
SC	0.846	0.808	0.316	0.463	0.769	0.837		
TF	0.455	0.463	0.633	0.732	0.644	0.504	0.519	

Table 6. Inner VIF values

	AT	BI	CU	DR	PEOU	PU	SC	TF
AT		**2.799**						
BI								
CU						**1.170**		
DR					**1.645**			
PEOU	**2.590**					**2.206**		
PU	3.178	**2.799**						
SC	**2.796**					**2.056**		
TF					**1.645**			

As shown in **Table 4**, each construct's AVE values exceed their shared variances, indicating that the study's data meet the requirements for discriminant validity. Additionally, discriminant validity can be confirmed by examining indicator loadings; it is established when a construct's loadings are higher than its cross-loadings with other constructs (Hair et al., 2016).

Table 5 shows that all HTMT values fall below 0.90, suggesting that they are significantly different from 1. Hence, discriminant validity is confirmed. Following the completion of the measurement model assessment, 37 indicators were used to evaluate the structural model.

Hair et al. (2016) outline six systematic approaches for evaluating the structural model. In this study, we followed these approaches, beginning with an examination of collinearity. In the second stage, we assessed the path coefficients (β). The third stage involved evaluating the coefficient of determination (R^2). Additionally, we reported the effect size (f^2) in stage 4. In stage 5 and stage 6, we examined the predictive relevance (Q^2) and its f^2, respectively.

Collinearity Issue

In this study, we assessed the set of predictors for collinearity. The predictors are, as follows:

(a) AT and PU as predictors of BI,

(b) SC, PU, and PEOU as predictors of AT,

(c) CU, PEOU, and SC as predictors of PU, and

(d) TF and DR as predictors of PEOU.

Hair et al. (2016) suggest that VIF values should be less than 3. **Table 6** reveals that most of VIF values are below 3. Therefore, we conclude that collinearity is not an issue for the proposed model.

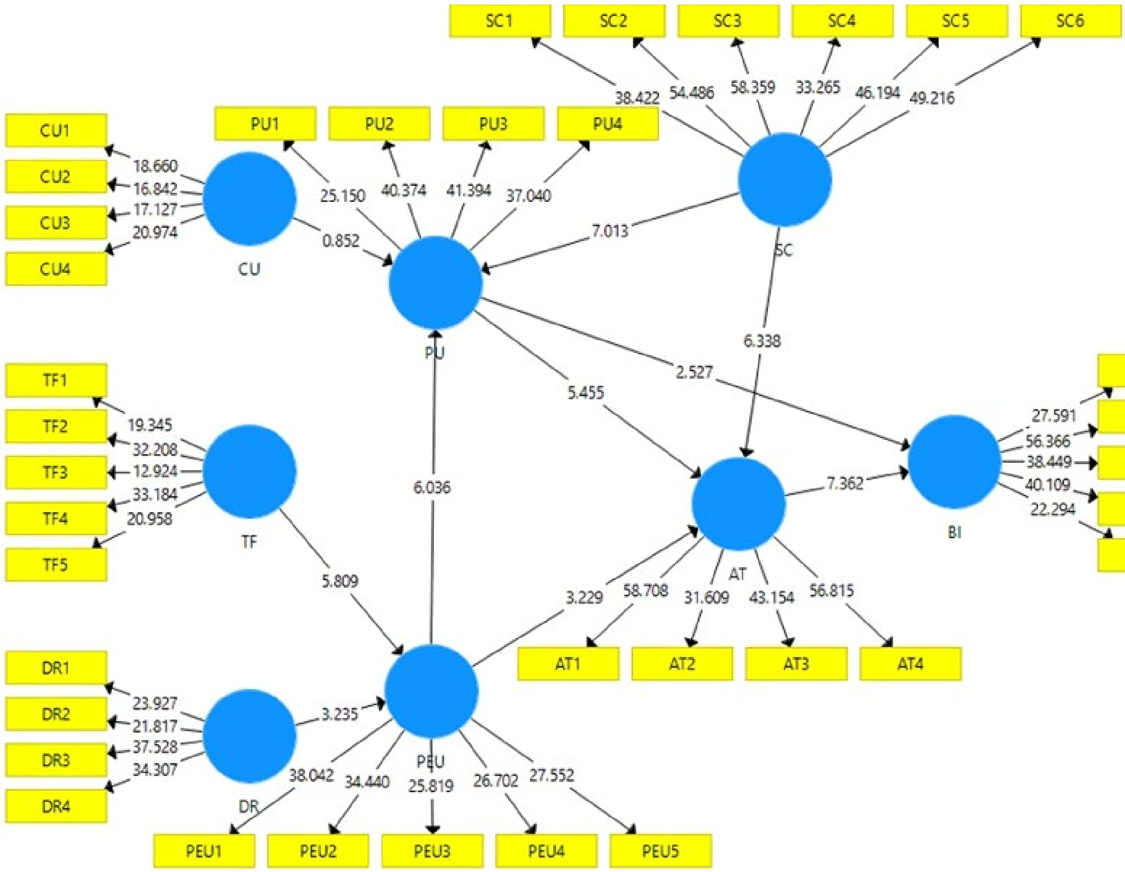

Figure 4. Final model (The authors' own work)

Structural Model Relationship

We performed bootstrapping with a sample size of 5,000 to determine the significance of the relationships between the independent and dependent variables. The results indicated that, at a 5% significance level, all relationships in the structural model were significant, except for the relationship between CU and PU

In terms of digital literacy, the results indicate that TF ($\beta = 0.410$; $p < 0.01$) and DR ($\beta = 0.257$; $p < 0.01$) are significant predictors of PEOU, thereby providing statistical support for **H2** and **H3**. However, CU does not significantly predict PU ($\beta = 0.050$; $p > 0.05$), leading to the rejection of **H1**.

Regarding SC, the results show that this external factor has a significant impact on PU ($\beta = 0.478$; $p < 0.01$) and AT ($\beta = 0.367$; $p < 0.01$), providing statistical support for **H7** and **H8**. Additionally, PEOU significantly influences both PU ($\beta = 0.396$; $p < 0.01$) and AT ($\beta = 0.200$; $p < 0.001$), confirming support for **H4** and **H5**.

PU has a significant effect on AT ($\beta = 0.365$; $p < 0.001$) and BI ($\beta = 0.221$; $p < 0.05$), supporting **H6** and **H9**. Additionally, the results indicate that AT significantly influences BI ($\beta = 0.597$; $p < 0.001$), confirming support for **H10**. This finding suggests that AT is the strongest predictor of BI. Further details of the bootstrapping results can be found in **Figure 4** and **Table 7**.

Coefficient of Determination

Hair et al. (2016) explain that the model's predictive accuracy can be assessed by examining the R^2, which is calculated as the squared correlation between an endogenous construct and its predicted value. The R^2 value ranges from 0 to 1, with higher values indicating greater predictive accuracy. An R^2 value of 0.75 is considered substantial, 0.50 is moderate, and 0.25 is weak (Hair et al., 2016). According to **Table 8**, only one construct (PEOU = 0.361) falls into the weak category, while the other constructs–PU (0.697), BI (0.613), and AT (0.732)–are categorized as moderate. Therefore, we can conclude that the study data demonstrates a good level of predictive accuracy.

Table 7. Bootstrapping results

Hypothesis		Original sample (O)	Sample mean (M)/β	Standard deviation (SD)	t-statistics (|O/SD|)	p	Decision
H10	AT → BI	0.595	0.597	0.081	7.362	0.000	Supported
H1	CU → PU	0.045	0.050	0.053	0.852	0.394	Not supported
H3	DR → PEOU	0.255	0.257	0.079	3.235	0.001	Supported
H5	PEOU → AT	0.197	0.200	0.061	3.229	0.001	Supported
H4	PEOU → PU	0.394	0.396	0.065	6.036	0.000	Supported
H6	PU → AT	0.365	0.365	0.067	5.455	0.000	Supported
H9	PU → BI	0.221	0.221	0.087	2.527	0.012	Supported
H8	SC → AT	0.370	0.367	0.058	6.338	0.000	Supported
H7	SC → PU	0.482	0.478	0.069	7.013	0.000	Supported
H2	TF → PEOU	0.407	0.410	0.070	5.809	0.000	Supported

Table 8. R^2 values

	R^2	Consideration
PU	0.687	Moderate
PEOU	0.361	Weak
BI	0.613	Moderate
AT	0.732	Moderate

Table 9. f^2 values

	Original f^2	Effect
AT → BI	0.326	Medium
CU → PU	0.006	No Effect
DR → PEOU	0.062	Small
PEOU → AT	0.056	Small
PEOU → PU	0.225	Medium
PU → AT	0.157	Medium
PU → BI	0.045	Small
SC → AT	0.183	Medium
SC → PU	0.361	Large
TF → PEOU	0.157	Medium

The f^2 was assessed to determine the impact of an exogenous variable on an endogenous variable. It examines how the R^2 value changes when a specific exogenous variable is removed from the model, effectively measuring the real impact of that variable on the endogenous construct. Hair et al. (2016) classifies f^2s as small (0.02), medium (0.15), and large (0.35). According to **Table 9**, all exogenous variables demonstrate an f^2 on the endogenous variables, except for the relationship between CU and PU. In addition, there is one exogenous variable (SC) that has a large effect on an endogenous variable (PU), while the others (DR → PEOU, PEOU → AT, and PU → BI) and (AT → BI, PEOU → PU, PU → AT, SC → AT, and TF → PEOU) have small and medium f^2, respectively.

Predictive Relevance

In the final stage, we assessed the model's Q^2 by examining the Q^2 values. According to Hair et al. (2016), a model demonstrates Q^2 when its Q^2 values are greater than 0, indicating that it can accurately predict the indicators of the constructs. The levels of Q^2 are categorized as small (0.02), medium (0.15), and large (0.35). We used a blindfolding procedure to calculate the Q^2 values. As shown in **Table 10**, all Q^2 values are above 0, with most demonstrating large Q^2. Therefore, we can conclude that the model exhibits strong Q^2 for all endogenous variables.

DISCUSSION

The main aim of this study was to examine the role of digital literacy and SC in predicting university students continued use of web-based video conferencing in learning mathematics in the post-COVID-19 era. To achieve this goal, first, we adapted and developed survey items from previous related research; ZOOM and TAM (Alfadda & Mahdi, 2021), digital literacy (List et al., 2020), and SC (Smith & Sivo, 2012). After the

Table 10. Results of predictive relevance

	Q^2	Predictive relevance
AT	0.575	Large
BI	0.430	Large
CU	-	-
DR	-	-
PEOU	0.246	Medium
PU	0.494	Large
SC	-	-
TF	-	-

assessment of validity and reliability, forty questionnaire items were valid and reliable for further evaluation. Furthermore, we examined the model reflective indicator loading, internal consistency reliability, convergent and discriminant validity. During this process, three items did not meet the threshold values and were therefore removed. Consequently, the structural model assessment included 37 items. The study's findings indicate that the proposed model is valid for explaining university students' continued use of web-based video conferencing in the post-COVID-19 era. Moreover, digital literacy and SC, as external factors within the TAM framework, significantly contributed to the model's effectiveness. Based on these results, several important points need to be discussed.

First, two constructs of digital literacy, namely TF and DR, significantly affected PEOU. DR has been studied in various fields, such as in a second or foreign language (Reiber-Kuijpers et al., 2021), the relationship between social media use and DR (Chen et al., 2021b), the effect of metacognitive summary strategies and attitude toward technology on DR. The present study's finding enhances the literature in terms of confirming that DR significantly affects PEOU of web-based video conferencing for learning mathematics. It indicates that it is necessary to increase DR literacy in order to enhance students' engagement in using video conferencing in learning mathematics. Additionally, the TF conception of digital literacy aligns with the construct of digital propensity, which highlights that digital literacy stems from both access to and the use of technology (Thompson, 2013). The present study's findings indicate that access to and use of technology is critical for students to engage well with mathematics through web-based video conferencing.

Second, SC significantly affected PU and attitude toward using video conferring in the learning of mathematics. SC has been seen as a significant factor in users continued use of online learning platforms. For instance, Smith and Sivo (2012) The findings confirm that SC significantly influences an extended TAM in the context of teachers' ongoing use of e-learning for professional development. This indicates that fostering a sense of connection and interaction among users enhances teachers' acceptance and continued engagement with e-learning platforms for their professional growth. In addition, they also show a significant relationship between performance in e-learning and SC. The present study adds to the literature by revealing the significant effect of SC on the TAM model in the context of using web-based video conferencing for learning mathematics.

Third, PEOU significantly affects PU and attitude. A strong relationship between those factors has been well studied and reported in the literature. In the context of web-based conferencing such Zoom. Alfadda and Mahdi (2021) have reported a strong positive correlation between PU and their attitude toward using Zoom in a language course. We believe that the presence strengthens the view that PEOU and PU of a digital tool is very critical to ensure users have a positive attitude toward their adoption of technology in all contexts, including in the context of learning mathematics.

Fourth, BI was significantly influenced by attitude and PU. BI has been examined in many studies in order to understand users' continued use of a new technology. In the context of e-learning, previous studies have shown a significant correlation between BI and attitude (Hussein, 2017; Mailizar et al., 2021a; Teo et al., 2017) and a relationship between BI and PU (Fathema et al., 2015; Mailizar et al., 2021b). In the context of using video conferencing, the present study contributes to the literature by showing that AT is the most significant predictor of understanding university students' continued use of video conferencing in the learning of mathematics. In the context of using zoom for teaching and learning purposes, the findings in the present study support Alfadda and Mahdi's (2021) study, showing a strong positive impact of students' attitudes on BI.

Finally, as discussed previously, there is currently a lack of studies examining the effect of digital literacy and SC on university students' continued use of web-based learning for learning mathematics. Therefore, the present study fills this gap by revealing that the proposed model is valid and digital literacy and SC play a significant role in the model. To ensure the continued use of web-based video conferencing for learning mathematics in higher education, it is necessary to consider students' digital literacy and SC on the online platform.

CONCLUDING REMARKS AND FUTURE WORK

The present study has examined a model to understand university students continued use of web-based video conferencing for learning mathematics. We added digital literacy and SC as two external variables in the proposed model. The findings of the study suggest that the proposed digital literacy and SC are valid, reliable, and significant to predict university students continued use of video conferencing for learning mathematics in the post-COVID-19 era. This finding indicates that when students have sufficient digital literacy and web-based video conferencing accommodates SC, university students will likely fully engage in learning.

This study has methodological limitations. First, we only collected samples from six universities in Indonesia. As Indonesia is a big and diverse country, our study would be much more rigorous if we were to incorporate several universities from the eastern part of Indonesia in this study. As this study shows the significant role of digital literacy and SC on students continued use of web-based conferencing for learning mathematics in the post-COVID-19 era, we suggest a future study on the design of a model of web-based video conferencing classroom that fully incorporates SC through interactive features such as virtual breakout rooms, online group discussion, and collaborative whiteboards.

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Declaration of interest: The authors declare no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

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