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Factors Affecting the Use of Digital Mathematics Textbooks in Indonesia

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Abstract: Digital mathematics textbooks differ from traditional printed textbooks in, among other things, their dynamic structural elements, representing a potential that traditional textbooks cannot fulfil. Notably, dynamic structural elements, i.e., multimodal representations of mathematics, could be of particular importance for learning, which is why the scientific interest in digital mathematics textbooks has increased in recent years and many digital textbooks have been developed. However, research related to predicting teacher usage behavior of digital textbooks is still limited. Therefore, this research aims to analyze the predictors that may influence the intentions of mathematics teachers and the actual usage of digital textbooks by applying the Unified Theory of Acceptance and Use of Technology (UTAUT). Data were collected from 277 teachers in West Java Province, Indonesia, and analyzed using structural equation modeling (SEM). The results indicated that Performance Expectancy (PE) is the biggest significant factor, followed by Social Influence (SI), that influences the Behavioral Intention (BI) of mathematics teachers to use digital textbooks in Indonesia. Effort Expectancy (EE) does not affect the intention to use a digital textbook. In turn, BI has the largest and most significant effect on teachers' actual usage of digital textbooks. This result contributes to the understanding of the predictors that can increase the use of digital textbooks by mathematics teachers.

Keywords: UTAUT model; digital textbook; technology adoption; mathematics teacher; future education

MSC: 97U20

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1. Introduction

The rapid development of technology in the 21st century has led to the change of textbooks from paper-based to digital forms [1,2]. The OECD [3] defines digital textbooks as digital versions of paper-based books accessible on electronic platforms and mobile devices. Based on data released by Amazon, sales of digital textbooks now exceed those of printed books [4,5]. The popularity of smartphones, tablet PCs, and other digital devices has changed the perception of digital textbooks as effective learning media [5–7]. Interactive digital textbooks have more features which are usable by teachers in the classroom or by students at home [8,9]. Both parties can use digital textbooks to preview lessons, and as such, learning activities can be student-centered [10,11]. Additionally, after class, students can also use digital textbooks to review lessons [12]. Finally, digital textbooks can also facilitate interactive and adaptive learning [13].

Digital textbooks significantly affect education and provide new experiences for teachers and students [14–16]. Research associated with this topic became far more widespread in early 2010 [17]. Furthermore, many countries have initiated programs to analyze the effect of using digital textbooks on students' abilities [18–21].

The development of digital textbook creation software coupled with the increase in the quantity of related research indicates that the world of education is now focusing on the usage of such resources [22,23]. In 2019, the International Conference of Mathematics Textbooks in Germany focused on the development of digital textbooks [1]. The themes raised at the International Conference on Mathematics Textbook Research and Development (ICMT) included the development of digital textbooks, their influence on students' abilities, as well as evaluations on the use of such media. In Indonesia, the use of digital mathematics textbooks has led to a large body of research on their importance in mathematics lessons [24,25]. The purpose of developing digital mathematics textbooks is mostly focused on improving mathematical literacy, high order thinking skills (HOTS), and alternative learning resources for the 21st century. Amalia et al. [26] and Kusumadewi et al. [27] developed digital mathematics textbooks to support mathematics learning during the coronavirus pandemic. However, information on the determinants that influence mathematics teachers in Indonesia to use digital mathematics textbooks is still limited. Adequate information regarding the determinants of BI and the usage of the digital mathematics textbooks by mathematics teachers would help decision-makers at the school and local government levels to increase intention of usage by teachers.

A great deal of research has been conducted on the adoption and acceptance of digital mathematics textbooks among students [2,10,28–33]. The fact that most of the predictors which influence teachers' intention and actual usage of these resources remain unknown, specifically regarding mathematics education, motivated the present research.

This research aims to determine and analyze the predictors with the greatest significant effect on teachers' intention and actual use of digital mathematics textbooks. The unified theory of acceptance and use of technology (UTAUT) [34] is used as a theoretical basis to identify relevant factors.

The remaining sections of this paper are organized as follows. Section 2 presents the theoretical background, model, and initial hypotheses. Section 3 includes an analysis of respondent information, and sampling steps and data processing methods are presented. In Section 4, a data analysis and results are reported, while the last section presents the conclusions.

2. Literature Review

The literature review is divided into three main parts. The first part highlights the benefits and directions of digital textbooks in the world of education in the future. In part two, an explanation of the advantages of the UTAUT model compared to other models to measure the behavioral intentions and usage behavior of mathematics teachers relative to digital textbooks is explained. The last part provides explanations of the proposed model and of each hypothesis in this study.

2.1. Digital Textbooks in Future Mathematics Education

According to the summary by Rezat and Pepin [35], the opportunities for multimodal representations of mathematics, interactive elements, and opportunities for communication and collaboration are central elements of digital curricula resources. Although interactive elements and opportunities for communication and collaboration may be central elements of digital textbooks in general, opportunities for multimodal representations are specific to mathematics content. Following Klein and Kirkpatrick [36], multimodal representations of mathematics mean that problems or issues are represented as text, mathematical equations, and graphs. As such, multimodal representations in digital mathematics textbooks could provide opportunities which are beyond the abilities of printed textbooks.

Bringing technology into the classroom has a positive impact on the quality of education [37–40]. Most teachers and students agree with the benefits of using digital mathematics textbooks [26,41]. The goal of developing such textbooks is to simplify and enhance the overall learning experience, making mathematics teaching and learning activities more interesting and efficient [5,8].

In future education with digital resources, students will not be passive, i.e., merely listening to the teacher explain material, but rather, can actively participate in teaching and learning activities [42]. This student-centered learning process has been proven to positively affect students' perspectives on mathematics lessons [29]. With a digital textbook, one device contains the syllabus for a semester or a year. Of course, digital textbooks can be used at all levels of education, from kindergartens to universities [43].

Effective teaching and learning activities must ensure that students are active in the teaching and learning process [42,44,45]. Digital mathematics textbooks will bring about educational reforms which can help students learn more effectively [8,46]. Below are some of the benefits of digital textbooks in future education.

2.1.1. Study Anywhere and Any Time

Digital textbooks are easy to carry compared to bags full of text books [47]. Most students currently have their own mobile devices, be it smart phones, tablets or laptops; commonly, they are more proficient in using this technology than their parents [48]. With the portability of digital textbooks, students can take notes and open digital textbooks anywhere they want.

2.1.2. Multiple Interactive Features

Digital mathematics textbooks are not just plain reading materials; rather, they are equipped with many features that can help students to write notes and highlight important information [49,50]. Such textbooks are equipped with annotations, pen tools, page zoom, search options, read aloud and many other features [51]. As such, they can be widely used to help students with special needs. Search tools are one of my favorite features because they can be used to quickly locate specific information. Bookmarks and chapters are also available, and are very helpful [52,53]. Online dictionaries can help students to find the meaning of new terms. In addition, students can change the font size and style and adjust the brightness of the device screen. In the end, a digital textbook is an all-in-one learning resource that can provide students with a whole new learning experience. According to Weinhandl et al. [54], it is precisely such a single-source learning environment that could facilitate the learning of mathematics.

2.1.3. Edutainment Value in Digital Mathematics Textbooks

Methods for the modification of course content in digital textbooks are currently still being developed. In future, music, animation, video, micro-lectures and audio explanations will likely be included in learning modules [16,22]. Micro-lecture videos have been proven to improve students' mathematical abilities and make learning more interesting [55,56]. Students can pause and rewind the video lecture when they do not understand something. Watching micro-lecture videos when learning new knowledge aids in terms of information retention, and may be better than students just reading and listening to a teacher's explanation [57]. Many publishers are now focusing on inserting videos into digital textbooks to make students engage more in course material. Furthermore, animations can be fun and entertaining, and may further increase retention. In the end, video micro-lectures and animations add entertainment value which is informative. This can improve students' abilities to learn new knowledge and recollect information.

2.1.4. Augmented Reality and Virtual Reality

Augmented reality and virtual reality are transforming the learning space at an incremental pace [58–60]. Bringing augmented reality and virtual reality experiences to digital mathematics textbooks provides students with an immersive learning experience [17]. Such technology can transform normal images into 3D images, whereby students can see shapes from all angles [5,61]. A 3D view can provide students with a compelling learning experience, e.g., in geometry lessons [62]. Sometimes teachers find it difficult to use dynamic mathematics software to explain geometric shapes [63].

2.1.5. Reducing the Cost of Printed Books

In the current era of education and in the future, technological developments will make paper-based materials obsolete [64]. This will have a positive impact on the environment, as millions of trees are cut down every year to produce books. In addition, the carbon footprint will be reduced. Additionally, not having to buy printed books every semester and every year will allow students to save money [3,65].

2.1.6. Interactive Assessments

Digital mathematics textbooks include self-assessments for students to test their knowledge [5,66]. As such, teachers will no longer need to do quizzes on each chapter. In addition, assessments in digital mathematics textbooks can provide instant results, so that after taking the test, students will immediately know the result [53,67]. According to Weinhandl et al. [68], the instant feedback provided by digital approaches could be particularly helpful for students. Additionally, teachers can also view and analyze test results and provide immediate feedback.

In the end, digital mathematics textbooks can optimize teaching and learning activities and make learning activities more fun and engaging. Students do not need to sit quietly listening to teachers' explanations for hours. Digital mathematics textbooks can make students proactive in terms of interacting with course material. These advantages have the potential to increase the academic performance of students.

2.2. Taking UTAUT into a Digital Mathematics Textbook Context

A hypothesis was developed based on a strong foundation derived from contemporary research. The UTAUT model was used to achieve certain objectives based on empirical tests involving a sample of mathematics teachers in West Java Province, Indonesia. This research analyzes the teacher intentions and the actual use of digital textbooks in mathematics lessons at the Junior High School level.

Several researchers have used the technology acceptance (TAM) [44,69,70], the unified theory of acceptance and use of technology (UTAUT) models [69,71,72]. TAM was developed in 1989, while UTAUT was introduced in 2003 by Venkatesh et al. [34]. The TAM model is used to measure a user's attitude toward technology. This model consists of four factors, namely: performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC). It has been used by many researchers to measure user acceptance of technology in the field of education, with the main respondents being teachers. Conversely, UTAUT was designed based on eight theories, namely: the theory of reasoned action (TRA), TAM, the motivation model (MM), the theory of planned behavior (TPB), combined TAM and TPB (C-TAM-TPB), the model of PC utilization (MPCU), innovation diffusion theory (IDT), and social cognitive theory (SCT). The combination of these theories allows UTAUT to explain up to 70% of the variance in user intentions regarding technology, while TAM can only explain up to 40% [34]. Based on a review conducted from 2010 to 2020, the UTAUT model is becoming more popular and widely used to analyze technology acceptance and adoption. The present research adopted the UTAUT model to measure teacher behavioral intentions (BI) and the actual use of digital textbooks for teaching mathematics.

2.3. The Proposed Model and Hypothesis

The UTAUT model is used to analyze behavioral intention (BI) and use behavior (UB) among teachers regarding digital textbooks. The predictors studied as determinants of BI are PE, SI, EE, and FC. BI and FC are then studied as determinants of UB. Previous preliminary research used only a subset of the UTAUT model, and moderators were frequently dropped because there were no differences in the adoption and use of technology [73,74].

According to Moore and Benbasat [75], there was no effect on user intention regarding the use of technology in terms of education, moderators' gender, age, and experience, indicating that no further exploration of these parameters was needed. Figure 1 shows a research model that explains teachers' intention and technology usage regarding digital textbooks in mathematics lessons.

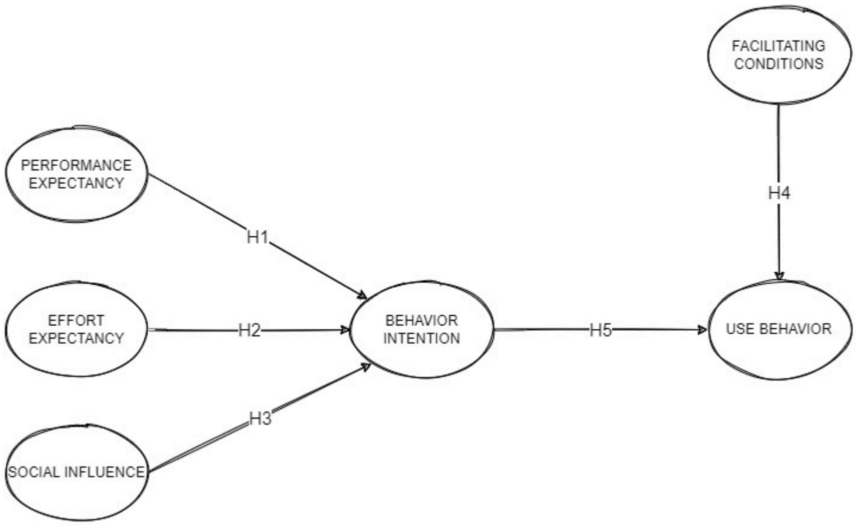

Figure 1. Conceptualized UTAUT model.

2.4. Performance Expectancy (PE)

PE is the degree to which a person believes that technology can help them improve their work abilities [34]. This definition is used to determine how mathematics teachers think digital textbooks can enhance their teaching performance and effectiveness.

H1. *PE will influence BI to use digital mathematics textbooks.*.

2.5. Effort Expectancy (EE)

EE quantifies the level of user convenience associated with the use of technology [34]. A large amount of research has shown that EE influences teachers' intention to use technology [76–78]. In this research, EE represents mathematics teachers' opinions regarding the ease of use of digital textbooks; the higher the ease of use of technology by mathematics teachers, the greater their intention to use digital textbooks. This led to the following hypothesis:

H2. *EE influences BI to use digital mathematics textbooks.*

2.6. Social Influence (SI)

SI is the degree to which a person believes in the use of technology, represented as normal subjective in Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), and Theory of Planned Behaviour (TPB) [34]. Existing research by Shiferaw [79] and Timothy [76] found an insignificant effect of SI on BI, while works by Koshiba [80], Wijaya [81], and Shah [82] showed the opposite. In this research, SI relates to mathematics teachers' beliefs regarding the importance of using digital textbooks to teach mathematics by coworkers, principals, and students. This led to the following hypotheses:

H3. *SI influences BI to use digital mathematics textbooks.*

2.7. Facilities Condition (FC)

FC is the degree to which a person believes that an organization and its associated technical infrastructure support the use of technology [34]. In the original version of UTAUT, FC is only a driving force for someone's intention to use technology, while in the revised version, namely UTAUT 2, it is considered to potentially influence BI [83].

Previous empirical research stated that FC has a significant effect on teachers' intention to use technology [77,78,81,82]. According to those authors, it is the second most important predictor after PE. Additionally, a considerable body of research showed that FC has a direct effect on actual technology usage [82,84,85]. Therefore, the following hypothesis was proposed:

H4. *FC affects UB to use digital mathematics textbooks.*

2.8. Behavioral Intention (BI)

BI is defined as the factor that has the most significant influence on technology usage [34], as proven in previous research in the field of education [78]. This led to the following hypothesis:

H5. *BI influences UB to use digital mathematics textbooks.*

3. Research Methodology

This quantitative research examined teachers' intention to use technology with data collected through a questionnaire-based survey. According to Tondeur et al. [86], such a quantitative method is suitable for determining teachers' BI to adopt the technology.

3.1. Participants

A convenient sampling technique was used to find respondents comprising mathematics teachers in West Java who would volunteer to participate in the "*kampus mengajar*" (teaching campus) program. "*Sekolah Penggerak*" (Moving schools) is a program developed by the Indonesian government to help improve the quality of education in each province through the use of digital textbooks. Data were collected by distributing questionnaires through this province's head of the "*Sekolah Penggerak*" program. From a total of 350 distributed questionnaires, 277 were declared valid and used for further analysis. Table 1 shows the demographic profiles of respondents, comprising 68 males and 209 females. Among participants 63.9% and 36.1% were working in public and private schools, and 46.21%, 41.88%, and 33% had basic, good and excellent technology skills, respectively.

Table 1. Demographic data of participants.

Demographic		Total	Percentage
Gender	Male	68	24.55%
	female	209	75.45%
Age	20–25	143	51.62%
	26–30	33	11.92%
	31–35	42	15.16%
	35 above	59	21.30%
Education	Public	177	63.90%
	Private	100	36.10%
Education Level	Junior High School	185	66.79%
	Senior High School	92	33.21%
The ability to use technology to teach	Basic	128	46.21%
	good	116	41.88%
	excellent	33	11.91%

3.2. Measurement Instrument

Numerous research initiatives have developed and validated instruments regarding ICT acceptance [34,87]. However, in this research, questionnaire items were adopted from the existing validated instrument in the ICT acceptance literature to represent each construct, although the wording was modified to fit the relevant context. Table 2 shows the sources of the 16-item questionnaire comprising a five-point Likert scale from 1 strongly disagree to 5 strongly agree. The original English questionnaire items were translated into Indonesian and verified by other authors.

Table 2. UTAUT questionnaire to assess teachers' intention and usage of mathematics digital textbook.

	Questionnaire Constructs and Items	Sources
	Performance expectancy (PE)	[32,34]
1	I feel that teaching using a digital mathematics textbook is more effective.	
2	Teaching using digital mathematics textbooks is more productive.	
3	I find it easy to master the use of digital mathematics textbooks to teach.	
4	Using a digital mathematics textbook will increase my chances of getting promoted.	
	Effort expectancy (EE)	[32,34]
1	Learning to use a digital mathematics textbook is easy for me.	
2	I can easily use a digital mathematics textbook to teach.	
	Social Influences (SI)	[32,34]
1	Other teachers think that I should use a digital mathematics textbook to teach.	
2	My students think I should use a digital mathematics textbook to teach.	
	Facilitating condition (FC)	[32,66]
1	I use a laptop connected to a projector to teach digital mathematics textbooks in class.	
2	Digital mathematics textbook enables the use of the tablet, cellphone, and computer to teach.	
3	I get help from other people when I have difficulty using the digital mathematics textbook.	
	Intention to use/behavioral intension (BI)	[34,66]
1	I plan to use the digital mathematics textbook to teach in the future.	
2	I will recommend digital mathematics textbooks to my friends.	
	Use behavior (UB)	[34]
1	I use a digital mathematics textbook to teach mathematics.	
2	Digital mathematics textbook has become part of my teaching strategy.	
3	I use many digital mathematics textbooks in math lessons.	

3.3. Data Collection Procedure

The distributed questionnaires provided information on the research purpose, and all responses were confidential. All mathematics teachers were allowed to participate voluntarily without any form of obligation or coercion. They were expected to be able to fill out each item of the questionnaire honestly and correctly according to their perception of the use of digital textbooks, and could ask questions when needed to provide accurate answers. This data collection lasted for 6 weeks, i.e., from January to February 2022.

3.4. Data Analysis

SPSS and AMOS software were used for data processing and hypothesis testing of the full structural model. These applications have been widely used in previous research to analyze BI to use technology [82,88,89]. In the first stage, an analysis of the validity and reliability of the measurement scale was conducted using confirmatory factor analysis (CFA). The second step used SPSS to determine descriptive statistics and perform a correlation analysis. Multivariate normality checking using AMOS software was also used to determine the skewness and kurtosis of each variable. Finally, for hypothesis testing between variables, SEM was run using AMOS with maximum likelihood as the method for estimating the parameters.

According to Kline [90], the sample required for structural equation models should not be less than 200 respondents. The number of respondents in the present research was 277 teachers.

3.5. Ethical Considerations

All ethical considerations needed for data collection, analyses, findings, and providing suggestions based on these findings were determined. Prior permission was requested from the head of the "*Sekolah Penggerak*" as well as the respondents to use the questionnaire data for research purposes on the condition of strict confidentiality. Participants took part voluntarily without pressure while filling out the questionnaire.

4. Data Analysis and Results

The results and discussion section is divided into three parts, namely: a descriptive analysis, measurements, and structural models.

4.1. Descriptive Statistics

Table 3 shows the descriptive statistics of the construct with the average value ranging from 4.07 to 4.31 on a 1–5 point scale. A limit value of kurtosis and skewness of ∣2.3∣ was used to determine whether the data was normally or abnormally distributed [91]. Based on the results, the kurtosis and skewness values were found to be within acceptable limits, and the data were normally distributed. Therefore, it was appropriate to use SEM to analyze the associations between the constructs.

Table 3. Descriptive statistics of construct model.

	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Mean PE	277	4.28	0.51	−0.15	0.14	−0.52	0.29
Mean EE	277	4.31	0.50	0.33	0.14	−1.28	0.29
Mean FC	277	4.27	0.55	0.07	0.14	−0.79	0.29
Mean BI	277	4.07	0.50	0.18	0.14	−0.40	0.29
Mean UB	277	4.31	0.54	0.00	0.14	−0.99	0.29
Mean SI	277	4.24	0.53	0.15	0.14	−0.87	0.29
Valid N (listwise)	277						

4.2. Analysis Measurement Model

Confirmatory factor analysis (CFA) provides evidence that the instrument used has convergent and discriminant validity [92]. Three criteria were used to determine the convergent validity of all items, namely, Composite reliability (CR), Cronbach's average, and average variance-extracted (AVE) [93,94]. According to Fornell and Larcker [95], all factor loading indicators are significant, assuming they are greater than 0.5. In this research, all scale items were more than 0.7 (Table 4), and the composite reliabilities for all items were in the range of 0.814 to 0.967, which exceeded the minimum criteria (0.5). Furthermore, the AVE values for all constructs were above the threshold value of 0.50. In conclusion, all constructs met the three conditions of convergent validity.

Table 4. Full model validity instrument test results. Note: *** $p < 0.001$.

Variable	Indicator	Standardized Loading (>0.70)	R^2 (>0.50)	C.R	*p*	Criteria
Performance Expectancy (PE)	PE1	0.725	0.573	0.910	***	Valid
	PE2	0.776	0.551		***	Valid
	PE3	0.761	0.602		***	Valid
	PE4	0.794	0.714		***	Valid
Efforts Expectancy (EE)	EF1	0.781	0.610	0.889	***	Valid
	EF2	0.760	0.578		***	Valid
Social Influences (SI)	SI1	0.920	0.922	0.967	***	Valid
	SI2	0.919	0.906		***	Valid
Facilitating Conditions (FC)	FC1	0.727	0.529	0.814	***	Valid
	FC2	0.722	0.587		***	Valid
	FC3	0.773	0.528		***	Valid
Behavioral Intentions (BI)	BI1	0.763	0.582	0.896	***	Valid
	BI2	0.858	0.736		***	Valid
Use Behaviour (UB)	UB1	0.874	0.764	0.867	***	Valid
	UB2	0.793	0.629		***	Valid
	UB3	0.727	0.529		***	Valid

Discriminant Validity

Discriminant validity is defined as the extent to which a construct is completely different from another based on empirical standards [96]. This research measured it using the Fornell-Larker criterion [95], while validity was measured by comparing the AVE value in each latent construct, which must be greater than the squared correlation between these constructs. In Table 5, all bolded loadings in the diagonal dimension are larger than those in the vertical. This proves that the applied model fulfilled Fornell and Larcker's criteria [95] and indicates that discriminant validity was met.

Table 5. Interconstruct correlations and discriminant validity (Fornell–Larcker Criterion [95]). Note: The items on the diagonal on bold represent the square roots of the AVE.

	FC	SI	EE	PE	BI	UB
FC	**0.171**					
SI	0.014	**0.306**				
EE	0.027	0.217	**0.216**			
PE	0.024	0.194	0.168	**0.190**		
BI	0.022	0.215	0.182	0.181	**0.244**	
UB	0.043	0.224	0.192	0.188	0.233	**0.250**

5. Analysis Structural Model

After completing the validity and reliability tests, the next step was to analyze the structural model [79]. Table 6 shows the results of the degree-of-freedom (CMIN/df), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA) as 1.775, 0.928, 0.899, 0.969 and 0.053, respectively. Doll et al. [97] suggested that the value of GFI and AGFI need to be more than 0.8 for the overall statistics to reveal a moderately acceptable fit model. Therefore, it can be concluded that the results of this research accurately reflected the intentions of mathematics teachers, and the actual usage of digital textbooks was well-fitted. The resulting model produces a suitable index, as shown in Figure 2.

Table 6. Model-fit indices for the model.

Goodness-Fit Indexes	Recommended Value	Result Model	Criteria
Normed Chi-Square (CMIN/df)	$\leq$3.00	1.775	Fit
Probability	$\geq$0.05	0.057	Fit
Goodness-of-fit index (GFI)	$\geq$0.80 *	0.928	Fit
Incremental fit index (IFI)	$\geq$0.90	0.969	Fit
Adjusted goodness-of-fit index (AGFI)	$\geq$0.80	0.899	Fit
Comparative fit index (CFI)	$\geq$0.90	0.969	Fit
Root mean square error of approximation (RMSEA)	$\leq$0.08	0.053	Fit

* GFI $\geq$ 0.8 according to Forza and Filippini [98], as well as Greenspoon and Saklofske [99].

5.1. Hypothesis Test

Initial hypothesis testing was conducted using structural equation modeling (SEM) in the AMOS software because SEM has a multiple regression feature that can test the entire model simultaneously [82]. Table 7 shows the regression weights for each construct as well as the standard error, critical ratio (t-values), and significant level.

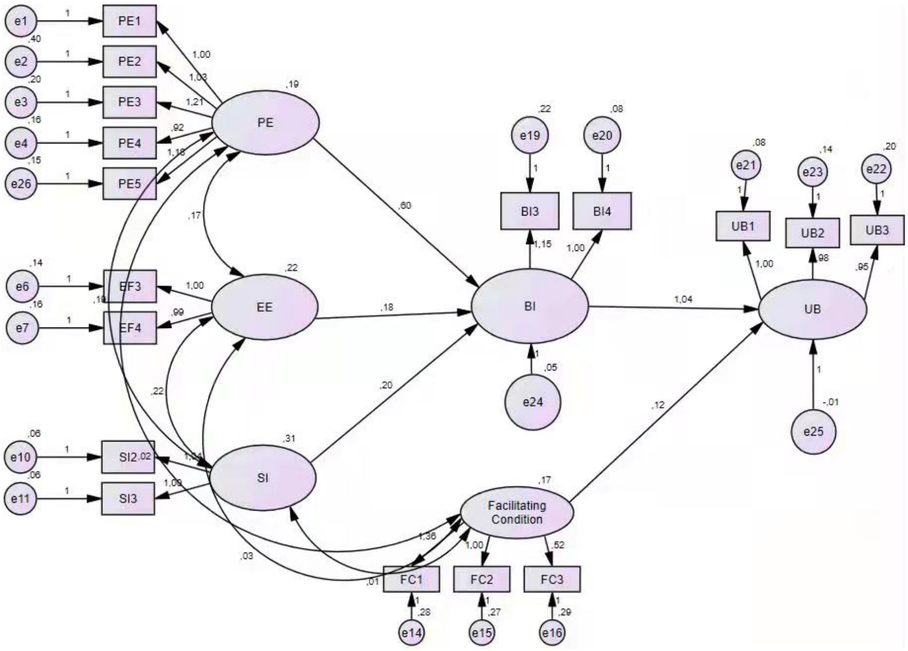

Figure 2. CFA confirmatory factor analysis.

Table 7. Relationships between variables in the SEM model. Note: *** $p < 0.001$.

Hypothesis	Pathway	Estimate (β)	Standard Error	Critical Ratio	p-Value	Comment
H1	PE → BI	0.601	0.124	40.843	***	Sig
H2	EE → BI	0.175	0.124	10.247	0.213	Not Sig
H3	SI → BI	0.197	0.406	20.204	0.028	Sig
H4	BI → UB	10.036	0.056	180.565	***	Sig
H5	FC → UB	0.121	0.049	20.471	0.013	Sig

The hypothesis testing results in Table 7 show that out of five hypotheses, four had a significant relationship while H2 (EE to BI) was insignificant. The results prove that PE and SI influence teachers' intention to use digital textbooks, while BI and FC directly affect UB. Furthermore, as shown in Figure 3 and Table 7, PE most significantly influences BI to use digital textbooks in mathematics lessons.

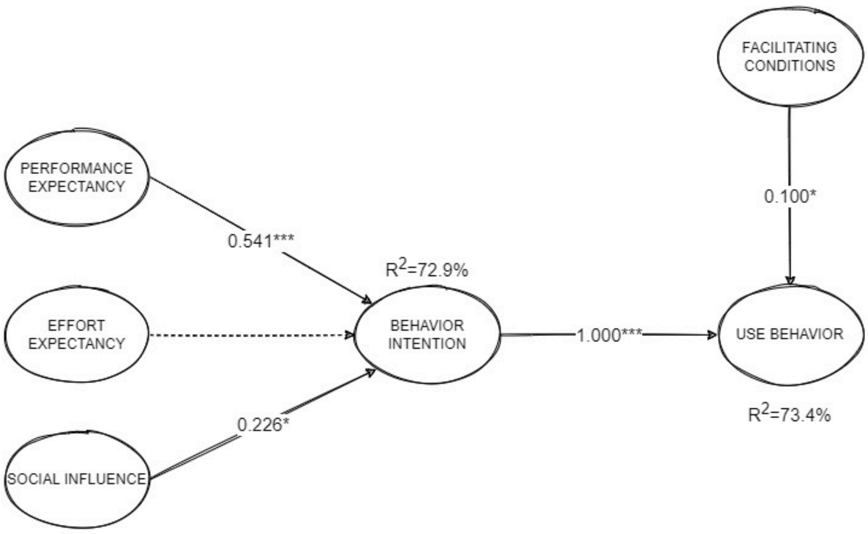

Figure 3. Final model with R variance and total effect. Note: * $p < 0.05$, *** $p < 0.001$.

5.2. Path Analysis

The structural model also contains variance (R^2) values on functions to examine the extent to which dependent variables could be analyzed by independent variables in our research. As shown in Figure 3, the final model in this research indicated that BI comprises 78.2% of the total variance (R^2), explained by three exogenous variables, i.e., PE, SI, and FC, while BI and FC influence 71.5% of the total variance (R^2) in UB. This model therefore showed more than 70% accordance with the [34] UTAUT model.

5.3. Direct, Indirect and Total Effects

This model consists of direct and indirect effects. When the variable does not have an indirect effect, for example, PE to BI, it indicates that it becomes similar to the total effect. Based on Table 8, PE, and SI were identified as predictors of teacher behavior and their intentions to use digital textbooks, as indicated from the significant direct effects of these variables on BI. EE had a fairly good value and insignificant direct effect on BI, while FC and BI acted as predictors of teacher usage behavior.

Table 8. Direct, indirect and total effects for each construct.

Factor	Determinant	Direct Effect	Indirect Effect	Total Effect
Behavioral Intentions (BI) (R^2 = 0.729)	PE	0.541		0.541
	EE	0.169		0.169
	SI	0.226		0.226
Usage Behavior (UB) (R^2 = 0.734)	PE		0.541	0.541
	EE		0.169	0.169
	SI		0.226	0.226
	FC	0.100		0.100
	BI	1.00		1.000

6. Discussions

This research aimed to identify the factors that influence the intention of mathematics teachers to use digital textbooks in West Java, Indonesia, using the UTAUT model. The results from AMOS confirmed the model's consistency and reliability. This research showed that PE, SI, and FC have a significant effect on the intention of teachers (BI) to use digital textbooks. Meanwhile, EE did not significantly influence BI, which was found to be the strongest factor affecting UB. Social influence (SI) was the second most significant factor after PE. According to [33,100], SI does not significantly affect students' intention to use digital textbooks. Conversely, the authors of [73,101] stated that SI has the smallest effect on teachers' intention to use technology. Mathematics teachers often embrace digital textbooks because principals, educators, and students espouse the benefits thereof. The "*Sekolah Penggerak*" and "*kampus mengajar*" programs are intended to improve the quality of teaching and learning activities in the classroom via the integration of technology [102]. Furthermore, the cohesiveness of teachers in schools may be one of the factors that influence their intentions [103].

Performance Expectancy (PE) was found to be the factor with the largest direct effect on mathematics teachers' intention to use digital textbooks. This factor means that mathematics teachers use digital textbooks because they perceive that such materials help them to improve the quality of learning in their classrooms. From the students' point of view at the university level in China, PE was also shown to be the main factor that significantly influenced them regarding the use of digital textbooks [100].

Social influence (SI) is the second most significant factor after PE that affects teachers' intention to use digital textbooks. This result is in contrast to previous studies (e.g., [33,73,100,101]) that reported that SI has the least significant influence on students' and teachers' intention to use technology.

The significance of SI is closely related to the cultural context of the participants in this study. Mathematics teachers in the province are all working at schools that implement the "*Sekolah Penggerak*" and "*kampus mengajar*" programs [102]. Consequently, these teachers are already aware of, and are exposed to, digital textbooks in schools, and therefore, perceive the technology as a tool with which to deliver their daily lessons.

Additionally, the cohesiveness of teachers in schools may be one of the factors that influence their intentions [103]. In the case of the present research, all of these mathematics teachers shared similar organizational backgrounds, that is, they were all teachers of the "*Sekolah Penggerak*" and "*kampus mengajar*" programs, and were surrounded by school principals, coworkers, and students who shared their expectations and supported the use of digital textbooks.

Effort expectancy (EE) did not affect the intention of teachers (BI) to use digital textbooks. The mathematics teachers in this research stated that the ease of use factor was not sufficient to increase their intention to use digital textbooks. However, the performance expectancy and social influence factors were stronger predictors. This is in line with previous findings by Azhar [40], who stated that EE does not affect teachers' BI to use online learning platforms. Other research on teachers' BI to use new technologies also showed that EE does not affect BI [101,104–106]. Mathematics teachers consider the use of online learning platforms difficult, and therefore, it can be concluded that EE does not have a particularly significant influence on BI.

According to previous research [73,107], facilitating conditions (FC) affect the usage of digital mathematics textbooks. Mathematics teachers tend to use digital textbooks when resources and technical support are available. Therefore, schools must motivate teachers by providing everything necessary for their implementation in the classroom, as well as support training. Venkatesh et al. [34] showed that FC affects the actual student usage of technology [4,92,108–110]. In Indonesia, this variable has an insignificant and direct effect on the actual usage of digital textbooks and a significant effect on usage among mathematics teachers. Furthermore, more than 50% of the respondents were teachers under 30 years of age, i.e., Generation Y and Z, and more than 50% stated that they can use technology adequately, as shown in Table 1. This implies that FCs are less important predictors because teachers are proficient with technology and may already know how to use digital textbooks.

Finally, Behavioral intention (BI) was shown to have the largest and most significant effect on teacher usage of digital textbooks [73].

7. Practical Implications and Conclusions

This research has several theoretical and practical implications on digital mathematics textbooks which are currently being developed, allowing governments and institutions to increase digital textbook acceptance and usage. The increased use of digital textbooks by teachers will give rise to a new experience for students learning mathematics, e.g., ensuring they do not feel bored [5]. However, not many countries have used digital textbooks specifically for mathematics. There is still limited research on the use of the UTAUT model to analyze teachers' intention and ICT in future education in developing countries, specifically for examining the use of digital textbooks by mathematics teachers [111]. The UTAUT model adopts eight theories which are capable of providing information about predictors that contribute to the readiness of teachers to adopt and use digital textbooks and other technology-based learning media. Similar to other significant investigations [81,106], this research provides new evidence on the use of the UTAUT model in the context of mathematics education. This study is among the first to assess the behaviors of middle school mathematics teachers in West Java, and could serve as a useful guide for the development, expansion and use of digital textbooks in the future.

The significant impact of PE on BI, and later UB, is consistent with other research, indicating that teachers need to be exposed to various technological applications that will improve their teaching practices and effectiveness. Teachers will be more likely to use these technologies in their classrooms once they see and understand the direct and indirect benefits thereof [47,65].

Although the use of digital textbooks does not guarantee high-quality learning, it does assist students in terms of making learning more personalized to their individual preferences. For example, interactive features in digital textbooks enable students to visualize abstract mathematical concepts that they may be struggling to grasp [48] and to use learning objects repeatedly until they achieve the desired level of understanding [18,47,48].

Digital textbooks also give students more control over the materials they are presented with, such as the ability to change the text size, screen brightness, and diagram size [47]. Additionally, they support students' "just-in-time" learning needs by allowing them to go directly to the needed resources using keyword searches and hyperlink features [18].

Some digital textbooks include assessment tools that enable students to complete and submit activities online. This feature enables teachers to digitally assess and monitor their students' progress, even outside of school hours, and to plan and adjust their teaching objectives accordingly. Furthermore, based on the data analytics provided by the platform that hosts the digital textbooks which were the focus of the present research, teachers can customize and even assign specific intervention activities for low- and high-performing students.

As a result, teacher training, particularly on the technological/pedagogical aspects of digital textbooks, are critical for providing teachers with up-to-date knowledge and skills, as well as encouraging teachers to use these resources to achieve meaningful learning experiences. Furthermore, the government should invest in the development of well-designed digital textbooks with various functions [16,18] to support meaningful and personalized learning, resulting in an improved standard of education in Indonesia.

In conclusion, this research analyzed the factors that influence teacher BI and usage of digital textbooks in West Java, Indonesia, applying the UTAUT model. The results showed that PE, SI, and FC significantly influence the use of digital textbooks through BI mediators. PE and SI play important roles in terms of influencing teachers' usage intentions, as opposed to EE. This may provide important information for understanding the dynamics of the use of digital textbooks in mathematics lessons, and has theoretical and practical implications.

Hence, it is important that teachers are convinced both before using technologies, i.e., that such resources will improve their ability to work, and during their use of such materials, i.e., they are reminded of the benefits thereof. These objectives could be achieved by, among other things, targeted initiatives by policy organizations.

Based on the results of our study, it may also be essential for teachers to have colleagues, principals and students who are convinced of the benefits of the use of such technologies. As such, special attention should be paid to key teachers, such as regional subject group leaders and principals, in attempts to integrate technologies into the teaching of mathematics. If key people are convinced of the benefits of using technologies, this should facilitate the integration of such resources into mathematics classrooms.

8. Limitation and Suggestions for Future Research

Although this research significantly contributes to the mathematics education community, its various limitations create opportunities for further investigation. The findings only focus on teachers' intention and usage of digital mathematics textbooks, and therefore, its application to other contexts must be done with caution.

The present research focused on teacher data to analyze their intention and usage of mathematics digital textbooks to improve students' mathematical abilities and learning interest. Further research could expand the approach applied herein to other fields of knowledge and at other levels, such as tertiary education.

It was found that the difference between an interactive mathematics textbook and a digital one, as well as age, experience, and gender, may affect teachers' intention and usage. Digital textbooks can be used both inside and outside the classroom for online learning, affecting teachers' intention and usage thereof. Future research could consider the differences in their use, such as blended learning in mathematics, which has recently received significant attention.

Although this research used the UTAUT model for analyses, it is imperative to factor in other important variables. Venkatesh et al. [34] suggested the creation of new constructs, the use of attributes, and the merging of all moderating variables, such as gender, age, experience, volunteerism, and various demographic variables, in a new research context. Further research could endeavor to shed new light on digital textbook acceptance. Lastly, more empirical research needs to be conducted to build on the literature.

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