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Teacher's Intentions to Use GeoGebra in Teaching Mathematics: An Empirical Study to Validate Technology Acceptance Model in the Philippines

[a]*Joseph Mangubat, [a]Gesselle Batucan

[a]Danao City Division, Department of Education, Danao City, Cebu 6004 Philippines

*Corresponding author: joseph.mangubat@deped.gov.ph

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Abstract

This study used the Technology Acceptance Model (TAM) to identify factors affecting teachers' behavioral intention to use GeoGebra in teaching mathematics from a developing economy perspective. The present study tested the hypothesized relationships of the subjective norm among the core constructs of TAM. The model was tested using covariance-based structural equation modeling on a sample of 702 secondary mathematics teachers in the Philippines. The model testing revealed suitable fit measures supporting the eight hypothesized paths. The main results suggest that the teachers' attitude towards use has the most significant positive effect on behavioral intention. The research findings validate TAM to explain teachers' behavioral intention to use GeoGebra in teaching secondary school mathematics in a developing country like the Philippines. The implication of this research to policymakers suggests that teacher training programs aiming to enhance the skills in using technology in the classroom should focus on teachers' increasing behavioral intention to use, perceived usefulness, and attitude towards using software such as GeoGebra.

Keywords: *Technology Acceptance Model, Subjective Norm, GeoGebra, Secondary Mathematics Teachers, Structural Equation Modeling*

1. Introduction

The world has experienced rapid technological growth in recent decades, which involves introducing and designing educational software (Singh, 2018). Consequently, various studies have explored the realm of technology-assisted teaching and learning, identifying critical factors for successfully integrating such technology (Akkaya et al., 2011; Reis &

Ozdemir, 2010). Among the educational software examined, GeoGebra has been a focal point of investigation in determining the extent to which its utilization improves students' conceptual knowledge and attitudes toward mathematics (Adegoke, 2016).

Research into GeoGebra's potential as an ICT tool for improving students' mathematical thinking indicates its effectiveness, provided it is integrated appropriately into the teaching of mathematics across all education levels, from primary education (Bulut et al., 2016) to postgraduate studies (Aydos, 2015). Dockendorff and Solar (2018) argued that there is a need to incorporate GeoGebra as an ICT tool and dynamic software in the teaching and learning mathematics. Furthermore, using GeoGebra in teaching mathematics helps arouse students' accomplishment and interest (Wassie & Zergaw, 2019).

GeoGebra is a graphing utility software that helps teach and learn topics in mathematics, such as trigonometry, geometry, calculus, and many more, through graphs and visuals. The integration of GeoGebra software as a tool in Geometry instruction has been linked to improved student grades, enhanced conceptual understanding of mathematics, and advancements in teachers' professional development (Kepceoglu, 2016; Jelatu et al., 2018; Mainali & Key, 2008). Various studies demonstrated that incorporating GeoGebra into Geometry instruction positively impacted students' academic performance (Jelatu et al., 2018; Seloraji & Eu, 2017; Singh, 2018). The authors affirmed that using GeoGebra in teaching and learning Geometry provides students with opportunities to explore concepts in-depth, fostering the development of their knowledge in Geometry. Furthermore, Kepceoglu (2016) found that using GeoGebra provides an alternative approach to teaching Trigonometry, particularly when addressing the periodicity of trigonometric functions.

The author concluded that GeoGebra-assisted mathematics instruction proves more effective than traditional methods, which predominantly involve expositive mathematical instruction. Similarly, during the instruction of linear algebra, Mudaly and Fletcher (2019) observed that integrating GeoGebra aided learners in successfully identifying the properties of straight-line graphs. While existing literature has extensively explored the use of GeoGebra in the mathematics classroom, with specific attention to in-service teachers' acceptance (Venter, 2015) and learners' motivations (Septian & Monariska, 2021), a limited body of research persists in the investigation of factors influencing the acceptance of GeoGebra among teachers.

Although some studies have delved into the broader landscape of technology acceptance (Aman et al., 2020; Belgheis & Kamalludeen, 2018; Chen, 2020; Johar, 2021), there remains a scarcity of research dedicated to comprehensively understanding the specific determinants that shape teachers' intentions to use GeoGebra in the context of teaching mathematics. This shortage prompts the need for an empirical study that validates the Technology Acceptance Model (TAM) within the specific domain of GeoGebra usage among teachers, shedding light on crucial factors influencing their acceptance and intention to integrate this instructional software into their mathematics teaching practices.

This study aimed to determine the teachers' behavioral intentions to use GeoGebra in teaching Mathematics through the lens of the Technology Acceptance Model (TAM) developed by Davis (1989) since GeoGebra is a technological innovation. This study will unfold how subjective norm and teachers' perceptions regarding GeoGebra's perceived usefulness, perceived ease of use, and their attitude towards using it could affect their behavioral intentions of using the software in teaching mathematics.

2. Research Model and Hypothesis Development

According to the proposed model, as indicated in Fig. 1, a teacher's intentions to use GeoGebra in teaching mathematics could be predicted and explained by his or her subjective perception of the software's usefulness and ease of use, in conjunction with the subjective norm and his or her affective evaluation of using the software.

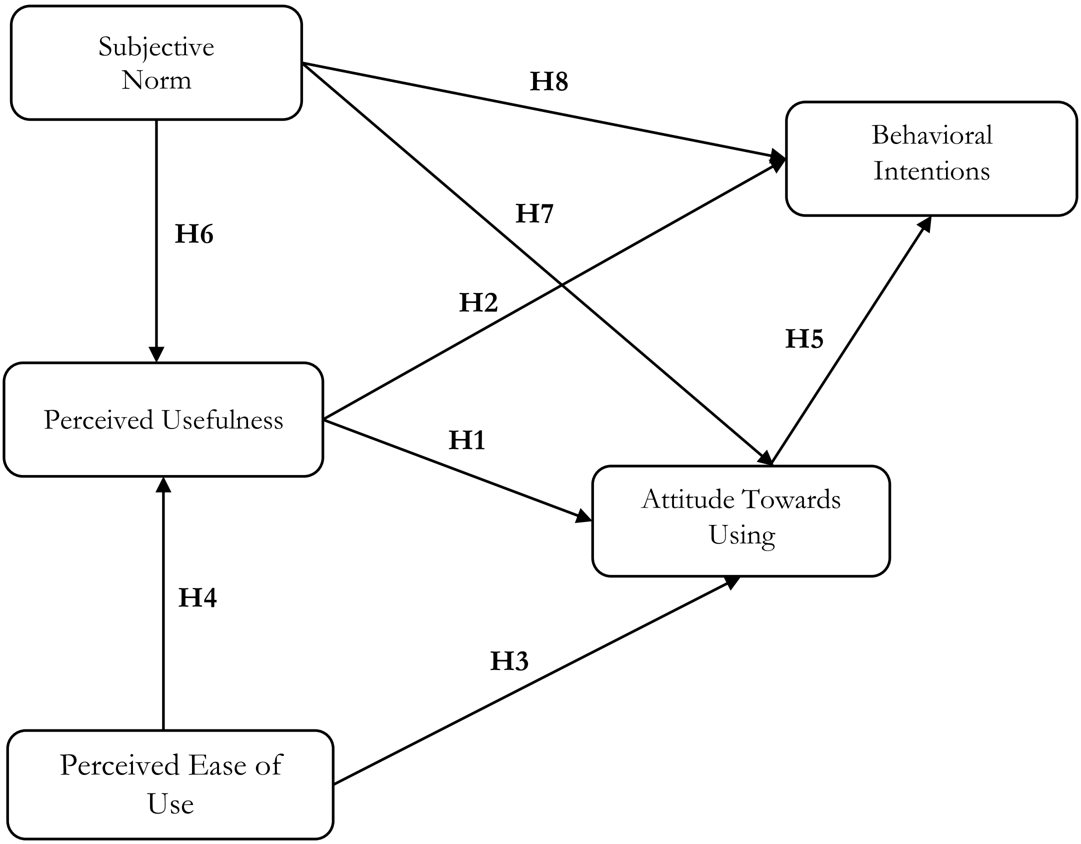

FIG 1. Conceptual Framework

2.1. Perceived Usefulness

Perceived Usefulness measures the degree to which an individual believes a system is up to the performance of a task (Davis, 1989). Hence, Akman and Turhan (2017) indicate that if the user believes that the system helps learn a particular topic, he/she tends to have a more positive attitude toward using the system. His/her intention to use the system will increase. It means that as the perceived level of usefulness increases, the user's plan to use the system also increases. Teo (2011) also indicates that it is clear that when teachers perceive technology to be helpful and that using technology would increase their productivity, their intention to use it will significantly increase.

Moreover, the research results of Sánchez-Mena et al. (2019) suggest that perceived usefulness is the primary antecedent of higher education teachers' attitude towards educational video games; this is, the higher the teachers' perceptions of technology to be useful for their teaching, the better the attitude towards it. Within our conceptual framework, the perceived usefulness of using the dynamic mathematics software GeoGebra in teaching mathematics can influence teachers' attitudes toward using the software in actual classroom teaching. Furthermore, Bingtan et al. (2022) argued that the relationship between perceived usefulness and attitude towards use had enjoyed empirical solid support in existing studies on individual adoption of an innovation. Thus, it hypothesized that:

H1: Perceived Usefulness significantly influences attitude toward using the software.

H2: Perceived Usefulness has a significant influence on behavioral intentions.

2.2. Perceived Ease of Use

Perceived Ease of Use is the degree to which a person believes that using a particular system would be free from effort (Davis, 1989). Davis (1989) states that perceived ease of use influences perceived usefulness because a system's simplicity can improve results. Technology is perceived as being more valuable if it is easier to use. In light of this, TAM posits that perceived ease of use positively affects perceived usefulness. Moreover, analysis of previous studies also revealed that if computer technology is regarded as easy to use, it would be perceived as more useful (Szymkowiak et al., 2005; Tahar et al., 2020). Boateng et al. (2016) also showed that perceived ease of use directly influences perceived usefulness and attitude toward the behavioral intention to use e-learning. Given this, perceived ease of use predicted usefulness and was a more reliable predictor of an attitude than perceived usefulness (Cheung & Vogel, 2013). In connection, perceived ease of use has been theorized by many researchers as having a direct influence on perceived usefulness and ease of use (Akman & Turhan, 2017; Boateng et al., 2016; Cheung & Vogel, 2013). With these results, we propose the following hypotheses:

H3: Perceived ease of use significantly influences attitude towards using the software.

H4: Perceived ease of use has a significant influence on perceived usefulness.

2.3. Attitude

Attitude refers to the degree of a person's favorable or unfavorable evaluation or appraisal of the behavior in question (Ajzen, 1991; Boateng et al., 2016). Sánchez-Mena et al. (2019) argued that attitude also refers to an individual's beliefs concerning the behavior. The attitude affects behavioral intention to use technology (Davis, 1989). The study result of Sánchez-Mena et al. (2019) emphasized that teachers' attitudes towards using educational video games directly and positively influence their intention to use the technology in their courses. Through this, it is posited that teacher's attitudes toward innovation affect their intention to use technology in teaching.

Moreover, Boateng et al. (2016) stated that attitude towards use and e-learning intention behavior had a direct relationship. It means that when people have a positive attitude toward technology, they will have a better intention to adopt it (Boateng et al., 2016). Furthermore, studies show that teachers' positive or negative attitudes toward teaching with technology may depend on how they believe such teaching will impact students' learning (Adov et al., 2020). Therefore, the following hypothesis is developed:

H5: Attitude towards use significantly influences behavioral intention to use the software.

2.4. Subjective Norm

Subjective Norm is "a person's perception that most people who are important to him think he should or should not perform the behavior in question" (Venkatesh & Davis, 2000). In the Philippines, where technology integration in teaching mathematics is still in progress, teachers' decision to use new technology in classroom instruction is either encouraged by the immediate supervisors or suggested by co-teachers who have experience using it. Lee and Wan (2010) argue that minimal exposure and experience with new technology would compel potential adopters to look to the opinions of those they trust to help them in their adoption intentions. It is perceived that teachers' intention to use new technology is influenced by the notions and suggestions of the people within their working environment. The research findings of Choi and Chung (2013) demonstrated that subjective norm is a significant predictor of perceived usefulness on the acceptance of social networking sites. Many studies investigated the significant influence of subjective norms on perceived usefulness. For example, Winarno et al. (2021) reported that subjective norm directly influences perceived usefulness. Moreover, the works of Greisel et al. (2023) on the impact of subjective norms on pre-service teachers' attitudes towards computer use reported that subjective norm is a significant predictor of attitude towards use. From the discussions above, we propose the following hypotheses:

H6: Subjective norm has a significant influence on perceived usefulness.

H7: Subjective norms significantly influence attitudes towards using the software.

H8: Subjective norm has a significant influence on behavioral intention.

3. Method

This study utilizes a quantitative survey method as a data collection process. Data was obtained through an online survey distributed to targeted respondents. An online questionnaire through Google Forms was sent to a possible respondent who could not be reached due to distance and time constraints. The purpose of the study and participants' rights to withdraw from the study at any time during or after the completion of the questionnaire were presented before the respondents started to respond to the survey items.

3.1. Participants

A total of 786 teachers from the Philippines participated in the study. We gather data using online survey forms. In the data quality audit, we excluded 84 responses due to duplication, missing data, and failure to hold the sincerity test. The specified inclusion criteria for our final analysis involved ensuring data integrity and sincerity. The total number of respondents included in the analysis was 702. Table 2 reveals the demography of the final participants.

3.2. Instrument

The survey instrument in this study is divided into two sections. The first section covers the demographic details and teaching experiences of the respondents. In contrast, the second section contains twenty-five (25) statements evaluating the five constructs of the proposed research model. Participants' responses are measured using a five-point Likert scale ranging from 1 = Strongly Disagree and 5 = Strongly Agree on the constructs: Subjective Norm (SN), Perceived Usefulness (PU), Perceived Ease of Use (PEU), Attitude Towards Using (ATU), and Behavioral Intentions (BI). This study utilizes multi-item scales adopted from several other studies and modified to fit the specific area of interest, teachers' beliefs of using the dynamic mathematics software GeoGebra in teaching mathematics (see Table 1).

Table 1. List of Constructs and Corresponding Items Used in This Study

Construct	Item	Questionnaire items referring to using GeoGebra in teaching Mathematics	Reference/s
Perceived Usefulness	PU1	Using GeoGebra in my job would allow me to accomplish tasks more quickly.	Davis (1989) Abbad et al. (2009)
	PU2	My students' performance is improved by using GeoGebra in teaching Mathematics.	Nam et al. (2013)
	PU3	My students' productivity is improved by using GeoGebra in teaching Mathematics.	(Davis, 1989) (Nam et al., 2013a) Teo et al. (2016)
	PU4	GeoGebra improves my work.	Teo et al. (2016) Akman & Turhan (2017)
	PU5	Using GeoGebra would make it easier for me to do my job.	Davis (1989)
Perceived Ease of Use	PEU 1	Learning to use GeoGebra would be easy for me.	Davis (1989) Nam et al. (2013)
	PEU2	I would find it easy to get GeoGebra to do what I want.	Davis (1989) Nam et al. (2013) Teo et al. (2016)
	PEU3	I would find GeoGebra to be flexible to interact with.	Davis (1989) Edmunds et al. (2012)
	PEU4	It would be easy for me to become skillful at using GeoGebra.	Davis, (1989) Nam et al. (2013) Teo et al. (2016)
	PEU5	I would find GeoGebra easy to use.	Davis (1989) Nam et al. (2013) Teo et al. (2016)

Attitude Towards Using	ATU1	GeoGebra can improve my confidence in teaching.	Chen & Wu (2020)
	ATU2	I look forward to those aspects of my job that require using GeoGebra.	Teo (2011) Teo et al. (2016)
	ATU3	I hold a positive attitude toward using GeoGebra.	Chen & Wu (2020)
	ATU4	GeoGebra makes work more enjoyable.	Teo et al. (2016, 2017)
	ATU5	I am satisfied with using GeoGebra.	Wu & Chen (2017)
Behavioral Intentions	BI1	Assuming I have access to the software, I intend to use it.	Venkatesh (2000) Teo et al. (2016)
	BI2	I think GeoGebra should be used in the actual classroom teaching.	Wu & Chen (2017)
	BI3	I expect that I will use this software in the future.	Teo (2011)
	BI4	I plan to use GeoGebra often in teaching mathematics, especially in graphing.	Teo et al. (2017)
	BI5	GeoGebra is a teaching tool worth promoting.	Wu & Chen (2017)
Subjective Norm	SN1	My immediate supervisors think that I should use GeoGebra.	(Abbad et al., 2009)
	SN2	People who are important to me think that I should use GeoGebra.	(Abbad et al., 2009) (Teo, 2011)
	SN3	People who influence my behavior think that I should use GeoGebra.	(Abbad et al., 2009) (Teo, 2011)
	SN4	People whose opinions I value will encourage me to use GeoGebra.	(Teo et al., 2016)
	SN5	My colleagues are very supportive of the use of GeoGebra for my teaching.	(Cheung & Vogel, 2013a)

3.3. Ethical Statement

Ethical approval for this study was granted by the Local Research Ethics Committee (LERC) of a state university in the Philippines, affirming adherence to ethical guidelines. The clearance covered vital aspects such as informed consent, confidentiality, anonymity, voluntary participation, and secure data handling. Participants were thoroughly informed, and their confidentiality and privacy were safeguarded throughout the study.

3.4. Data Analysis

Before the primary data analysis procedures, we computed internal consistency in each group of indicators of the constructs. The results revealed Cronbach's alpha values ranging from 0.924 to 0.956, as reflected in Table 3. It is followed by model specification among the constructs and indicators by exploratory factor analysis (EFA). After establishing the internal consistency within and among the constructs, we conducted a confirmatory factor analysis (CFA) to ensure that all model fit measures were acceptable. The same data set was used in EFA and CFA following the works of Van Prooijen and Van Der Kloot, as cited by Teo et al. (2016) and Lee & Lehto (2013), where they used the same data set to derive a factor model by EFA and subsequently test this model by CFA to rule out inappropriate applications of EFA, incomparability of EFA and CFA, and inappropriate applications of CFA. Lastly, we tested the proposed model utilizing structural equation modeling (SEM) analysis. The determination of internal consistency by Cronbach's alpha and the EFA was done in IBM SPSS Statistics 24, while CFA and SEM analyses were done using the AMOS 26.

4. Results

Section 4 outlines the results of our analysis, examining the links between in the proposed model. Through CB-SEM, we uncover insights into the acceptance of GeoGebra from a developing economy perspective.

4.1. Descriptive Measures of the Constructs

The descriptive statistics of mean and standard deviation were calculated for the items and constructs measured. The means of all constructs were rated above 3.0 on the one-to-five scale, ranging from 3.53 (subjective norm; SD = 0.86) to 4.05 (behavioral intention; SD = 0.95). The means of items ranged from 3.43 (SN2; SD = 0.81) to 4.11 (BI1 and BI3; SD = 1.05). Further characterization of the descriptive statistics includes the indices for the skewness and kurtosis of the sample data obtained (Teo & Noyes, 2011). Since the maximum likelihood estimation procedures were used in this study, it is a common criterion to test that the normality assumption is not severely violated (Teo, 2011). Following the guidelines of severe nonnormality proposed by Kline (2016), the cutoff of an absolute value of 3 and 10 for skewness and kurtosis, respectively, is suggested. As seen in Table 3, the skewness of all the items ranged from −1.588 to −0.450, and the values of kurtosis ranged from 0.665 to 2.554, implying that the values fall well within the guidelines and could be regarded as reasonably usual for further analyses.

4.2. Scale Refinement

Internal consistency was assessed to determine the extent to which measured items within the same construct were related. As reported in Table 3, Cronbach's alpha coefficients, calculated for each of the five constructs, ranged from 0.924 to 0.956, all exceeding the recommended cutoff of 0.7 (Fabrigar et al., 1999; Hair et al., 2014). The results indicate that the constructs in the survey questionnaire exhibited high internal reliability. Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were computed for all measured items prior to proceeding with exploratory factor analysis (Howard, 2016; Watkins, 2018). The results provided the suitability of conducting factor analysis, with statis of chi, squared , open paren 300, close paren equals 20,061.32 open paren p less than .000, close pare $20{,}61.32(p < .000)$ and the KMO measure $= 0.971 > 0.500$. An exploratory factor analysis was performed to ensure the factorial stability of the five constructs. A maximum likelihood approach was used as the extraction method because it introduces a vast array of goodness-of-fit information that can be used to determine the appropriate number of factors (Fabrigar et al., 1999). The results indicated that five factors were extracted, accounting for 82.43% of the total variance. According to Howard (2016), a factor loading above 0.40 was considered acceptable in this study. In Table 4, all factor loadings exceeded 0.40, which entails that all factors are satisfactory for further analysis.

Table 2. Demographic characteristics of the participants (*N* = 702)

Category	Demographic	Gender			
		Male *N* = 292		Female *N* = 410	
Age	21-25	62	21.2	100	24.4
	26-30	74	25.3	98	23.9
	31-35	52	17.8	64	15.6
	36-40	48	16.4	59	14.4
	41-45	23	7.9	30	7.3
	46-50	18	6.2	24	5.9
	51-55	14	4.8	27	6.6

	56-60	0	0.0	7	1.7
	61-65	1	0.3	1	0.2
Type of school	Public	246	84.2	355	86.6
	Private	46	15.8	55	13.4
School location	Urban	123	42.1	169	41.2
	Suburban	26	8.9	21	5.1
	Rural	143	49.0	220	53.7
Highest educational attainment	Doctorate holder	4	1.4	6	1.5
	Master's degree holder	81	27.7	89	21.7
	Baccalaureate degree holder	205	70.2	311	75.9
	Post tertiary diploma holder	2	0.7	4	1.0

Table 3. Descriptive Statistics of the Measurement Instruments

Construct	Item	Mean	SD	Skewness	Kurtosis	Cronbach's α
Perceived Usefulness (Mean = 3.85, SD = 0.92)	PU1	3.95	.99	-1.125	1.410	0.954
	PU2	3.68	.95	-.932	1.249	
	PU3	3.70	.96	-.896	1.082	
	PU4	3.92	1.05	-1.099	1.090	
	PU5	3.98	1.05	-1.206	1.319	
Perceived Ease of Use (Mean = 3.81, SD = 0.83)	PEU1	3.85	.93	-1.109	1.773	0.938
	PEU2	3.78	.92	-1.004	1.549	
	PEU3	3.82	.89	-1.126	2.047	
	PEU4	3.80	.91	-1.021	1.600	
	PEU5	3.81	.96	-1.068	1.493	
Attitude Towards Using (Mean = 3.92, SD = 0.90)	ATU1	3.91	.96	-1.204	1.870	0.951
	ATU2	3.89	.98	-1.342	2.090	
	ATU3	3.98	.99	-1.411	2.302	
	ATU4	4.03	1.02	-1.404	2.024	
	ATU5	3.80	.98	-.967	1.085	
Behavioral Intention (Mean = 4.05, SD = 0.95)	BI1	3.97	.98	-1.347	2.144	0.956
	BI2	3.99	1.01	-1.289	1.744	
	BI3	4.11	1.05	-1.632	2.554	
	BI4	4.07	1.06	-1.483	2.033	
	BI5	4.11	1.05	-1.588	2.398	

Subjective Norm (Mean = 3.53, SD = 0.75)	SN1	3.45	.83	-.450	.665	0.924
	SN2	3.43	.81	-.539	.873	
	SN3	3.49	.85	-.650	.915	
	SN4	3.60	.88	-.764	1.094	
	SN5	3.67	.91	-.711	.937	

Table 4. Exploratory factor analysis (EFA) and rotated component matrix: loadings and cross-loadings of item measures.

Item	Component				
PU1	**0.837**	0.047	-0.018	0.012	0.026
PU2	**0.858**	0.000	0.041	-0.017	0.002
PU3	**0.872**	0.006	0.037	-0.037	-0.008
PU4	**0.915**	0.010	-0.017	0.034	-0.009
PU5	**0.860**	0.033	-0.010	0.085	-0.007
PEU1	-0.033	0.052	-0.018	**0.807**	0.075
PEU2	0.029	0.010	0.028	**0.911**	-0.098
PEU3	0.082	0.010	0.033	**0.707**	0.075
PEU4	0.039	0.078	-0.006	**0.644**	0.125
PEU5	0.034	0.031	0.029	**0.842**	-0.018
ATU1	0.028	0.008	0.004	0.050	**0.809**
ATU2	-0.037	0.145	0.063	0.042	**0.731**
ATU3	0.016	0.086	-0.007	0.062	**0.807**
ATU4	0.102	0.191	-0.019	-0.014	**0.706**
ATU5	0.209	0.083	0.017	0.086	**0.516**
BI1	-0.005	**0.732**	0.013	0.036	0.090
BI2	0.022	**0.736**	0.085	0.032	0.041
BI3	-0.005	**0.850**	-0.008	0.002	0.089
BI4	0.032	**0.980**	-0.018	0.047	-0.112
BI5	0.062	**0.921**	-0.009	-0.006	-0.006
SN1	0.101	-0.052	**0.732**	-0.009	0.029
SN2	-0.004	-0.061	**0.924**	-0.027	0.014
SN3	-.0074	0.067	**0.962**	0.020	-0.094
SN4	-0.001	0.054	**0.817**	0.009	0.029
SN5	0.063	0.033	**0.622**	0.067	0.086
Eigenvalue	15.838	1.836	1.292	0.969	0.671
% of variance explained	63.252	7.346	5.169	3.877	2.685

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalization.

Rotation converged in 6 iterations.

The value in bold represents the item loading exceeding the 0.40 threshold.

4.3. Convergent Validity

Convergent validity shows the degree to which the items of a particular instrument are related. Fornell and Larcker (1981) listed three procedures to assess convergent validity. These are the item reliability of each measure, the composite reliability of each construct, and the average variance extracted. Hair (2014) suggested the following criteria to evaluate the measurement scales: (1) all indicator factor loadings should be significant and must be ≥ 0.7; (2) composite reliability must be ≥ 0.7, and average variance extracted (AVE) must be ≥ 0.5. As shown in Table 4, the measurement model's confirmatory factor analysis showed that all the items' standardized factor loading ranged from 0.764 to 0.950, exceeding the recommended threshold of 0.7. The composite reliabilities of constructs ranged from 0.929 to 0.954, exceeding the recommended threshold of 0.7. The AVE, the final indicator in establishing convergent validity, ranged from 0.725 to 0.808 and exceeded the recommended threshold at 0.5. Thus, all the model evaluation criteria proposed by Hair et al. (2014) were met, supporting the measurement model's convergent validity.

4.4. Discriminant Validity

Discriminant validity represents the extent to which the construct is empirically distinct from other constructs or, in other words, the construct measures what it is intended to measure (F. et al. et al., 2014). The Fornell and Larcker criterion is one method for assessing the existence of discriminant validity (Chen & Wu, 2020; F. et al. et al., 2014). This method states that the construct shares more variance with its indicators than any other construct. To test this requirement, the square root of each construct's AVE must be greater than its highest correlation with any other construct. Table 5 shows the correlation matrix for the constructs. The square roots of the average variance extracted have replaced the diagonal elements. For discriminant validity to be judged adequate, these diagonal elements should be greater than the off-diagonal elements in the corresponding rows and columns. All diagonal values exceeded the inter-construct correlations. Thus, discriminant validity appears satisfactory for all constructs.

Table 4. Measurement Model

Constructs	Item	Standardized Factor Loadings	Average Variance Extracted (AVE)	Composite Reliability (CR)
Perceived Usefulness (PU)	PU1	0.893	0.793	0.950
	PU2	0.840		
	PU3	0.832		
	PU4	0.932		
	PU5	0.950		
Behavioral Intentions (BI)	BI1	0.852	0.808	0.954
	BI2	0.874		
	BI3	0.922		
	BI4	0.911		
	BI5	0.932		
Perceived Ease of Use (PEU)	PEU1	0.881	0.758	0.940
	PEU2	0.866		
	PEU3	0.881		
	PEU4	0.839		
	PEU5	0.885		
Attitude Towards Using (ATU)	ATU1	0.870	0.797	0.952
	ATU2	0.897		
	ATU3	0.930		
	ATU4	0.924		
	ATU5	0.841		
Subjective Norm (SN)	SN1	0.764	0.725	0.929
	SN2	0.895		
	SN3	0.895		
	SN4	0.910		
	SN5	0.782		

Table 5. Correlation Matrix and Discriminant Validity

Constructs	PU	BI	PEU	ATU	SN
PU	**0.89**				
BI	0.71**	**0.90**			
PEU	0.73**	0.76**	**0.87**		
ATU	0.77**	0.83**	0.81**	**0.89**	
SN	0.58**	0.62**	0.65**	0.65**	**0.85**

Note: The value in bold represents the square root of AVE.
**$p \leq 0.01$

4.5. Model Fit of the Measurement Model

The first step in SEM analysis is to estimate the measurement model using Confirmatory Factor Analysis (CFA). Maximum likelihood estimation (MLE) procedure was employed in CFA using AMOS 26 to test the congeneric research model for the goodness of fit. The overall model fit was assessed using the chi-square to degrees of freedom ratio (χ^2/df), with a value of between 2.0 to 5.0 is considered acceptable (Hair et al., 2014). Also, other fit indices such as the Tucker-Lewis index (TLI), comparative fit index (CFI), root mean square error of approximation (RMSEA), and standardized root means square residual (SRMR) were consulted. Hu & Bentler (1999) proposed that TLI and CFI statistics ≥.90 represent a good model fit, and those for RMSEA and SRMR, values with ≤.06 and ≤.08 respectively, would represent an upper limit for acceptable model fit. From the results, there was a good model fit for the measurement model in this study χ^2/df = 2.324, RMSEA = 0.043, SRMR = 0.0342, TLI = 0.962, and CFI = 0.966.

4.6. Hypothesis Testing

Structural equation modeling was employed to test the proposed hypothesis using maximum likelihood estimation in AMOS 26 for Windows. Table 6 shows the results of the SEM analysis. All of the fit measures of the final model are acceptable: chi-squared chiedχ^2/df = 2.356, RMSEA = 0.044, SRMR = 0.0350, TLI = 0.980, and CFI = 0.982. Since all the values of the fit indices are acceptable, it indicates an excellent fit between the hypothesized model and the observed data (Nam et al., 2013b). The results of the structural equation model analysis are illustrated in Figure 2. Table 6 revealed that all previously suggested hypotheses in our model are supported. The structural model test showed that PEU had a significant and direct influence on PU and ATU, which also had a mediated indirect effect on BI. ATU had a significant and direct effect on BI. PU significantly influenced ATU and BI and reflected a mediated influence on BI through ATU. SN had a significant and direct effect on PU, ATU, and BI, directly influencing ATU through PU and BI through ATU.

Table 6. SEM Results

Hypothesis	Path	β	SE	CR	p	Results
H1	PU ⟶ ATU	0.323	0.033	9.680	< 0.001	Supported
H2	PU ⟶ BI	0.100	0.036	2.756	< 0.01	Supported
H3	PEU ⟶ ATU	0.513	0.041	12.421	< 0.001	Supported
H4	PEU ⟶ PU	0.751	0.044	16.927	< 0.001	Supported
H5	ATU ⟶ BI	0.728	0.048	15.306	< 0.001	Supported
H6	SN ⟶ PU	0.169	0.051	3.297	< 0.001	Supported
H7	SN ⟶ ATU	0.158	0.037	4.213	< 0.001	Supported
H8	SN ⟶ BI	0.125	0.038	3.264	< 0.01	Supported

As shown in Fig. 2, behavioral intention to use GeoGebra in teaching mathematics was jointly predicted by SN $(\beta = 0.169,\ p < 0.01)$, PU $(\beta = 0.100, p < 0.01)$, an ATU $(\beta = 0.728, p < 0.001)$. These three variables of SN, PU and ATU, together accounted for 77.6% of the variance in behavioral intention. The amount of variance in PU explained by PEU $(\beta = 0.751, p < 0.001)$ and SN $(\beta = 0.751, p < 0.0169)$ was 60.7%. ATU was significantly predicted by PEU $(\beta = 0.513, p < 0.001)$, PU $(\beta = 0.323, p < 0.001)$, and SN $(\beta = 0.158, p < 0.001)$. These three predictors together explained 78.9% of the total variance in ATU.

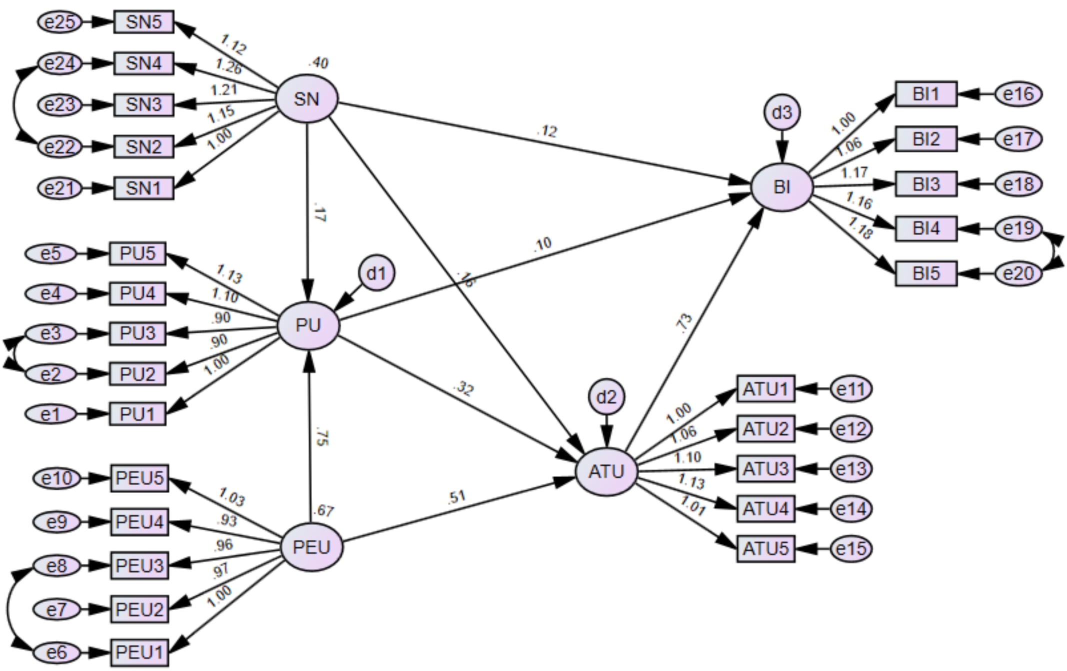

FIG. 2. The final study.

5. Discussion

The present study developed and tested a hypothesized relationship among core constructs of the Technology Acceptance Model, such as the PU, PEU, ATU, and BI, and added SN as an external factor in determining teachers' intention to use GeoGebra in teaching Mathematics. Venkatesh and Davis (2000) emphasized that consistent with the Theory of Reasoned Action of Fishbein and Ajzen, an essential theoretical underpinning for the original development of TAM, social influences must be considered via subjective norms. Lee & Wan (2010) argued that subjective norms tend to be more critical during the introductory stages of adoption when people who intend to use new technology have limited direct experience. In the teaching profession, teachers establish linkages and partnerships that allow them to share and gather educational resources that they believe can make their teaching relevant and meaningful. This established network will subconsciously shape teachers' perceptions of using new technology and innovation.

The SEM results showed that SN had a significant influence on BI. It is consistent with previous studies on the direct effect of subjective norms on behavioral intention to use collaborative technology (Cheung & Vogel, 2013). It suggests that teachers intend to use technology when people within their network believe they should use it in classroom instruction. The results also reflect a significant influence of SN on PU and ATU. This is supported by previous research on the impact of subjective norms on the acceptance of social networking sites by Choi & Chung (2013) and Teo (2009) on the effect of subjective norms on pre-service teachers' attitudes toward computer use. Moreover, SN also influences BI to use technology indirectly through PU and ATU, respectively. This finding is consistent with the previous research on the factors influencing teachers' intention to use technology (Teo, 2011).

Consistent with the predicted hypotheses, the core constructs of TAM have a significant direct and indirect influence on the teachers' behavioral intention to use GeoGebra in teaching mathematics. According to previous studies, PEU is known to influence ATU and PU (Cheung & Vogel, 2013; Nam et al., 2013; Teo, 2011). This suggests that when teachers perceive technology as easy to use, it significantly influences their attitudes toward it and its usefulness. This positive influence of PEU on ATU and PU may be regarded as teachers considering GeoGebra to be beneficial, thus forming a positive attitude towards its use. Consistent also with our prediction, PU has a significant influence on BI. The works of Akman and Turhan (2017), Chen and Wu (2020), and Rodrigues et al. (2018) support these findings. It can be deduced from this result that teachers intend to use technology if it is helpful in their profession. From the results, ATU has a major significant influence on BI. This is consistent with previous findings that teachers' attitudes toward educational video games directly and positively influence their intention to use them (Sánchez-Mena et al., 2019). This finding signifies that the teachers' positive attitude influences their intention to use GeoGebra in classroom instruction. No matter how novel technology is, the teacher's attitude toward the technology still matters.

The findings in this study also show that TAM is a valid model to explain the teachers' behavioral intention to use GeoGebra in teaching mathematics. Together, the constructs in this study's proposed research model explain 77.6% of the teachers' behavioral intention variance. This percentage compares well against other TAM studies that had examined behavioral intention as one of the constructs. For example, Ma et al. (2005) found that SN, PU, and PEU had explained 43% of the variance accounted for the student teachers' intention to use computer technology. In another study, Sánchez-Mena et al. (2019) applied the TAM to study the teachers' intention to use educational video games. They found that PU, PEU, and ATU explained that 66.4% of the variance accounted for the intention to use educational video games. This study supports the growing evidence that suggests the TAM is a valid model with the exploratory utility to explain behavioral intention to use a computer technology like GeoGebra. It suggests that teachers' intention to use GeoGebra in teaching mathematics was influenced by their perceived usefulness, perceived ease of use, attitude towards using, and what they thought others expected of them regarding technology use (Choi & Chung, 2013; Teo, 2009). In the context of the developing country experience, the study conforms to the findings of Gonzales and Gonzales (2021), where GeoGebra is mostly favored among preservice mathematics teachers over other graphing utility software as they develop technology-enhanced lessons while planning to teach with interactive whiteboards.

6. Conclusion

The results of this study demonstrate that the proposed model is a good fit for the data. TAM's conceptual model was preceded to include subjective norm as an external factor affecting behavioral intention. The results show the significance of SN, PU, PEU, and ATU's direct and indirect influence on teachers' behavioral intention to use GeoGebra in teaching mathematics. The teachers' attitude towards use has the most substantial and direct effect on behavioral intention. This finding can guide educational stakeholders in introducing technologies to teachers. The research findings validate that TAM is a valid and efficient model in explaining teachers' behavioral intention to use GeoGebra in teaching mathematics in the Philippine context.

A noteworthy limitation should be considered since some respondents reported that they did not try or do not have experience using GeoGebra. This finding entails that these respondents had responded only based on their knowledge about the applicability of this software in teaching mathematics. The subjective norm as an external variable used in this study has been widely used in the TAM literature. Future research should consider other external variables like facilitating conditions, which refer to user-perceived availability of support in the environment that encourages and facilitates technology adoption (Teo, 2009). In the field, the use of technologies in teaching varies depending on the availability of resources. It is difficult for teachers to introduce new technologies when there is no support in funding, resources, or a conducive working environment that will allow them to do so.

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