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Geometric AR-based pedagogical module is beneficial: Affecting factors from the lens of Malaysian mathematics secondary school teachers

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ABSTRACT

The purpose of this study was to predict the likelihood that teachers would consider the Geometric AR-based Pedagogical Module (GeAR-PM) as beneficial, and study the factors that influence their decision. The data for this study was gathered via a survey method. A sample of 202 Malaysian secondary school teachers was randomly selected as respondents for this study. Specifically, the respondents were asked to answer questions using an instrument which was developed based on the Unified Theory of Acceptance and Use of Technology (UTAUT) model. This study comprised four UTAUT variables: performance expectation, effort expectancy, social influence, and facilitating conditions, and one additional variable, self-efficacy. All variables showed high reliability with Cronbach Alpha's values between 0.87 to 0.91. The data was analyzed using a binary logistic regression via Statistical Package for the Social Sciences (SPSS) version 27.0. The findings revealed that a teacher's belief that GeAR-PM is beneficial was significantly related to his/ her perception on effort expectancy, social influence, and self-efficacy. Hence, when developing the GeAR-PM, these three factors should be weighed up.

Contribution/Originality: This study is one of several studies that employed the Unified Theory of Acceptance and Use of Technology (UTAUT) model. However, the application of logistic regression method to model the relationship between the benefit of a product to be developed, the GeAR-PM, and the UTAUT's variables is an innovative approach.

1. INTRODUCTION

As early as the 1980s, educators have emphasized the importance of technology in mathematics teaching and learning. The National Council of Teachers of Mathematics (NCTM), a prestigious American educational organization, issued a report in 1989 (National Council of Teachers of Mathematics, 1989) stressing that students can enhance their comprehension of mathematics when they utilize technology effectively in the classroom setting. Over the years, the adoption of technology among mathematics teachers has steadily increased due to the creation of various technological teaching aids, which is in line with the rapidly evolving technological trends.

In the context of teaching geometric lessons, the use of technology is undoubtedly prevalent. Teachers have employed geometrical software to boost student understanding and create meaningful learning. GeoGebra, Geometer's Sketchpad, Cabri, and Geometer Pad (Ganesan & Eu, 2020; Juandi, Kusumah, Tamur, Perbowo, & Wijaya, 2021; Laborde, Kynigos, Hollebrands, & Strässer, 2006) are just a few examples of geometrical software that can be used when teaching geometric lessons. In addition, recent advancement in augmented reality (AR) technology have also created new avenues for teaching geometrical concepts. Specifically, students would be able to understand complex geometrical concepts in more depth because AR offers three-dimensional visualization and realistic simulation.

Even though educators have embraced AR technology for teaching geometry, the quantity of AR-based geometric teaching modules is limited, particularly in the setting of diverse eastern countries such as Malaysia. Therefore, we intend to develop a teaching and learning module called Geometric AR-based Pedagogical Module (GeAR-PM) that can be used by the Malaysian secondary school teachers to teach geometric topics. However, prior to developing the GeAR-PM, gathering information on whether teachers think that the GeAR-PM is beneficial, and what factors contribute to their response, is deemed necessary. Specifically, this study adopts Unified Theory of Acceptance and Use of Technology (UTAUT) model by Venkatesh, Morris, Davis, and Davis (2003) to explain factors influencing teacher's perception that the GeAR-PM is beneficial.

In sum, this study seeks to predict the odds that teachers would think the GeAR-PM is beneficial, and whether their perceptions on performance expectancy, effort expectancy, social influence, facilitating conditions and self-efficacy contribute to their response. Precisely, the research question is as follows:

Research Question: What factors predict the likelihood that teachers would report that GeAR-PM is beneficial?

Hypothesis: The likelihood that a teacher stated that GeAR-PM is beneficial is related to his/her perceptions on performance expectancy, effort expectancy, social influence, facilitating conditions and self-efficacy.

2. LITERATURE REVIEW

2.1. The Use of Technology in Teaching Geometry

In general, the roles and effects of technology on student's mathematical learning has constantly undergone evolution throughout the years (Xie & Hawk, 2017). In the early phase, the use of technology in mathematical classrooms only served as an auxiliary instrument to supplement teacher's existing pedagogical materials. However, with the emergence of modern technologies, its technological applications have shifted to achieve complex teaching objectives. As pointed out by Delgado-Rebolledo and Zakaryan (2020) instead of primarily aiding students in acquiring basic skills, technology now seeks to promote a more intricate understanding and thought process concerning conceptual mathematics.

When it comes to teaching geometry, the use of different kinds of technology has been particularly helpful in creating learning environments where students can grasp, relate, and visualize properties of shapes; either 2D or 3D objects. For instance, Pittalis (2021) study demonstrated that employing a dynamic geometry environment (DGE) on tablets allows students to gain insights into the geometric relationships between various shapes they construct, facilitated by action-perception feedback loops. Similarly, a meta-analysis study by Juandi et al. (2021) which reviewed 57 effect sizes across 50 articles affirmed that using Geogebra, markedly boosts students' mathematical skills. Not confined to software, the integration of AR technologies and visual manipulatives like 3D blocks as per Ibili, Resnyansky, and Billinghurst (2019) and Yaniawati, Sudirman, Mellawaty, Indrawan, and Mubarika (2023) have also shown positive scores in student's acquisition of 3D geometric skills. In essence, these innovative tools are revolutionizing the pedagogical approach to geometry.

Realizing the importance of technology, the Ministry of Education Malaysia has consistently motivated educators to integrate technology in their classroom. This emphasis is not just limited to teaching geometry but also spans across all subject areas to enhance overall quality of Malaysia's education (Malaysia Education Blueprint

2013-2025 by Ministry of Education Malaysia (2012)). Nevertheless, despite the beneficial effects of technological use and its rising trend in mathematics learning over the years (De Brey, Snyder, Zhang, & Dillow, 2021; Mailizar & Johar, 2021; Setambah, Rajoo, Othman, Shuib, & Ibrahim, 2023) previous Trends in International Mathematics and Science (TIMSS) reports (Mullis, Martin, Gonzalez, & Chrostowski, 2004; TIMSS, 2015) have shown fluctuating geometry performance, especially among Malaysian students, with some improvements in the past (in 2003, 2007 and 2011 reports), before continuing to decline of a total 39 points below the standard point in the latest TIMSS report (Ministry of Education Malaysia, 2019). TIMSS is a series of international studies conducted by the International Association for the Evaluation of Educational Achievement to track trends in students' performance in science and mathematics at the middle primary and lower secondary levels.

Compared to its neighboring country, Singapore, Malaysian students fared poorly in geometry, scoring only 57.1 percent correct on a question about the correct orientation of a 2D cut-out template for a cuboid in TIMSS 2015 report (TIMSS, 2015). From this result alone, it is inferenced that students have problems in learning geometry (Ministry of Education Malaysia, 2019). Moreover, there is consensus amongst researchers that students' inability to correctly interpret the relationship between geometrical properties in different dimensions is driven by their poor visualization skills due to inadequate imagination ability (Abdullah et al., 2022; Fujita, Kondo, Kumakura, Kunimune, & Jones, 2020; Shaimi, Shaharudin, & Adnan, 2023) and lack of knowledge about solids (Barut & Retnawati, 2020; Nadzeri, 2022). Therefore, there is a need to integrate the visualization process with technology to assist students in learning geometry effectively. With advanced technology nowadays, teachers have options to choose various technological devices, ranging from the less impactful to the most advanced ones. One of the options is an AR tool that has become popular among teachers worldwide.

An AR system, as defined by Azuma et al. (2001) should have the following properties, which are (1) the capacity to amalgamate both real and virtual objects in a physical setting; (2) the ability to operate in real-time and interactive mode; and (3) store data about the physical and digital objects in use. Initially developed as a pilot training tool (Krueger, Gionfriddo, & Hinrichsen, 1985) AR applications have spread widely, particularly in education (Bacca Acosta, Baldiris Navarro, Fabregat Gesa, & Graf, 2014; Farah & Hanani, 2019; Nincareana, Alia, Halima, & Rahmana, 2013; Töröková, Dupláková, Török, & Duplák, 2021). In one specific case, a pilot study conducted by Rossano, Lanzilotti, Cazzolla, and Roselli (2020) on the 3rd to 4th grade primary students in Italy using the AR application 'Geometry-Plus' or GEO+ revealed positive gains during the post-test after using the app, and higher memory retention about solids in general. This exemplifies the assertion that AR provides a unique, dynamic platform for students to engage with 3D shapes when studying geometry. According to Andrea, Lailiyah, Agus, and Ramadiani (2019) they noted that through a marker-based AR geometry textbook, interactive hands-on activities significantly facilitated students' understanding of geometric shapes and eased their learning of geometry formulas. Students also gain a better grasp of complex concepts with the help of AR technology's three-dimensional visualization and realistic simulation capabilities (Rohendi & Wihardi, 2020).

2.2. The Unified Theory of Acceptance and Use of Technology (UTAUT) Model

The UTAUT model was first conceived by Venkatesh et al. (2003) following a comprehensive evaluation of eight prior user acceptance models. In general, the proposed UTAUT model posits three constructs that directly influence user's behavioral intention towards adopting technology: *performance expectancy*, *effort expectancy*, *social influence*, with additional *facilitating conditions* construct as a predictor of user's behavioral outcome. Therefore, in this study, all these factors together with self-efficacy will be used as predictor variables towards teacher's perception that the GeAR-PM would be beneficial.

Specifically, *performance expectancy* can be represented as perceived usefulness of technology in improving the user's job outcome. Based on literature reviews, research have yielded mixed results, with some studies demonstrating significant influence of perceived usefulness on a teacher's intention to use technology, especially those who see technology's positive effects or benefits on students' learning outcomes (Abbad, 2021; Chao, 2019; Fatmasari, Gunherani, Murniarti, Sampaleng, & Sugiarti, 2018; Wijaya, Cao, Weinhandl, Yusron, & Lavicza, 2022). In a specific example, Radu, McCarthy, and Kao (2016) found that most Mathematics teachers in public schools in San Francisco expressed a general consensus that AR-based instructional tools can be beneficial in aiding students to visualize geometrical concepts such as 3D shapes and spatial properties. Furthermore, a study by Sudirman, Kusumah, and Martadiputra (2021) exploring teachers' perceptions of AR blended learning for advancing geometric knowledge further corroborated that teachers' view of the technology as pertinent to their instructional approach, helping them meet their students' learning objectives. Additionally, for instructors who had direct experience with technology and witnessed its benefits in teaching, they were also more inclined to integrate it into their curriculum for pupils (Cox & Graham, 2009; Kim & Lee, 2022). Conversely, Pittalis (2021) argued that perceived usefulness did not directly impact teachers' technology behavioral intention, but rather is moderated by teacher's own perceived pedagogical-learning fit.

Effort expectancy construct was originally derived from three main antecedents namely perceived ease of use, complexity, and ease of use according to Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw, 1989) Model of Personal Computing Utilization (MPCU) (Thompson & Higgins, 1991) and Diffusion of Innovations Theory (DIT) (Moore & Benbasat, 1991) theories and can be interpreted as the user's ease of use adopting technology. It is also considered as a prominent predictor in user's technology behavioral intention in which recent research exploration suggests that teachers tend to incorporate technology in classroom instruction if they perceive technological devices as user-friendly and easy to use (Mailizar & Johar, 2021; Teo, 2011). For example, as reported by Yuan, Liu, Deng, Ding, and Wijaya (2023) when it comes to using AR technology as a pedagogical aid, educators in China believe its benefit is tied to how easily it can be incorporated into lesson plans. In particular, effort expectancy is a significant determinant of teacher's usage behaviour when using GeoGebra in elementary schools, where lack of technology training significantly affected their usage behaviour (Mailizar & Johar, 2021).

As for *social influence*, it refers to the effect that others have on an individual's decision to adopt technology. Recent research has highlighted the significant role of social influences such as strong support from colleagues and school administrators, for individuals to embrace IR-4 technologies which includes applications of AR (Ab Jalil, Rajakumar, & Zaremohzzabieh, 2022; Jain & Jain, 2022). Notably, communities with collective mindset, as prevalently seen in Southeast Asia exhibit higher propensity to follow like-minded peers who have already embraced innovation, as discussed by Zhao, Wang, Li, Zhou, and Li (2021). Therefore, for teachers in these regions, they will readily embrace the benefits of incorporating AR technology in the classroom once they acquire enough affirmative feedback from their peers or those around them.

Facilitating conditions, which refer to the provision of required resources for effective technological utilization, are important factors in determining teachers' intention to use pedagogical technology tools. The provision of reliable technology, adequate training, and ongoing support are deemed essential elements driving teachers' decisions in incorporating technology in their classroom (Kundu, Bej, & Dey, 2021; Wang & Shih, 2009). According to Taimalu and Luik (2019) teachers' personal experience with tech-assisted teaching tools and alignment of the tools with their pedagogical style significantly impact their intent to leverage technology in classroom instructions.

2.3. Self-efficacy

On top of the UTAUT domains, this study also incorporates *self-efficacy* as one of the predictor variables. As one of the indirect determinants on intention to use technology in the UTAUT model, self-efficacy, as defined by Bandura (1986) refers to an individual's personal evaluation of their competence in executing a specific task. Research has demonstrated that individuals' technological behavioral intentions, which also indirectly implies his/ her perception that technology is beneficial, are strongly and positively influenced by self-efficacy (Kundu et al., 2021; Teo & Zhou, 2014). In the context of educational setting, Bakar, Maat, and Rosli (2020) research has shown that regardless of gender and teaching experience, teacher's self-efficacy plays a major role in influencing their intention to incorporate technology into their instructional methods, a finding that remains relevant around two decades later. Wang and Shih (2009) research reaffirmed that although improved self-efficacy does not directly translate in technology adoption among teachers, it remains a crucial aspect in shaping technology behaviour intention. Similarly, Henson (2002) also proposes that teachers' technology self-efficacy is closely linked with their students' own technology self-efficacy. In other words, if a teacher is confident in using technology and recognizes its benefits for educational purposes, their students are more likely to emulate and opt for digital tools for their own learning endeavors.

3. METHOD

3.1. Respondents

The respondents for this were 202 mathematics teachers from Malaysia's national secondary school. These teachers were chosen at random from the whole population of Malaysian Mathematics teachers.

3.2. Data Collection and Instrument

The data for this study was gathered via a survey method. Specifically, the respondents were asked to answer questions using an instrument which was developed based on the UTAUT model. Four domains of the UTAUT model were incorporated in this study, which are *performance expectancy*, *effort expectancy*, *social influence*, and *facilitating conditions*. In addition, self-efficacy domain was also included in this study. All the domains consist of four items with the Likert-scale of 5 points: *1 – strongly disagree; 2 – disagree; 3 – somewhat agree; 4 – agree;* and *5 – strongly agree*.

3.3. Instruments Validity and Reliability

The reliability of the questionnaire was evaluated by examining the Cronbach Alpha value for each domain.

As displayed in Table 1, the Cronbach Alpha values for all the domains surpasses the cut-off point of 0.7, which is the recommended value suggested by Pallant (2020). It shows that all the items can be used to represent its domain, respectively.

Table 1. Cronbach alpha coefficient for each domain.

Domain	Alpha coefficient
Performance expectancy	0.91
Effort expectancy	0.81
Social influence	0.91
Facilitating conditions	0.92
Self-efficacy	0.87
Overall	0.88

3.4. Data Analysis

This study employed a logistic regression method for data analysis to answer the research question. The analysis was done using the Statistical Package for the Social Sciences (SPSS) version 23.0.

Specifically, in contrast to simple or multiple linear regression typically applied to predict continuous variable(s), logistic regression is employed when the dependent variable is categorical. In cases where the dependent variable falls into two categories, such as "Yes" and "No", binary logistic regression model can be used. On the other hand, another type of logistic regression, namely ordinal logistic regression, can be used when the dependent variable is divided into multiple categories, but with a clear sequence or order predefined. Besides being used to predict the probability of a categorical dependent variable, logistic regression can also be used to identify factors associated with a particular outcome. However, the independent variables can be in the form of both continuous and/or categorical.

Thus, a binary logistic regression was selected in this study because the dependent variable, which a teacher stated that the GeAR-PM is beneficial, was categorical in nature. Precisely, the dependent variable has two categories, which were coded as 0 = No and 1 = Yes. The logistic regression model was also used because it can identify factors related to the UTAUT model that are associated with the teacher's response. According to the literature, prior studies on the UTAUT model used a variety of analysis approaches, including logistic regression. As a result, the application of the binary logistic regression model in this study was consistent with past research, and more importantly, this method was found appropriate for answering the research question.

The data analysis in this study follows suggestions from Peng, Lee, and Ingersoll (2002).

3.5. Binary Logistic Regression

Let Y be an outcome variable with binary response coded as 0 = No, 1 = Yes, and X be the predictor variable. The logistic regression model predicts the logit of Y from X. Essentially, the logit represents the natural log (ln) of the odds ratio of Y. The fundamental form of the logistic regression model can be expressed as follows:

$$logit(Y) = natural\ log\ log\ (odds) = ln\left(\frac{\pi}{1-\pi}\right) = \propto\ + \beta X \quad (1)$$

Where π is the probabilities of Y occur, and $1 - \pi$ is the probabilities of Y does not occur. The probability of the the outcome's occurrence can be determined by computing the antilog of Equation 1:

$$\pi = Probability\ (Y \mid X = x) = \frac{e^{\propto\ +\ \beta X}}{1+e^{\propto\ +\ \beta X}} \quad (2)$$

Where $\propto$ is the Y intercept, β stands for regression coefficient, and e = 2.71828.

To predict a dichotomous outcome variable using multiple predictors, the logistic regression can be extended as follows:

$$logit(Y) = natural\ log\ log\ (odds) = ln\left(\frac{\pi}{1-\pi}\right) = \propto\ + \beta_1 X_1 + \beta_2 X_2 + \ldots \quad (3)$$

Taking antilog of Equation 3 will yield the following:

$$\pi = Probability\ (Y \mid X = x) = \frac{e^{\propto\ +\ \beta_1 X_1 +\ \beta_2 X_2 + \ldots}}{1+e^{\propto\ +\ \beta_1 X_1 +\ \beta_2 X_2 + \ldots}} \quad (4)$$

Where $\propto$ is the Y intercept, βs denotes the regression coefficients, *X*s are a set of predictors, and e = 2.71828, in which maximum likelihood method are used to estimate these parameters.

3.6. Statistical Assumption

Before conducting the logistic regression, we checked for high correlations among the independent variables or multicollinearity via Pearson correlation values. The process is used to account for the high correlations among the independent variables, which can otherwise bias the results of logistic regression.

4. RESULTS

To answer the research question "What factors predict the likelihood that respondents would report that GeAR-PM is beneficial?', we calculated the means and standard deviations of the independent variables as shown in.

The data consisted of *performance expectancy*, *effort expectancy*, *social influence*, *facilitating conditions*, and *self-efficacy* scores of 202 teachers. Of these teachers, 195 (96.5%) stated that GeAR-PM is beneficial, and only 7 (3.5%) did not agree that GeAR-PM is beneficial. Table 2 shows that the mean scores of the predictor variables ranged from 2.15 to 3.60. The *performance expectancy*, *effort expectancy*, and *social influence* showed a high mean score (3.29), indicating teachers reported that GeAR-PM would help them improve their teaching and learning. The *effort expectancy* also showed a high score (3.60), which indicates that teachers would be able to use Gear-PM easily. In addition, the *social influence* also showed a high mean score, implying that peers and school administrators help teachers in using the GeAR-PM. On the contrary, *facilitating conditions* showed a rather moderate mean score, suggesting that teachers possess moderate familiarity with using the GeAR-PM, and the supporting facilities to enable teachers to use GeAR-PM were also somewhat fair.

Table 2. Description of data set for logistic regression.

GeAR-PM is beneficial?	Total sample	Performance expectancy		Effort expectancy		Social influence		Facilitating conditions		Self-efficacy	
		M	SD	M	SD	M	SD	M	SD	M	SD
Yes	195	2.43	1.27	2.43	0.98	2.14	0.69	1.71	0.76	2.43	0.98
No	7	3.32	1.03	3.65	0.80	3.47	0.83	2.16	0.72	3.01	1.00
Total	202	3.29	1.05	3.60	0.84	3.43	0.86	2.15	0.72	2.99	1.00

Table 3 shows the Pearson correlation values among the independent variables, ranging from -0.01 to 0.60. These values indicate there were no issues of multicollinearity.

Table 3. Correlations between independent variables.

No.	Item	Performance expectancy	Effort expectancy	Social influence	Facilitating conditions	Self-efficacy
1	Performance expectancy	1.00				
2	Effort expectancy	0.60**	1.00			
3	Social influence	0.53**	0.58**	1.00		
4	Facilitating conditions	-0.01	0.58	0.07	1.00	
5	Self-efficacy	0.51**	0.60**	0.57**	0.02	1.00

Note: **Correlation is significant at the 0.01 level (2-tailed).

After confirming that there was no multicollinearity issue, we fitted the five-predictor logistic regression to test the hypothesis of the relationship between the likelihood that teachers reported that GeAR-PM would be beneficial and his/ her perceptions on performance expectancy, effort expectancy, social influence, facilitating conditions and self-efficacy. Based on Table 4, the result of the logistic regression is as follows:

Predicted logit of (GeAR-PM is beneficial) = -4.408 + 2.654*(effort expectancy) + 2.366*(social influence) - 2.310*(self-efficacy).

Based on the model, the log odds of a teacher stated that GeAR-PM would be beneficial was positively related to his/ her perceptions on *effort expectancy* ($p < 0.05$) and *social influence* ($p < 0.05$), but negatively related to his/ her perception on *self-efficacy* ($p < 0.05$). In other words, the higher the score on *effort expectancy* and *social influence*, the more likely that a teacher would agree that GeAR-PM would be beneficial. On the contrary, the higher the higher the score on *self-efficacy*, the less likely that a teacher would agree that GeAR-PM would be beneficial.

The odds of a teacher with high score on *effort expectancy* stated that GeAR-PM would be beneficial were 14.22 ($=e^{2.654}$) times greater than the odds for a teacher with lower score on *effort expectancy*. Similarly, the odds of a teacher with high score on *social influence* stated that GeAR-PM would be beneficial were 10.65 ($=e^{2.366}$) times greater than the odds for a teacher with lower score on *social influence*. On the contrary, the odds of a teacher with high score on *self-efficacy* stated that GeAR-PM would be beneficial were only 0.099 ($=e^{-2.310}$) times greater than the odds for a teacher with lower score on *self-efficacy*.

We also examined the effectiveness of our logistic regression model by conducting overall model evaluation using likelihood ratio test, assessing goodness-of-fit statistics via Hosmer-Lemeshow test (Hosmer, Hosmer, Le Cessie, & Lemeshow, 1997) as well as validating predicted probabilities through classification table. From Table

4, the likelihood ratio test showed that the logistic model (1) was more effective than the intercept-only model also known as the null model. The observed improvement over the null model suggests that the model was successfully fitted to the provided data. In addition, the Hosmer-Lemeshow goodness-of-test yielded a $\chi2(7)$ of 0.867 and was insignificant ($p > 0.05$). This also implies that the model was fit to the data. The value of the Cox & Snell R Square (Cox & Snell, 1968) is 0.119, and the value of the Nagelkerke (1991) R Square is 0.459, indicating that between 11.9% and 45.9% of the variability in the outcome variable was explained by the predictor variables.

Table 4. Logistic regression of 202 teacher's would report that the gear-PM would be beneficial.

Predictor	*β*	*SE β*	*Wald's χ2*	*df*	*p*	*e^β (Odd ratio)*
Constant	-4.408*	2.021	4.756	1	0.029	0.012
Performance expectancy	-0.154	0.599	0.066	1	0.797	0.857
Effort expectancy	2.654**	1.098	5.847	1	0.016	14.218
Social influence	2.366**	0.958	6.101	1	0.014	10.650
Facilitating conditions	0.064	0.891	0.005	1	0.942	1.066
Self-efficacy	-2.310*	1.079	4.583	1	0.032	0.099
Test	-	-	*χ2*	*df*	*p*	
Overall model evaluation	-	-	-	-	-	-
Likelihood ratio test	-	-	53.137*	-	-	-
Goodness-of-fit test	-	-	-	-	-	-
Hosmer & Lemeshow	-	-	0.867	7	0.997	-

Note: Cox and Snell R2 = 0.119, Nagelkerke R2 (Max rescaled R2) = 0.459.
*Value is significant at the 0.05 level (2-tailed).
**Value is significant at the 0.01 level (2-tailed).

We then examined the validity of the predicted probabilities based on the classification table. Table 5 shows that the percentage accuracy in classification was 97.0 per cent, an improvement over the 96.5 per cent in the null model.

Table 5. The classification table.

Observed (beneficial)	Null model			Logistic model		
	Predicted (beneficial)		% Correct	Predicted (beneficial)		% Correct
	No	Yes	No	No	Yes	
No	0	7	0	1	6	14.3
Yes	0	195	100	0	195	100.0
Overall % correct	-	-	96.5	-	-	97.0

5. DISCUSSION

This study intends to predict the perception amongst the Malaysian mathematics secondary school teachers that GeAR-PM is beneficial using five predictors, namely performance expectancy, effort expectancy, social influence, facilitating conditions, and self-efficacy. Upon analyzing the results, it was found that only three predictors were significant, namely effort expectancy, social influence, and self-efficacy.

Effort expectancy showed positive significant result, indicating that teachers who perceived GeAR-PM as user-friendly and easy to use tended to respond that GeAR-PM is beneficial. This finding aligns with earlier studies (Mailizar & Johar, 2021; Yuan et al., 2023) which indicate teachers that tend to think technology as beneficial, are more inclined to integrate technology in classroom instructions if they perceive technological devices as user-friendly. Similarly, social influence also exhibited positive significant result, implying that teachers whose peers, researchers and school administrators encouraged them to use GeAR-PM tended to respond that GeAR-PM is beneficial. This outcome is consistent with previous research (Ab Jalil et al., 2022; Jain & Jain, 2022) that has suggested social influence have a significant role in encouraging teachers to use the technology in the teaching and learning processes. Given the collectivist-minded nature in Malaysia, this result can be further explained by Zhao et al. (2021), which suggested that teachers are more inclined to embrace technology after observing their peers doing the same. Self-efficacy was also a significant predictor towards teacher's perception that GeAR-PM was beneficial. This result is consistent with the earlier studies, which showed that teacher's self-efficacy was closely related to his/ her perception that technology is beneficial and hence their intention to use technology (Bakar et al., 2020; Kundu et al., 2021; Teo & Zhou, 2014). Moreover, an earlier study by Henson (2002) demonstrated that teachers with high self-efficacies in addition to recognizing the technology's benefits in their lesson plans, were also able to influence their students to use technology as well.

On the contrary, performance expectancy or also referred to as perceived usefulness of technology in improving user's job outcome was not a significant predictor for the Malaysian teacher's perception that GeAR-PM is beneficial. This finding is coherent with previous study by Pittalis (2021) that found performance expectancy had no direct impact on a teacher's technology behavioral intention. Instead, it only moderated the relationship between teacher's technology behavioral intention and their perceived pedagogical-learning fit.

In addition, this study also determined that facilitating conditions had no significant effect on the teachers' perception towards the benefits of using GeAR-PM, implying that the availability of necessary tools and knowledge have no effect on how teachers perceived GeAR-PM's usefulness. This finding somewhat contradicted the earlier studies (Kundu et al., 2021; Taimalu & Luik, 2019) which revealed how facilitating conditions were crucial in shaping teachers' perception of technology and its benefits, leading to its adoption in the classrooms.

6. CONCLUSION

A logistic regression was performed to identify the main factors influencing the Malaysian secondary school teachers' perception that GeAR-PM is beneficial. In sum, research findings showed that a teacher's perception that GeAR-PM is beneficial was significantly related to their perception on effort expectancy, social influence, and self-efficacy. Therefore, when developing the GeAR-PM, it is encouraged to focus on the user's effort expectancy or in other words interpreted as user's ease of use adopting technology. This means, GeAR-PM must be designed with user-friendly features that are attractive to users. Moreover, the GeAR-PM development process needs to take into account the social influence factor, which specifically pertains to the impact of peers and other individuals on a user's intention to employ technology. Finally, bolstering a teacher's self-efficacy, or their personal assessment of their competence in executing a specific task, should also be considered as a crucial factor to be weighed in when developing the GeAR-PM. This is because teachers who possess high levels of self-efficacy are more susceptible to adopting new technologies. This study has its limitations. Since this study only included secondary school teachers as respondents, it is important to be cautious when generalizing the results. Furthermore, since this study was cross-sectional in nature, no causal relationship can be inferred from its results. Overall, unlike the origin of the UTAUT model in western culture, this study advances the theory in the setting of an eastern nation like Malaysia, which differs economically, socially, and culturally from western countries. Specifically, from the lens of Malaysian secondary teachers, only three out of five components of the UTAUT model, namely effort expectancy, social influence, and self-efficacy, significantly influenced how Malaysian secondary teachers perceived the value of GeAR-PM. As a result, these three factors must be considered when creating the GeAR-PM.

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Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
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