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An Empirical Evidence of Geometers' Sketchpad Acceptance

ZaihismaChe Cob, Nor'ashikin Ali, RohainiRamli

Abstract: The integration of educational technology such as geometer's sketchpad into school curriculum has been seen as a means in supporting teaching and learning innovation. However, the potential gains are not fully realized from the use of geometer's sketchpad due to some lack of acceptance. To examine the factors influencing the intention of secondary teachers to use geometer's sketchpad in their mathematics education, this study developed the research model using the constructs derived from Unified Theory of Acceptance and the Use of Technology (UTAUT). Based on the data gathered from teachers in secondary schools in Selangor and analysed using partial least square approach, it was found that infrastructure support and system quality affect teachers' intention to use geometer's sketchpad. Thus, infrastructure support and system quality should be enhanced to sustain use of geometer's sketchpad.

Keywords: Geometer Sketchpad (GSP); Success Model; Structural Equation Modelling

I.INTRODUCTION

With today's rising demand for more and better quality of education, educational institutions have taken initiatives to adopt and integrate education technology into schools. The use of education technology including educational software is highly encouraged for subject like mathematics that requires higher order thinking skills (HOTS). One of the educational software that was introduced in Malaysian education system is Geometer's sketchpad (GSP), which is used to create, explore and analyze in the field of geometry.

It is also used as a means of enhancing and transforming teaching and learning processes in the mathematics teaching including algebra, calculus, trigonometry, and other areas. Several studies have shown that the use of GSP for teaching mathematics has improved students' performance (Leong, 2013). However, GSP was reported to have low acceptance rate (Cheng Meng& Chap Sam, 2011). Saidin& Lim (2013) explored the usage level of GSP for teaching mathematics in classroom and found that 77.4% mathematics teachers are non-users of GSP (KalsomSaidin, & Lim, 2013).Varieties of reasons include insufficient time to prepare the materials for GSP lesson, inadequate skills in using GSP, lack of confidence to use GSP to teach mathematics in class and no equipment support (Cheng Meng& Chap Sam, 2011; KalsomSaidin, & Lim, 2013). Lack of user acceptance of technology becomes the impediment to the success of any new technology implementation that may lead to waste of investment resources such as money and time. Therefore, the failure rate of GSP implementation deserves attention from management and system designers.

In the past studies, it was highlighted that the success of technology implementation mostly relies on the acceptance and willingness of an individual to use the technology (Scherer, Siddiq, &Tondeur, 2019;Ramli& Ramli, 2015). It is evidently seen from the burgeoning of empirical studies in the area of adoption, acceptance and success factors that provided findings on the factors that affect individuals' use of technology (Blackwell, Lauricella, &Wartella, 2014; McCulloch, Hollebrands, Lee, Harrison, &Mutlu, 2018). In education, research on adoption and acceptance issues has started since a decade ago when the computer was first introduced in schools (Marcinkiewicz, 1993). Constant technological change has simultaneously encouraged researchers to continuously investigate the acceptance factors of technology among teachers and students to ensure that the ICT investment in education can bring positive outcomes to teaching and learning. Several factors were known to have an effect on the utilization of ICT in classroom. Early studies suggested that teachers' decision to use computer were associated with their self-competence and innovativeness (Marcinkiewicz, 1993). These findings are based on the study of computer use in the classroom that involves elementary teachers. More factors were explored as expectations on teachers to exploit ICT arise. These included personal factors such as self-efficacy (Tsai, Tsai, & Hwang, 2010), technological factors such as technological complexity and facilitating conditions (Teo, 2009).

While many researches have been conducted to investigate ICT usage in classroom, the focus on using GSP is still lacking. Prior studies focused mainly on the effect of using the GSP in the teaching and learning (Leong, 2013). Little is known of the reasons why teachers do not use GSP. As teachers always play a central role in sustaining changes in classroom practices, it is of the utmost importance to identify factors influencing their use of GSP as one of the solutions to foster the use of GSP as a sustained practice. This study therefore will address this research question: What are the factors that influence the use of GSP among Mathematics teacher?

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* Correspondence Author
ZaihismaChe Cob*, College of Computing and Informatics, Universiti TenagaNasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor
Nor'ashikin Ali, College of Computing and Informatics, Universiti TenagaNasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor
RohainiRamli, College of Computing and Informatics, Universiti TenagaNasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor

There are limited studies on the factors that affect user intention to use GSP, especially from the view of infrastructure, and the quality of the GSP itself. This mode of teaching and learning represents a new experience for most users; thus, we expect that user acceptance is a key driver in successful implementation of geometer's sketchpad.

II.RESEARCH MODEL

In understanding users' intention to use technology, many information systems (IS) researchers have used various theories to explain the acceptance of information technology. Among the most widely used and validated theories are Technology Acceptance Model (TAM) (Davis, Bagozzi, and Warshaw, 1989), and Unified Theory of Acceptance and use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003). These models have been applied to individual levels for acceptance of technology. Of these theories, UTAUT explains 70% of the variation in usage intention of technology, which is greater than other theories, and has gained supports from many scholars as a model that can better explain the acceptance of information technology than most other models. For this reason, UTAUT was chosen as the underlying theory for this study. The UTAUT has four key constructs-performance expectancy, effort expectancy, social influence, and facilitating conditions. In this study, UTAUT model was modified to suit the context of the study. Whereas past studies mainly used the original UTAUT model with four key constructs (Skoumpopoulou, Wong, Ng, & Lo, 2018; Thomas, Singh, &Gaffar, 2013) this study mainly focuses on two original constructs from UTAUT– performance expectancy and effort expectancy, and adds two other new constructs- infrastructure support and system quality to be examined in this context. Performance expectancy and effort expectancy were chosen in this study because it was mentioned that among the reasons given by teachers for not using geometer's sketchpad were firstly, they did not see the benefits of using geometer's sketchpad; secondly, they find it difficult to use (KalsomSaidin, & Lim, 2013) and lastly, there was no equipment support. The first reason is represented by the construct performance expectancy and the second reason is represented by the construct effort expectancy. Lastly, IT support is represented by infrastructure and system quality separately, and thus, facilitating conditions is not used in this study. Other construct in UTAUT such as social influence was dropped from this model as we presume that social influence such as from family and friends is not needed for teachers when using technology. The conceptual model and hypotheses were developed as in Figure 1.

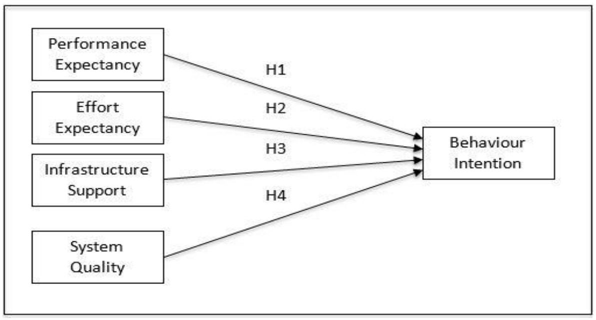

Fig. 1 Conceptual model of Geometer's Sketchpad Acceptance

Performance Expectancy (PE)

Performance expectancy (PE) refers to the degree which individuals believe that using technology will facilitate their task performance. In this study setting, PE refers to teachers' perception that using the geometer's sketchpad will enhance their performance, enable them to accomplish tasks more quickly, and improve their teaching quality. This construct is linked to utilitarian value (extrinsic motivation) in promoting teachers' use of geometer's sketchpad. If using geometer's sketchpad improves their task in teaching and thus, enhancing students' understanding, teachers will be happy to use this technology.

H1: Higher PE of GSP will result in higher BI in using the GSP amongst teachers.

Effort Expectancy (EE)

In this study, effort expectancy (EE) is defined as teachers' perception that it is easy to learn, become skillful, and use of GSP. This perspective is effort-oriented focusing on the overall effort needed in using this technology. This includes how easy and complex in using the GSP. In other words, user will not use GSP if they are having problem to understand how to use it.

H2: Higher EE of GSP will result in higher BI in using the GSP amongst teachers.

Infrastructure Support (IS)

Infrastructure support (IS) refers to teachers' perception of the technical support in using the GSP such as the availability of several machines and the network infrastructure that enables them to share sketches and enable students to access sketches online. Lack of machines, and the unavailability of support may hinder usage of GSP.

H3: Higher level of IS of GSP will result in higher BI in using the GSP among teachers.

System Quality (SQ)

System quality in this study refers to GSP quality related to the processing speed, flexibility, user interface, navigability and data quality as well as meets teachers' requirements in delivering lessons to students. It represents user perceptions of interaction with the system when completing a task. When teachers use GSP, they are interacting with that technology and thus, they may develop the perceptions whether the GSP system is of good quality such as reliable, accessible, flexible, good response time and user friendly. In most studies, system quality has been identified as the key initial antecedents for the success of information technology implementation. Therefore, in this study, system quality is perceived to influence use of GSP among teachers.

H4: Higher level of SQ will result in higher BI in using the GSP amongst teachers.

III.RESEARCH DESIGN AND METHOD

For data collection, a self-report questionnaires were distributed to 151 Mathematics teachers from 11 selected secondary schools in Selangorto gain information regarding the utilization of Geometer's Sketchpad (GSP) in the teaching and learning of Mathematics. The set of questionnaire consisted of twosections:Section 1 was designed to get the demographic information of respondents such as school name, gender and experience level of GSP usage and Section 2 was designed to know the respondents 'perception about the factors that affect their usage of GSP. The survey instrument is based on five constructs: performance expectancy, effort expectancy, infrastructure support, system quality and behavior intention. Likert scales ranged from strongly disagree to strongly agree (1 to 5)were used for developing the questionnaire to determine respondents' perception towards the factors that affect their intention to use GSP in classrooms.

IV.DATA ANALYSIS AND RESULTS

The GSP Acceptance model was evaluated using partial least square (PLS) technique that measure both measurement and structural models simultaneously (Hair et al., 2014).

Measurement Model

Convergent validity

Factor loading for all items are above 0.7 and the CR values exceeded the recommended value of 0.7 (Hair et al., 2014) (shown in Table 1). The AVE, which measures the amount of variance in the indicators also exceeding the recommended value of 0.5 (range between 0.660 and 0.872) (Hair et al., 2014). AVE of 0.5 and greater means that the latent construct accounts for 50% or more of the variance in the observed variables. The results demonstrate that the convergent validity is satisfactory.

Discriminant Validity

Table 2 confirms the discriminant validity; the measure of different constructs differ from one another. The square root of AVE (diagonal values in bold) for each construct are greater than the off-diagonal values,which confirmed that the Fornell and Larcker's criterion is met. All the reliability and validity tests are confirmed as all indicators that are used in the measurement model are valid and fit to be used to estimate the parameters in the structural model.

Table. 1Measurement Model Results

Constructs	Items	Loading	CR	AVE
Performance Expectancy (PE)	PE1	0.850	0.965	0.753
	PE2	0.874		
	PE3	0.893		
	PE4	0.884		
	PE5	0.879		
	PE6	0.852		
	PE7	0.828		
	PE8	0.858		
	PE9	0.889		
Effort Expectancy (EE)	EE1	0.872	0.966	0.738
	EE2	0.847		
	EE3	0.915		
	EE4	0.914		
	EE5	0.905		
	EE6	0.865		
	EE7	0.893		
	EE8	0.836		
	EE9	0.770		
	EE10	0.758		
Infrastructure Support (IS)	IS1	0.738	0.946	0.660
	IS2	0.828		
	IS3	0.843		
	IS4	0.845		
	IS5	0.834		
	IS6	0.886		
	IS7	0.772		
	IS8	0.783		
	IS9	0.772		
System Quality (SQ)	SQ1	0.846	0.974	0.822
	SQ2	0.878		
	SQ3	0.892		
	SQ4	0.944		
	SQ5	0.925		
	SQ6	0.927		
	SQ7	0.914		
	SQ8	0.922		
Behavioural Intention (BI)	BI1	0.940	0.953	0.872
	BI2	0.914		
	BI3	0.947		

Table. 2 Discriminant Validity of Variable Constructs

Constructs	Behavioural Intention	Effort Expectancy	Infrastructure Support	Performance Expectancy	System Quality
Behavioural Intention	**0.934**				
Effort Expectancy	0.643	**0.859**			
Infrastructure Support	0.639	0.740	**0.812**		
Performance Expectancy	0.600	0.793	0.587	**0.868**	
System Quality	0.691	0.768	0.646	0.730	**0.906**

Structural Model

The validity of the structural model is assessed using the coefficient of determination (R^2) and path coefficients. For this study, the bootstrapping generated 500 samples from 151 cases. The result of the structural model is presented in Figure 2. Table 3 shows the path coefficients, observed t-statistics, and significance level for all hypothesized path.

Infrastructure Support (β= 0.146, $p<0.05$) and System Quality (β= 0.100, $p<0.05$) were all positively related to Behavior Intention explaining the 54.9% of the variance in Behavior Intention. Thus, H3 and H4 were supported. The R^2 value of 0.549 was above the 0.26 value as suggested by Cohen (1988) indicating a substantial model. However, contrary to previous studies, Performance Expectancy (β= 0.055), and Effort Expectancy (β= 0.03), had no significant effect on intention to use GSP. Thus, H1 and H2 were not supported by the findings. To determine the size of the effect, f^2, measured using (Cohen, 1988) which suggested 0.02, 0.15 and 0.35 to represent small, medium and large effects respectively (see Table 3). The resulting conceptual model is shown in Figure 2.

Table. 3 Hypotheses Testing

Hypothesis	Relationship	Std Beta	Std Error	t-value	Decision	R^2	f^2
H1	Performance Expectancy (PE) → Behaviour Intention (BI)	0.940	0.124	0.940	Not Supported	0.549	0.0100
H2	Effort Expectancy (EE) → Behaviour Intention (BI)	0.205	0.163	0.205	Not Supported		0.0006
H3	Infrastructure Supports (IS) → Behaviour Intention (BI)	2.776	0.106	2.776	**Supported		0.0829
H4	System Quality (SQ) → Behaviour Intention (BI)	3.001	0.130	3.001	**Supported		0.1214

**$p<0.05$

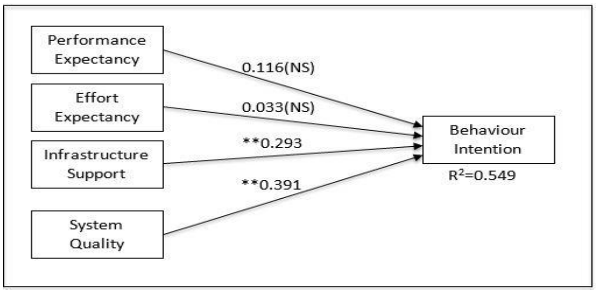

Fig. 2 Structural Model Results

V.CONCLUSION

This study endeavored to investigate the factors influencing the behavioral intention of teachers' usage of geometers' sketchpad in secondary mathematics education. Based on the Unified Theory of Acceptance and UTAUT, this study formulates and empirically tests a theoretical model relating potential antecedent factors to geometers' sketchpad usage in secondary mathematics education. Several key conclusions have emerged from this study. First, ensuring the system quality of the geometers' sketchpad which provides user friendly interface that require less efforts in using the technology is critical in any effort to promote teachers to use this technology in classroom. Second, the infrastructure support is critical to encourage usage of geometer's sketchpad where sufficient numbers of machines for students as well as internet facilities are available to enable students to share their design and sketches online.

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