MANAGING TEACHER ACCEPTANCE OF NEW TECHNOLOGY: THE CASE OF ROBOTICS KIT

Jarupan Noosong[1,*], Naree Achwarin[2], Somsit Duang-Ek-Anong[3]

Abstract

This quantitative research aims to identify a model for the acceptance of an educational robotics kit among primary school teachers, providing educators, administrators, and policy makers practical insight for planning design. This study collected the opinions from a population of 871 in-service teachers of mathematics, science, and technology, at public and private primary schools in Phatthalung province. Purposive sampling and quota sampling were applied, generating a total of 488 responses, collected via questionnaire. The data were analyzed using a structural equation modeling method, generating a structural model to predict the behavioral intent for the adoption of the educational robotics kit. The model comprised of 4 independent variables – perceived ease of use; technology, pedagogy, and content knowledge; perceived usefulness; and facilitating conditions. The model explained 88.2 percent of the variance in behavioral intentions. The findings revealed that perceived usefulness had the strongest direct effect on behavioral intentions. Perceived ease of use had the strongest indirect and total effect on behavioral intentions; moreover, it produced a direct effect on perceived usefulness. In addition, perceived ease of use could be predicted by technology, pedagogy, and content knowledge. The implications discussed include the suggested managerial actions to stimulate the intention to adopt educational robotics kits in accordance with the findings.

Keywords: Robotics, Primary Education, Technology Acceptance Model, Educational Technology

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[1,*] Ms. Jarupan Noosong is a Ph.D. candidate in Teaching and Technology at Assumption University of Thailand. Currently, she is running private schools in Phatthalung Province, Thailand. Email: jarupannoosong@hotmail.com

[2] Dr. Naree Achwarin obtains a Doctoral Degree in Educational Administration from Srinakharinwirot University, Thailand. She is currently working as a full-time lecturer in the Graduate School of Business and Advanced Technology Management, Assumption University of Thailand.

[3] Dr. Somsit Duang-Ek-Anong obtains a Ph.D. in Information Technology from Assumption University of Thailand. He is currently working as a full-time lecturer in the Graduate School of Business and Advanced Technology Management, Assumption University of Thailand.

INTRODUCTION

A new educational paradigm has evolved from the conventional classroom teaching, through the integration of technology, forcing teachers to unlearn and relearn their pedagogical approaches, to ensuring effective learning through engaged participation, and the development of cognitive and technological skills. The most pertinent aspect encompassing this educational revolution is the acceptance by teachers and their consequent adaptation to the integration of this new educational outlook, which is a crucial topic of study as it can influence teachers' behavior and teaching pedagogy, in turn having a significant impact on students' learning (Daher et al, 2012 & Masril et al., 2021).

The integration of robotics enables students to learn various concepts through the construction and manipulation of robots (Nemiro et al., 2017). It has been proven to be beneficial in many fields such as facilitating improvements in sequencing (Bers et al., 2014), understanding of mathematics and science concepts (Barker & Ansorge, 2007; Highfield, 2010; Williams et al., 2014; Toh et al., 2016; Lopez-Caudana et al., 2020), and problem-solving (Barak, 2009), as well as increasing interest in engineering (Toh et al., 2016).

However, educational robotics kits are still not widely used at the primary school level due to various circumstances and constraints which can be discouraging for teachers and lead to a lower rate of acceptance. Ensign (2017) pointed out several challenges of educational robotics in primary school, from not having sufficient training for effective pedagogy, to the lack of financial support and tools for developing teachers' self-efficacy. This was reflected in the report of Kiatvateerattana & Srifawattana (2019) which claimed that constraints had forced the burden on teachers. The situation was worsened by the scarcity of specialized teachers in the field, meaning that teachers still lack preparedness in delivering the subject when the implementation rolled out.

Likewise, Savela et al. (2018) suggested that it was crucial to be aware of factors affecting the acceptance or rejection of the users toward the new technology, explaining that people without first-hand experience of robots tend to exhibit a negative attitude toward robots, with self-efficacy playing a major role in their attitude.

Based on the current context discussed in Kiatvateerattana & Srifawattana (2019) and the findings of Savela et al. (2018), it was necessary to study the behavioral intentions of the teachers involved in the process of adopting educational robotics kits.

Phatthalung is a southern province of Thailand with low urbanization, and an economy dominated by the agricultural sector. Among its population of 524,865 (National Housing Authority, 2019) only 25.06% reside in the urban area, compared to the country average of 34.55%. The data from the Office of the National Economic and Social Development Council (2019) also showed Phatthalung's economy was driven by the agricultural sector, contributing up to 31.31% of its Gross Provincial Product (GPP) in 2019, while the industrial sector accounted for only 11.41%; this is almost the reverse of Thailand's Gross Domestic Product (GDP), of which 8.14% and 31.12% is generated by the agricultural and industrial sectors respectively. With such a social context, the awareness toward robotics use is low. However, as educational robotics is becoming a part of computing science, a compulsory subject according to Thailand's Basic Education Core Curriculum B.E. 2551 (A.D. 2008), which had been partially implemented in the academic year 2018 and was fully implemented in academic year 2020, a practical solution was required to ensure the successful adoption of robotics kits for the learning benefit of Thai students. The issue should be taken as an urgent matter, considering that, as of 2020 - the third year of implementation, none of the 114 schools under Phatthalung's Primary Education Service Area Office 2, had successfully adopted an educational robotics kit. In fact, only 7 schools out of 270 schools (2.6%) in the province had adopted educational robotics kits. Such a low adoption rate could diminish the academic performance of the province in the long run.

Educational technology integration is an integral part of the education reform, with teachers being the key contributors to the success of the reform process (Datnow, 2020). Teo (2010) urged administrators to be aware of the variables affecting teachers' acceptance of this new technology. Hence the objective of this study was to produce a model for teacher acceptance of robotics kits for the successful utilization and integration of educational robotics kits by school management, with Phatthalung as the focal location of the study.

LITERATURE REVIEW

Educational Robotics Kit in Primary Education

Educational robotics was regarded by Andruseac and Iacob (2013) as a learning field allowing students to gain experimental learning of certain processes through designing, constructing and programming robots imitating a real world object with the aim of stimulating curiosity and developing practical and cognitive abilities.

An educational robotics kit is a set of parts and equipment to construct robots for learners; it includes structural and mechanical parts, motors, sensors, and controllers. The majority of kits are produced by private companies. Mqawass (2018) and Masril et at. (2021) claimed that the LEGO Mindstorms kit was received well by young learners. On the other hand, to reduce the cost, Botelho et al. (2012) came up with an open source robotics kit built from typical or reused parts and material which yields a much cheaper robot kit.

Educational robotics in primary education, while being advocated for its advantages, still lacks empirical evidence regarding possible and effective implementation approaches. In particular, the studies on the topic of educational robotics in primary schools is still very limited; according to the systematic review of Lathifah et al. (2019), there were only 28 articles conducted in 2012-2019 on the topic, leading to unsystematic implementation and reluctance in the adoption of educational robotics.

Unlike secondary education where robotics has been an independent elective subject with the official learning platform provided by the Office of Basic Education Commission (thairobot.in.th) for many years, or vocational and tertiary education, where robotics is considered a major of study, fully equipped with specialized teachers and experts, robotics in primary education barely existed until the recent inclusion of computing science in the Core Curriculum.

Computing science had been expected to be fully integrated by 2020, but struggles regarding its implementation can be witnessed. Despite the push through the inclusion of computing science in the national curriculum, the number of schools receiving appropriate support were very limited in number; as of 2020, in Phatthalung province, only 7 out of 270 schools have adopted robotics in their teaching. Moreover, the results of the survey showed that while 13.6% of respondents said that their school possessed robotics kits, only 7.01% were using these in class, indicating the reluctance in utilization.

To aid the effective systematic implementation of educational robotics kits, further research is required, especially regarding primary schools in Phatthalung province, which have never been studied before in this context.

Teacher Acceptance of Educational Robotics

Interviews were conducted with 4 teachers and 2 administrators of 3 schools in Phattalung province, regarding the acceptance of an educational robotics kit. The common denominator among the concerns of the respondents was the lack of proper professional training and insufficient equipment, both of which required a personal investment of time or funding.

The previous studies at other locations showed mixed results. In Germany, Reich-Stiebert & Friederike (2016) suggested robots were beneficial for the learning of science, technology, engineering, and mathematics (STEM). However, the possibility of class disruption, extra workload and the reduction of human interaction were sources of concern.

On the contrary, workshop attendants viewed educational robots to be beneficial for STEM learning. Similarly, Kim et al. (2015) had congruent results with pre-service teachers in Korea. The respondents actively participated in the workshop and decided to include educational robots in their consequent lesson planning; the teachers were willing to integrate robots given that the school permitted and had the budget to do so. In Italy, Scaradozzi et al. (2014) indicated teachers' satisfaction after using educational robotics in class, as it yielded positive differences in students' performance. These studies suggest that teachers are receptive in using educational robots with STEM lessons if they receive proper training and are conversant in its use.

Technology Acceptance Model

Technological acceptance has been widely explored over a few decades, identifying the factors that lead to the successful acceptance of new technology in personal lives and in the workplace. Several theories including the Technology Acceptance Model (TAM), have confirmed Behavioral Intentions (BI) as the most influential predictor of behavior (Davis, 1989).

Based on the TAM, there are two primary constructs of interest, namely Perceived Ease of Use (PEU), defined as the degree to which one believes that using the new technology would enhance their performance (Davis, 1989; Shiue, 2007; Tarhini et al., 2014 & Mei et al., 2018), and Perceived Usefulness (PU), defined as the degree to which one believes adopting the new technology will be free from effort (Davis, 1989; Mei et al., 2018; Tarhini et al., 2014).

In this study, the researcher employed TAM and its variations based on the flexibility and variety of adaptations, including the Technology Acceptance Measure for Pre-Service Teachers (TAMPST; Teo, 2010) and the Extended TAM (Tarhini et al., 2014).

TAMPST expands TAM to include Social Norms (SN) and Facilitating Conditions (FC). Social Norms is one's perception of social pressure from the external environment, such as the opinions of the people who are important to the respondent regarding the adoption of technology into their lessons (Ajzen, 1991; Teo & Lee, 2010; Tarhini et al., 2014). In the educational setting, Marcinkiewicz and Regstad (1996) recommended inclusion of the principal, colleagues, pupils, and professional bodies within the concept of Social Norms. Facilitating Conditions are the degree to which one believes that there is sufficient organizational and technical infrastructure to support use of the technology (Khan & Iyer, 2009). FC can influence teachers' desire to perform or adopt a new technology such as an educational robotics kit. This includes training, technical instruction, and classroom support as well as supporting policies such as time, money, and IT compatibility issues, that could possibly become a constraint in application of the technology (Taylor and Todd, 1995b; Karahanna and Straub,1999; Lee et al., 2003; Teo, 2010; Mei et al., 2018).

Thus, the extended TAM comprises Social Norms (SN) and Self-Efficacy (SE), as well as gender and age as moderators of the main relationships. SE represents teachers' beliefs regarding their own competency to impact students' learning and success (Bandura, 1997) involving the invention of new teaching strategies, perseverance, and achieving a higher goal, and directly relates to students' academic progress (Kiili et al., 2016). SE is a critical factor in the human decision to perform tasks with direct and indirect influences on BI (Latikka et al., 2019; Downey, 2006; Guo & Barnes, 2007; Hernandez et al., 2009; Shih & Fang, 2004; Yi & Hwang, 2003). SE regarding technology integration has been defined as teachers' confidence in using technology effectively for instructional purposes (Bandura, 1997; Anderson & Maninger, 2007; Kiili et al., 2016).

The teaching of robotics faces many challenges including pedagogy, claimed Santos et al. (2016) and Alimisis (2012). Technological, Pedagogical, and Content Knowledge (TPACK) refers to the knowledge that enables teachers to adopt technology effectively (Mishra and Koehler, 2006; Onal, 2016). The framework is commonly used to study the knowledge interaction in most studies on technology integration (Onal, 2016). Ensign (2017) conducted an after school educational robotics workshop, finding that developing teachers' TPACK through the workshop and post-workshop in-class implementation led to a change in teachers' attitude. Having a good TPACK means teachers are better able to understand methods of robotics integration, thus, ensuring relevancy of the lesson content through effective delivery methods, which are comprehensible in relating to the technological aspects of the educational robots.

Conceptual Framework & Hypotheses

The conceptual framework was derived from the theory of the Technology Acceptance Model (Davis, 1989) and its variations including the Technology Acceptance Measure for Pre-Service Teachers, TAMST (Teo, 2010) and Extended TAM (Tarhini et al., 2014), as well as Technological, Pedagogical, and Content Knowledge, TPACK (Mei et al., 2018; Ensign, 2017; Mishra & Koehler, 2012).

The literature review of past studies and theories has instigated the following hypotheses:

H1: Technological pedagogical and content knowledge has a significant positive influence on teachers' behavioral intentions to use an educational robotics kit.

H2: Social norms have a significant positive influence on teachers' behavioral intentions to use an educational robotics kit.

H3: Social norms have a significant positive influence on teachers' perceived usefulness of using an educational robotics kit.

H4: Perceived usefulness has a significant positive influence on teachers' behavioral intentions to use an educational robotics kit.

H5: Perceived usefulness has a

significant positive influence on teachers' attitude towards using an educational robotics kit.

H6: Perceived ease of use has a significant positive influence on teachers' perceived usefulness of using an educational robotics kit.

H7: Perceived ease of use has a significant positive influence on teachers' attitude towards using an educational robotics kit.

H8: Perceived ease of use has a significant positive influence on teachers' behavioral intentions to use an educational robotics kit.

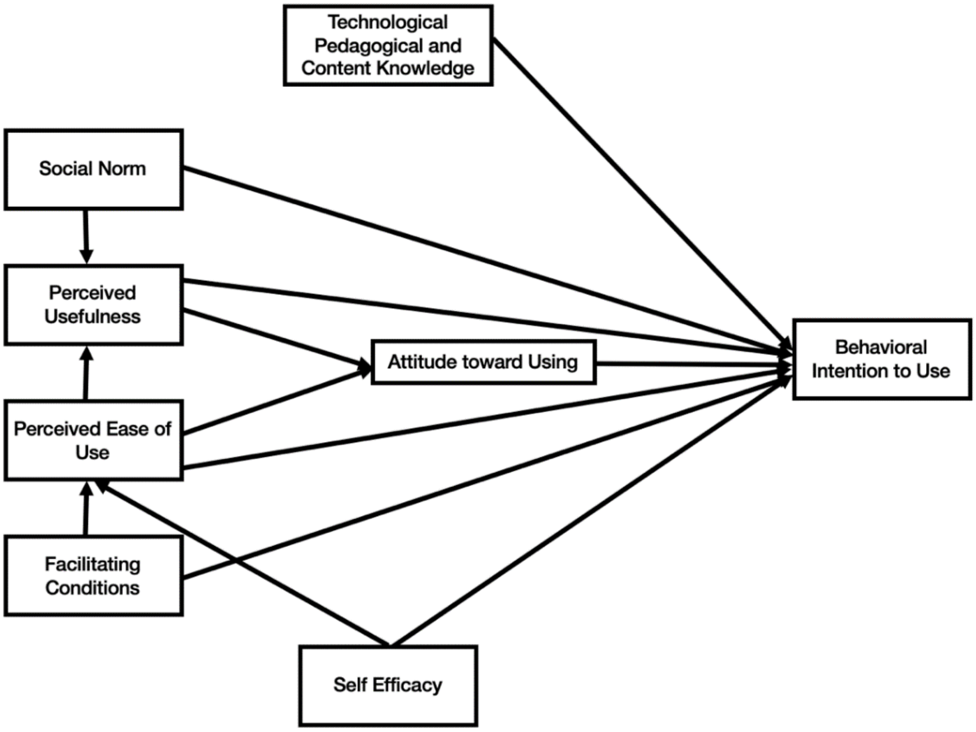
H9: Facilitating conditions have a significant positive influence on teachers' perceived ease of use for using an educational robotics kit.

H10: Facilitating conditions of use have a significant positive influence on teachers' behavioral intentions to use an educational robotics kit

H11: Self-efficacy has a significant positive influence on teachers' perceived ease of use for using an educational robotics kit.

H12: Self-efficacy has a significant positive influence on teachers' behavioral intentions to use an educational robotics kit.

H13: Teachers' attitude has a significant positive influence on their behavioral intentions to use an educational robotics kit.



METHODOLOGY

The study followed a quantitative design using a questionnaire as the main research instrument in the data collection from in-service mathematics, science, and technology teachers at primary level in Phatthalung province, between November 24 and December 14, 2020. It should be noted that data collection was carried out during the COVID-19 pandemic.

Population & Samples

The population consisted of 871 in-service teachers teaching mathematics, science, and technology in primary schools in Phatthalung Province, Thailand.

The sample of respondents was chosen through a purposive sampling method; the characteristics of the sample being in-service teachers, teaching mathematics, science, and technology at primary level with some

Table 1 Demographic Characteristics of respondents

Characteristics	Category	Frequency	Percentage
Subject field	Mathematics	231	49.04
	Science	287	60.93
	Technology	119	25.27
	Others	1	0.21
Experience	Teaching	19	7.01
	Training and Learning	452	92.99
Gender	Male	95	20.1
	Female	376	79.9
Age (Years)	Under 21	0	0
	21-30	150	31.8
	31-40	157	33.3
	41-50	82	17.4
	51-60	80	17.0
	More than 61	2	0.4
Education	Bachelor	359	76.2
	Master	97	20.6
	Doctoral	15	3.2
	Others	0	0
Teaching experience (Years)	Less than a year	19	4.0
	1-5	155	32.9
	6-10	112	23.8
	11-15	65	13.8
	16-20	13	2.8
	More than 20	107	22.7
Robotics kit ownership	Yes	64	13.6
	No	407	86.4

experience of educational robotics. The total number of responses collected was 488. However, 17 responses did not fit the sample description and were disregarded. The demography of the 471 responses included in the data analysis is illustrated in Table 1.

General demography showed that 79.9% of the respondents were female, leaving only 20.1% males. The different proportion between the genders reflected the population profile which comprised 83.4% females and 16.6% males (Phatthalung Primary Education Service Area Office 1, 2020). 61% were 20-40 years old, with 56.7% having 1-10 years of teaching experience, signifying that most of the respondents were comparatively young. The majority of respondents (76.2%) held a bachelor's degree.

Among all the respondents, only 7.01% had actual teaching experience using an educational robotics kit, while 92.99% claimed to have been trained in or learned about it before. This reflected how training did not effectively increase teachers' acceptance. 13.6% stated that their school did possess educational robotics kits. Compared with the 7.01% of teachers who had been teaching with an educational robotics kit, this shows that around half of the robotics kit owners did not utilize the tool in teaching. The overall information indicated low acceptance of educational robotics kits among the respondents.

Data Collection & Instrument

The questionnaire contained 3 parts, consisting of 2 screening questions, 5 demographic data questions, and 48 five-point Likert scale questions designed based on the previous studies of Davis (1989), Khan & Iyer (2009), Punnoose (2012), and Onal (2016). The index of item objective congruence (IOC) of 0.98 showed high validity, while the Cronbach's alpha of 0.974 also displayed high reliability during the pilot test with 30 respondents. In order to determine the sample size for SEM, Soper's (2020) A-priori Sample Size Calculator for Structural Equation Models was used, revealing a minimum sample size of 444. To ensure the samples represented the population, quota sampling was assigned according to the proportion of the number of teachers in each school affiliation with 21.40% and 63.29% from Phatthalung's Primary Educational Service Areas 1 and 2 respectively, 5.86% from the local administration, and 9.46% from private schools. The questionnaire was distributed online and offline to the population of 871, with 488 responses, 342 online, and 146 offline, being collected between November 24 and December 14, 2020, reflecting a 56.03% response rate. Based on the responses, 21.44% and 61.78% were from Phatthalung Primary Educational Service Area 1 and 2 respectively; 7.64% were from the local administration, and 9.13% were from private schools. However, only 471 respondents fitted the sample description and were used for further analysis.

RESULTS

Data Screening, Normality Check, Multicollinearity and Exploratory Factor Analysis

Before performing the normality test, 59 outlier cases were excluded, and the number of the sample was reduced to 412. Through the assessment of normality, the data was deemed normally distributed, given it had the overall skewness of -2.906 and kurtosis of -0.973, which were within the acceptable interval. Afterward, via multicollinearity and exploratory factor analysis, the three independent variables of self-efficacy, social norms, and attitude toward use, were removed from the model along with the related hypotheses (H2, H3, H5, H7, H11, H12 & H13). The model's goodness of fit was found to improve.

Confirmatory Factor Analysis

To obtain convergent validity, the Average Variance Extracted (AVE) was computed; the results ranged from 0.864-0.907, all exceeding 0.5, meaning that all the latent variables had acceptable convergent validity as shown in Table 2. To determine the construct reliability, Cronbach's alpha coefficient was tested, and all the constructs were deemed to be reliable. The results can be seen in Table 2.

Table 2 Convergent Validity and Internal Consistency

Variable	Convergent Validity			Internal Consistency
	Items	Factor Loading	AVE	Cronbach's Alpha
Technological Pedagogical and Content Knowledge (TPACK)	Tpack2	0.943	0.879	0.956
	Tpack3	0.928		
	Tpack7	0.941		
Perceived Usefulness (PU)	Pu1	0.947	0.882	0.974
	Pu2	0.923		
	Pu3	0.959		
	Pu5	0.923		
	Pu6	0.943		
Perceived Ease of Use (PEU)	Peu1	0.925	0.864	0.927
	Peu3	0.934		
Facilitating Conditions (FC)	Fc1	0.927	0.864	0.978
	Fc2	0.931		
	Fc3	0.933		
	Fc4	0.933		
	Fc5	0.914		
	Fc6	0.925		

Table 2 Convergent Validity and Internal Consistency (Continued)

Variable	Convergent Validity			Internal Consistency
	Items	Factor Loading	AVE	Cronbach's Alpha
	Fc7	0.945		
Behavioral Intentions to Use (BI)	Bi1	0.957	0.907	0.967
	Bi2	0.944		
	Bi5	0.956		

Table 3 Discriminant Validity

Construct	TPACK	PU	PEU	FC	BI
TPACK	0.937				
PU	0.865	0.939			
PEU	0.906	0.936	0.930		
FC	0.914	0.848	0.892	0.930	
BI	0.902	0.939	0.944	0.877	0.952

Table 3 illustrates the discriminant validity. The square root of the AVE was proven to be higher than the associated correlation values listed, except for PEU which exhibited less desirable discriminant validity.

Evaluation of the Structural Model

Originally, according to the goodness of fit indicators, the model met the cut off value for 4 criteria. However, the modification index suggested a new path between TPACK and PEU, as illustrated in Figure 2, indicating that there was a possible influence of TPACK on PEU.

The goodness of fit of the structural model was tested against the indices. The associated results are illustrated in Table 4. The Root Mean Square Residual (RMR) result was 0.027; Tucker Lewis index (TLI) was 0.945, and Root Mean Square Error of Approximation (RMSEA) was 0.099. The Normed Fit Index (NFI) value of 0.943 indicated a good fit. Similarly, with the Comparative Fit Index (CFI) of 0.953, the model was regarded as a good fit. The measurement model satisfied 5 out of 8 criteria, suggesting suitability for further analysis.

The corrected determination coefficient (adjusted R^2) was employed; the combination of the proposed independent variable, FC, TPACK, PU and PEU, was shown to explain up to 88.2% of the variance in BI. Facilitating Conditions, and Technological, Pedagogical, and Content Knowledge, together explained 77% of the variance in Perceived Ease of Use. Lastly, Perceived Ease of Use could explain 79.6% of the variance in Perceived Usefulness.

Direct Effect, Indirect Effect & Total Effect

The direct effects were tested

using the significance of the path coefficient of SEM. Table 5 displays the direct effects mentioned regarding the research hypotheses found in the model with the corresponding path coefficients and p-values.

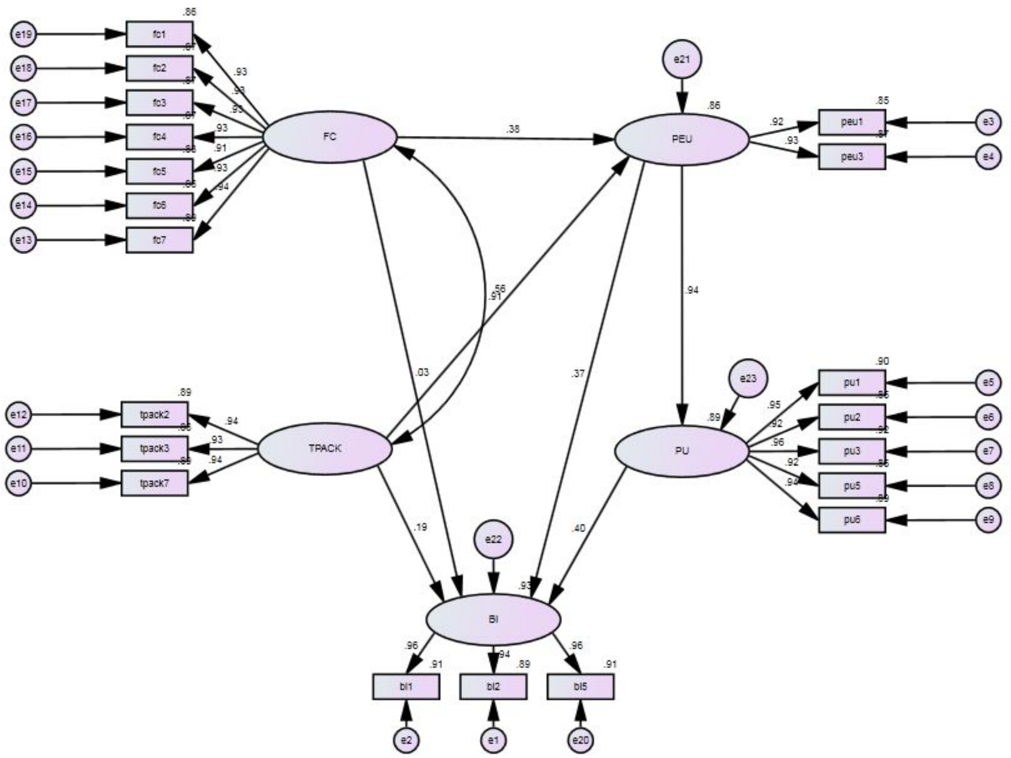


Figure 2 Structural Model After Adjustment (Final Model)

Table 4 Goodness of Fit Assessment (After adjustment)

Index	Threshold	Result	Goodness of Fit
Chi-Square Statistic (χ2)	p-value > .05	0.000	Not Fit
Relative Chi-Square (χ2 /df)	< 2.00 Good 2.00-5.00 Fair	5.009	Not Fit
RMR	< 0.05	0.027	Fit
NFI	≥ 0.90	0.943	Fit
TLI	≥ 0.90	0.945	Fit
CFI	> 0.95 Good 0.90-0.95 Fair	0.953	Fit
RMSEA	< 0.05 Good 0.05-0.10 Fair	0.099	Fit
GFI	> 0.95 Good 0.90-0.95 Fair	0.839	Not Fit

Table 5 Direct Effect of the Included Variables

Path	Path Coefficient (Standardized)	Path Coefficient (Unstandardized)	Standard Error	Critical Ratio	P-Value
TPACK→BI	0.208	0.202	0.039	5.168	0.000
PU→BI	0.458	0.508	0.042	12.093	0.000
PEU→PU	0.892	0.892	0.022	40.063	0.000
PEU→BI	0.231	0.256	0.054	4.690	0.000
FC→PEU	0.429	0.374	0.044	8.493	0.000
FC→BI	0.101	0.098	0.038	2.554	0.011
TPACK→PEU	0.475	0.415	0.44	9.396	0.000

Table 6 Summary of Total Effect Between Independents and Dependent Constructs

Dependent Variable	Adjusted R^2	Effects	Independent Variable			
			TPACK	FC	PU	PEU
BI	0.882	Direct	0.208	0.101	0.458	0.231
		Indirect	0.304	0.274	-	0.409
		Total	0.512	0.375	0.458	0.64
PEU	0.770	Direct	0.475	0.429	-	-
		Indirect	-	-	-	-
		Total	0.475	0.429	-	-
PU	0.796	Direct	-	-	-	0.892
		Indirect	0.424	0.383	-	-
		Total	0.424	0.383	-	0.892

A direct effect was found for 7 paths - TPACK on BI (H1), PU on BI (H4), PEU on PU (H6), PEU on BI (H8), FC on PEU (H9), FC on BI (H10) and TPACK on PEU. All paths were significant with a p-value of 0.000, except the path of FC to BI (p=0.011).

The results indicated that Behavioral Intentions was positively affected by Technological, Pedagogical, and Content Knowledge, Perceived Usefulness, Perceived Ease of Use, and Facilitating Conditions. Behavioral Intentions was found to be mostly affected by Perceived Usefulness with a standardized path coefficient of 0.458, while it received the least influence from Facilitating Conditions with a path coefficient of 0.101. The path coefficient of Perceived Ease of Use and Technological, Pedagogical, and Content Knowledge, on Behavioral Intentions had the coefficients of 0.231 and 0.208 respectively.

Perceived Usefulness was strongly influenced by Perceived Ease of Use with a path coefficient of 0.892. In turn, Perceived Ease of Use was affected by Technological, Pedagogical, and Content Knowledge, and Facilitating Conditions, with path coefficients of 0.475 and 0.429

respectively. Based on the Direct Effect pattern, Technological, Pedagogical, and Content Knowledge, and Facilitating Conditions, indirectly affected behavior through the Perceived Ease of Use and/or Perceived Usefulness.

After combining both direct and indirect effects (Table 6), it was revealed that Perceived Ease of Use had the highest total effect on Behavioral Intentions with a total effect of 0.64, followed by TPACK (0.512), Perceived Usefulness (0.458) and Facilitating Conditions (0.375).

DISCUSSION

Figure 3 illustrates the final model of teacher acceptance for educational robotics kits. The model suggests that teachers' Behavioral intentions (BI) to use an educational robotics kit have received influence from four factors, namely Technological, Pedagogical, and Content Knowledge (TPACK), Facilitating Conditions (FC), Perceived Ease of Use (PEU), and Perceived Usefulness (PU). Teachers' PU was strongly influenced by PEU which was affected by TPACK and FC. Table 7 summarizes the result of the hypothesis testing.

The overall model shared common features with the TAMST framework (Teo, 2010). The final model found FC to have a positive effect on PEU (H9), which further placed the influence on PU (H6). PU then affects BI (H4). This suggests that providing sufficient Facilitating Conditions can improve teachers' Perceived Ease of Use and Perceived Usefulness, both of which result in increasing the Behavioral Intention to use an educational robotics kit (H10). As stated in the interviews and the

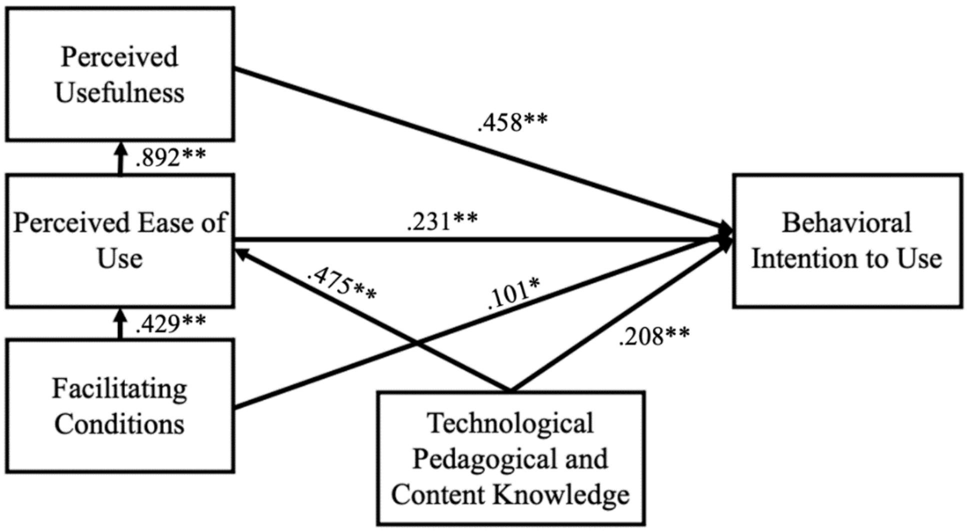


Figure 3 The Model of Teacher Acceptance for Educational Robotics Kits

Table 7 Hypothesis Testing Result

Hypothesis	Path	Result
H1	Technological, Pedagogical and Content Knowledge (TPACK) on Behavioral Intention (BI)	Supported
H2	Social Norm (SN) on Behavioral Intention (BI)	Not Supported
H3	Social Norm (SN) on Perceived Usefulness (PU)	Not Supported
H4	Perceived Usefulness (PU) on Behavioral Intention (BI)	Supported
H5	Perceived Usefulness (PU) on Attitude toward Use (ATU)	Not Supported
H6	Perceived Ease of Use (PEU) on Perceived Usefulness (PU)	Supported
H7	Perceived Ease of Use (PEU) on Attitude toward Use (ATU)	Not Supported
H8	Perceived Ease of Use (PEU) on Behavioral Intention (BI)	Supported
H9	Facilitating Condition (FC) on Perceived Ease of Use (PEU)	Supported
H10	Facilitating Condition (FC) on Behavioral Intention (BI)	Supported
H11	Self-Efficacy (SE) on Perceived Ease of Use (PEU)	Not Supported
H12	Self-Efficacy (SE) on Behavioral Intention (BI)	Not Supported
H13	Attitude toward Use (ATU) on Behavioral Intention (BI)	Not Supported

findings of Reich-Stiebert & Friederike (2016), Facilitating Conditions can lessen the concerns of teachers in terms of extra workload and personal investments of time and funding.

The Extended TAM included the direct effect of PEU on BI, which was initially absent in the original TAM. The final model confirmed Tarhini et al.'s (2014) result, that PEU produced a positive direct effect on BI (H8). Therefore, it is evident that teachers' Perceived Ease of Use has a direct impact on Behavioral Intentions to use educational robotics kits.

One interesting path revealed was the relationship between TPACK and other variables – PEOU and BI. TPACK, originally, was not usually incorporated as a part of any technology acceptance theories, except in that of Ensign (2017) & Mei et al. (2018), who found that TPACK had a positive influence on BI. The results of this study support the existence of this path, where increasing TPACK increases teachers' behavioral intentions to use an educational robotics kit. Furthermore, the final model also discovered that TPACK had a positive effect on PEU. This is understandable since TPACK ensures that teachers understand and are able to integrate the lesson content, with the delivery and the technical aspects of the technology. Once teachers master these skills, they would naturally perceive the technology to be easier to use.

In short, it must be demonstrated to teachers that using an educational robotics kit is easy, as this is the strongest factor influencing their intent for use. This involves having a standard operating guide or manual with clear and understandable instructions.

In motivating teachers' intentions to use the robotics kit and the Perceived Ease of Use, teachers should possess TPACK. Mei et al. (2018) found that teachers were well aware of the importance of the three areas of knowledge, namely technological knowledge, pedagogical knowledge, and content knowledge. In this case the technical knowledge consists of knowledge of the robotics kit itself, including both software and hardware aspects of the tool. Pedagogical knowledge refers to the idea that teachers should have competency in terms of pedagogy, knowing how they are going to effectively integrate the educational robotics kit into their lessons, and the teaching techniques required for such integration to ensure that it can assist students' comprehension of the lesson. Not only does this encompass the process of delivery, but teachers must also be equipped with a suitable assessment method for use after integration of the educational robotics kit. Content knowledge incorporates knowledge about the core content of the lesson, for instance, the class objectives, aimed at competency and the content coordination required to effectively deliver the lesson to students. Furthermore, teachers should be provided with facilitating conditions, such as supporting facilities, assistance, training, incentives, and leadership. This will improve the teachers' perception of the ease of use and increase the intention to use an educational robotics kit.

Lastly, better perceptions of the ease of use can yield better Perceived Usefulness; this means that when an educational robotics kit is perceived to be easier to use, it creates the perception of being useful, such as producing higher effectiveness, efficiency, and productivity, for the teachers. When that happens, it further generates a positive direct effect on the teacher's intention to use the robotics kit.

CONCLUSION

This study shows that Perceived Usefulness, Perceived Ease of Use, Facilitating Conditions, and Technological, Pedagogical and Content Knowledge, have a positive influence on teachers' acceptance of educational robotics kits, which together can explain 88.2 percent of the variance in teachers' Behavioral

Intentions. The final model indicates the major influence of Perceived Ease of Use and Perceived Usefulness on Behavioral Intentions. School administrators should make the adoption of educational robotics kits as easy and simple as possible. Thus, Facilitating Conditions along with Technological, Pedagogical, and Content Knowledge, are the two influencers of Perceived Ease of Use, which should take precedence. Teachers should be aware that organisational and technical infrastructure is available to support the use of new technology (Venkatesh et al., 2003) including supporting facilities, leaders and leadership, incentives, training, and accessible assistance. This is supported by Kim, et al.'s (2015) finding that pre-service teachers were eager to incorporate educational robotics kits in their lesson plans given that the school could provide sufficient funding and support. Furthermore, most teachers have no experience in teaching robotics. With that, teachers have the tendency to teach how they were taught (Llinares & Krainer, 2006; Ensign, 2017). It is necessary to design an effective systematic training with a mentoring program providing guidance and assistance. As Levitt (2002) suggested, teachers are motivated when they are provided with clear guidelines for ease of use; the application of a robotics kit must be clear and comprehensible. However, to achieve this, teachers must be very familiar with the equipment as well as its function, which is somewhat unattainable during the initial phase. To ease the daunting process, a practical robotics integrated lesson plan in accordance with the national curriculum should be provided.

Overall, this study has allowed administrators to pinpoint the drive behind teachers' behavioral intentions to adopt educational robotics kits, outlining the possible solutions to the problem of low acceptance of educational robotics kits in primary education. However, this requires further study as this research only focuses on the context of Phatthalung, Thailand, which is low in industrialization, lacks familiarity with robotics and is scarce in terms of human resources in this specialized field.

Future research should focus on the development of a practical teacher training model for robotics integration. To effectively implement the use of educational robotics kits requires time. Educational leaders and researchers should come together in developing a practical lesson plan that can be utilized by teachers without specialization in robotics. In addition, this study concentrated on primary school teachers, future research may consider emphasis on another educational level including pre-school, secondary level, or tertiary level.

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