Need analysis of technology-based Pedagogical Module in 2D Geometry: A case study in Malaysia

Analisis keperluan Pembangunan Modul Geometri 2D berasaskan Teknologi: Satu kajian kes di Malaysia

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Abstract

Current studies and achievements show students' low achievement in geometry and some improvements need to be made to overcome this problem. The purpose of this study is to identify the need for the development of a technology-based pedagogical module for students' Geometric Thinking Level (GTL) from the teacher's perception. This study is a case study using a survey method. The questionnaires were distributed to 60 Mathematics teachers from a district in Selangor. The finding of the study shows that 96.7% of teachers agree on the development of technology-based pedagogical module for the topic of 2D geometry. In addition, results show that there is a significant difference in performance expectancy and effort expectancy between teachers with less than 20 years and more than 20 years of teaching experience. The average mean for these two expectancies is also high. Thus, this teaching module should be developed as a teaching aid to enhance teaching and learning in Geometry.

Keywords: 2D geometry, technology, thinking level, pedagogical module, teachers

Abstrak

Kajian dan pencapaian semasa menunjukkan pencapaian yang lemah pelajar dalam geometri dan beberapa penambahbaikan perlu dilakukan untuk mengatasi masalah ini. Tujuan kajian ini adalah untuk mengenalpasti keperluan pembangunan modul pedagogi yang berasaskan teknologi untuk Tahap Pemikiran Geometri (TPG) pelajar daripada persepsi guru. Kajian ini adalag kajian kes dan menggunakan kaedah tinjauan. Soal selidik diedarkan kepada 60 orang guru Matematik di salah sebuah daerah di Selangor. Dapatan kajian menunjukkan 96.7% guru bersetuju untuk modul pedagogi berasaskan teknologi untuk topik geometri 2D ini dibangunkan. Tambahan pula, didapati terdapat perbezaan yang signifikan terhadap jangkaan prestasi dan jangkaan usaha antara guru-guru yang mengajar Matematik kurang 20 tahun dan lebih 20 tahun. Purata min bagi kedua-dua jangkaan ini juga adalah tinggi. Oleh itu, modul pengajaran ini perlu dibangunkan sebagai bahan bantu mengajar bagi memperkasakan pembelajaran dan pengajaran Geometri.

***Kata kunci**: Geometri 2D, teknologi, tahap pemikiran, modul pedagogi, guru*

INTRODUCTION

Malaysia has participated in the Trends in International Mathematics and Science Study (TIMSS) organized by International Association for the Evaluation of Educational Achievement (IEA) to ensure the quality of education in this country is comparable to international education. It is an international assessment joined by Malaysia in 1999 has involved form two students as their samples. The findings from the assessment are used as a benchmark by the Ministry of Education (MOE) to plan and carry out improvements for our education system.

As an effort, Malaysian Education Blueprint 2013-2025 aspires to access, quality, equity, unity, and efficiency in their system is produced. Aligned with National Education Philosophy, it is also intended for students to have the knowledge, thinking skills, leadership skills, bilingual proficiency, ethics, spirituality, and national identity in order to compete globally. Therefore, eleven shifts have been identified to achieve the desired outcomes and one of them is to leverage Information and Communication Technology (ICT) to intensify learning quality across Malaysia.

Figure 1 below shows the mean score in Mathematics achieved by Malaysian students throughout their participation in TIMSS. As shown in the figure, students' achievement throughout the years is not consistent. Starting from the first year of participation, the mean scores obtained are 519, 508, 474, 440, 465, and 461 (MOE, 2020). From this result, the highest mean score is 519, which exceeded the international mean score for the year 1999. However, the trend began to decline in subsequent years of participation and only showed an improvement of 25 points in TIMSS 2015. For TIMSS 2019, the mean score obtained is 461 and it is still below the international mean score.

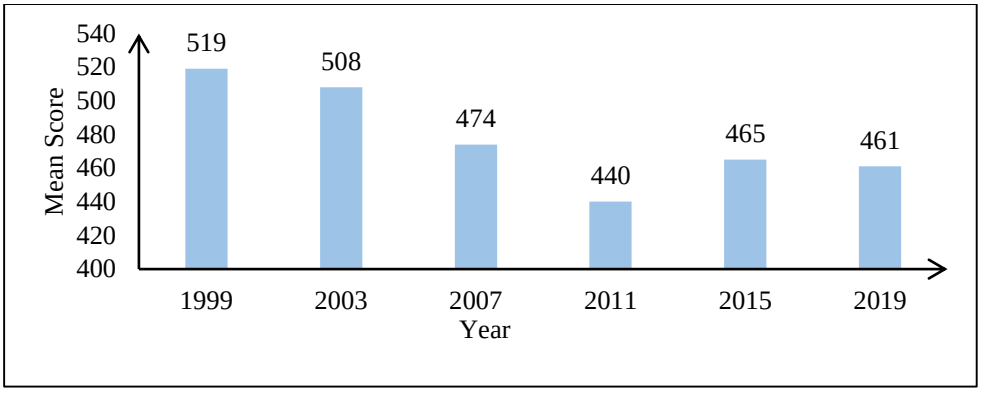

Figure 1: Malaysian Students' Achievement in Mathematics TIMSS 1999-2019

TIMSS assessment involves geometry as one of the assessed domains. Geometry is a branch of Mathematics that involves size, shape, 2-dimension shape (2D), and 3-dimension (3D) objects (Novita, Putra, Rosayanti & Fitrianti, 2018). MOE (2020) reported that Malaysian students' achievement in the geometry domain is below the international average score throughout the participation with a mean score of 474 (2007), 432 (2011), 455 (2015), and 466 (2019). These statistics show that students are facing problems in this field and improvements need to be made to enhance their Mathematics performance, especially in geometry.

According to Fauziah and Shaharudin (2020), low achievement in geometry is caused by misconceptions and weaknesses in geometry basic concepts. TIMSS 2019 analysis shows that students have not yet mastered 2D geometry although it is basic to 3D geometry. This is related to the teachers' teaching strategy as the use of textbooks alone and the teacher's traditional teaching approach in class has caused students to be less interested (Thangamani & Leong, 2019). In addition, memorization methods are often used and become a factor in students' lack of understanding of the concepts (Mohd Rizal Abdul Raman & Ying, 2021).

Moreover, this is because of students' low GTL (Muhammad Ammar Naufal, Abdul Halim Abdullah, Sharifah Osman, Mohd Salleh Abu & Hisyam Ihsan, 2020). According to van Hiele (1957), there are five levels in GTL namely visualization, analysis, informal deduction, formal deduction, and rigor. These levels need to be passed by students in learning geometry to ensure their full understanding of geometry. As GTL plays a significant role in learning geometry, the current situation is quite worrying. In an effort to enhance students' GTL, teachers need to play their role to improve their teaching and learning sessions as the formation of GTL requires a careful selection of learning strategies and activities that will catalyze students' understanding (Muhammad Nasiru Hassan, Abdul Halim Abdullah & Norulhuda Ismail, 2020).

Therefore, the integration of technology in the classroom is one of the strategies that can be used by Mathematics teachers that has been proven to improve students' achievement. According to Mishra and Koehler (2006), technology is divided into standard technology such as paper, chalk and blackboard, and digital technology (advanced technology) such as the internet and web. However, generally, the involvement of technology in Malaysian education is still low (MOE, 2020). This shows that teachers' competency needs to be improved as it will drive their teaching quality to be in line with today's needs. Thus, in this study, the researcher aimed to develop a pedagogical module that uses technology in teaching 2D geometry for students' GTL. This module will act as a reference for other teachers, improve their competency, and overcome problems faced by students in learning 2D geometry.

Unified Theory of Acceptance and Use of Technology (UTAUT)

The UTAUT model is introduced by Venkatesh, Morris, Davis, and Davis (2003) to determine users' technology acceptance of technology. It consisted of four main constructs which are performance expectancy, effort expectancy, social influences, and facilitating condition. In addition, age, gender, and experience act as the mediator that influences the behavioral intention to use technology. In this study, only performance and effort expectancy components will be involved because the study has shown that these expectancies are the strong determinant of teachers' intention to use technologies in the teaching and learning process (Buraimo, Yusuf, Olusanj, Ajijola & Aladesusi, 2020). Performance expectancy is the teacher's level of belief that the use of technologies will benefit teachers' performance in the education process. This includes that the use of technologies is useful, easier, and improves teaching quality. Meanwhile, effort expectancy is the level of ease of the technologies based on teachers' perceptions.

OBJECTIVE AND RESEARCH QUESTION

The objective of this study is to identify the need for Technology-based Pedagogical Module Development for Students' Geometry Thinking Level in 2D Geometry Topics based on teachers' perceptions. Hence, the need analysis conducted will answer these research questions:

1. Do teachers need the technology-based pedagogical module for students' geometry thinking level in 2D geometry topics?
2. What is teachers' level of performance and effort expectancy in using technology for teaching 2D geometry topics?
3. Is there a significant difference in mean score for Performance Expectancy between below 20 years of teaching Mathematics experience and above 20 years of teaching Mathematics experience?
4. Is there a significant difference in mean score for Effort Expectancy between those below 20 years of teaching Mathematics experience and above 20 years of teaching Mathematics experience?

Research Hypotheses

> $\boldsymbol{H_1}$: There is a significant difference in mean score for Performance Expectancy between below 20 years of teaching Mathematics experience and above 20 years of teaching Mathematics experience.
>
> $\boldsymbol{H_2}$:There is a significant difference in mean score for Effort Expectancy between those below 20 years of teaching Mathematics experience and above 20 years of teaching Mathematics experience.

METHODOLOGY

Design and Development Research (DDR) approach proposed by Richey and Klein (2007) is used in this study because according to Saedah Siraj, Muhammad Ridhuan Tony Lim Abdullah, and Rozaini Muhamad Rozkee (2021), DDR is a systematic approach for research involving the development of products such as module, model or program. The three phases in this approach are need analysis (phase 1), design and development (phase 2) and evaluation (phase 3). However, only the need analysis phase is involved in this paper to identify whether module development is needed by the teachers and to identify their level of acceptance towards the use of technology in teaching 2D geometry topics. It can be done using interviews, questionnaires, Delphi method, or Fuzzy Delphi method (Mohd Ridhuan Mohd Jamil & Nurulrabihah Mat Noh, 2021).

In this study, the need analysis is conducted through a survey method by using a questionnaire adapted from the UTAUT model as the instrument. It consists of six parts which are part A (demographic information), part B (perception towards teaching method practices), part C (perception towards geometric thinking level), part D (acceptance and intention to use technology), part E (the need for development of technology-based pedagogical module in teaching 2D geometry) and part F (title and software selection). For parts A, E, and part F, respondents need to tick one of the answers listed while for parts B to part D, they need to tick according to the seven points Likert scale which is 1 (strongly disagree), 2 (disagree), 3 (somewhat disagree), 4 (neutral), 5 (somehow agree), 6 (agree) and 7 (strongly agree).

To ensure the validation of the questionnaire, three experts in technology, mathematics, and language field is involved. All of them are university lecturers who have worked in their respective fields for more than five years. Their comments and suggestions are then used to improve the questionnaire. In addition, a pilot study was also conducted involving 30 Mathematics secondary school teachers to determine the reliability of the instrument. Later, an analysis is conducted, and Cronbach's alpha coefficient is found to be 0.959 which implies that the instrument has very good reliability. However, these 30 teachers are not involved in the actual needs analysis.

Lastly, the instrument is then distributed to the samples. 60 samples were chosen through a purposive sampling technique involving secondary school Mathematics teachers from a district in one of the states in Malaysia. Based on Education Statistics provided by District Education Office (2021), there are 17 secondary schools and a total of 104 mathematics teachers in the district chosen (MOE, 2023). This technique is used as they have the same criteria as other secondary school Mathematics teachers. Furthermore, according to Mohd Awang Idris, Haslina Muhamad, and R Zirwatul Aida R Ibrahim (2018), purposive sampling involves the selection of samples that have the same criteria and information needed in the research while Cohen, Manion, and Marrison (2018) stated that at least 30 respondents are needed to do statistics analysis of data. The data collected is then analyzed using Statistical Package for Social Sciences (SPSS), a commonly used tool in UTAUT acceptance studies (Yee & Abdullah, 2021).

RESULTS AND DISCUSSION

Demographic

Table 1 shows the samples' demographic information. From 60 teachers involved in this need analysis study, for education level, only one of them (1.7%) has a certificate, 50 of them (83.3%) have a diploma, and 9 of them (15%) have a degree. Also, 26 of the teachers (43.3%) have more than 20 years of teaching experience while 34 of them (56.7%) have less than 20 years of teaching experience. For the ICT skills level, only seven of them (11.7%) are in the novice category, 36 of them (60%) are in the intermediate category, 16 of them (26.7%) are in the advanced category, and one of them (1.7%) is already an expert.

Table 1: Demographic

Item		Frequency	Percentage (%)
Education level	Certificate	1	1.7
	Diploma	50	83.3
	Degree	9	15.0
Teaching Mathematics Experience	1-5 years	7	11.7
	6-10 Years	4	6.7
	11-15 Years	11	18.3
	16-20 Years	12	20.0
	More than 20 Years	26	43.3
ICT skills level	Fundamental Awareness	0	0.0
	Novice	7	11.7
	Intermediate	36	60.0
	Advanced	16	26.7
	Expert	1	1.7

Research Question 1

- Do teachers need the Technology-based Module Development for Students' Geometry Thinking Level in 2D Geometry Topics?

Based on Table 2, results show that 53.3% of the samples have referred to any pedagogical module in teaching 2D geometry. However, 56.7% of them have never referred to any technology-based pedagogical module in teaching 2D geometry while 58.3% of them have heard about technology-based pedagogical modules. Therefore, results show that 96.7% of the teachers feel that it is necessary to develop a technology-based pedagogical module for 2D Geometry topics. This result is in parallel with a study by Ruslina Othman, Nor'ain Mohd Tajudin, and Mazlini Adnan (2021) which found that a module is needed in learning Mathematics topics as it can help and guides them to conduct teaching and learning process. Moreover, mathematics teachers show a willingness and earnestness to gain knowledge related to technology although they have difficulty in preparing teaching materials (Ab Hajis, Rosli, Mahmud, Halim & Abdul Karim, 2022).

Besides, results show that 71.7% of teachers do not have enough material to refer to in teaching 2D geometry topics with the use of technology. Although some teachers are able to use technologies for teaching, guidance is still needed (Gaboy, Mabalay, Mananghaya, Mercado & Romblon, 2020). Thus, this module will serve as a reference and help teachers with a lack of technology skills as it is one of the reasons that teachers are in doubt about using technology in their classroom (Alda, Elejorde & Alda, 2022).

Table 2: The Needs of Technology-Based Module Development

Item		Frequency	Percentage (%)
1. Have you ever refer any pedagogical modules in teaching 2D geometry?	Yes No	32 28	53.3 46.7
2. Have you ever refer any technology-based pedagogical modules in teaching 2D geometry?	Yes No	26 34	43.3 56.7
3. Have you ever heard about technology-based pedagogical modules?	Yes No	35 25	58.3 41.7
4. Is it necessary to develop a technology-based pedagogical module for 2D Geometry Topics?	Yes No	58 2	96.7 3.3
5. Do you have enough material to refer to in teaching 2D geometry topics based on technology?	Yes No	17 43	28.3 71.7

Research Question 2

- What is teachers' level of performance and effort expectancy in using technology for teaching 2D geometry topics?

To answer the second research question, Table 3 is referred to determine the interpretations of the mean. For high and very high interpretation of mean, the mean score is in the range of 4.61 to 5.80 and 5.81 to 7.00 respectively (Abdul Razaq Ahmad, Mohd Mahzan Awang and Jamil Ahmad, 2017).

Table 3: Interpretation Of The Mean

Mean Score	Interpretation
1.00 – 2.20	Very Low
2.21 – 3.40	Low
3.41 – 4.60	Moderate
4.61 – 5.80	High
5.81 – 7.00	Very High

Findings for performance expectancy as shown in Table 4 show that all means are very high. The highest mean is 6.10 (SD=0.752), which shows that the use of technology in teaching 2D geometry topics helps teachers to make the teaching and learning process easier. The second highest mean is 6.08 (SD=0.766) for the item stating that teachers' performance will be better for 2D geometry topics through the use of technology. In addition, the lowest mean is 6.05 for items that show the use of technology is useful (SD=0.723) and can improve teaching quality for 2D geometry topics (SD=0.746). Despite that, the overall mean of 6.05 is very high. This concludes that teachers have a very high-performance expectancy for teaching 2D geometry topics with the use of technology. This result is supported by a finding that most teachers have positive perceptions regarding performance expectancy towards the use of technology which is believed to facilitate and improve teachers' performances (Al-Anezi & Alajmi, 2021). Furthermore, this result is also in parallel with a study by Abd Fattah, Yahya, Siraj, Kurniawan dan Mat Zain (2021) where teachers admit that their teaching performance can be enhanced with the use of technology.

Table 4: Performance Expectancy

Item	SD	Mean	Interpretation
1. I feel that teaching the 2D geometry topics with the use of technology is useful for my teaching.	0.723	6.05	Very high
2. The use of technology in teaching the 2D geometry topics helps me to make the teaching and learning process easier.	0.752	6.10	Very high
3. The use of technology is able to improve my teaching quality for 2D geometry topics.	0.746	6.05	Very high
4. My teaching performance will be better for 2D geometry topics through the use of technology.	0.766	6.08	Very high
Overall mean		**6.05**	**Very high**

Besides, findings in Table 5 show that the mean for all items in effort expectancy is also very high, which is 6.01. The highest mean is 6.10 (SD=0.629) for the item stating that the use of technology helps teachers to be more skilled in teaching 2D geometry topics. The two other items have the same 5.97 mean which is also very high. These two items showed that the use of technology makes teachers' interaction easier to understand (SD=0.758) and makes the teaching of 2D geometry topics easy (SD=0.780). In conclusion, teachers have a very high effort expectancy toward the use of technology in teaching 2D geometry topics. This finding is in line with a study conducted by Al-zboon, Gasaymeh, and Al-Rsa'i (2021) which found that mathematics teachers' perception of technology integration in the education process for the effort expectancy dimension is at a high level. Teachers also believe that the use of technology would help and ease students to master in geometry concepts (Abd Fattah et al, 2021).

Table 5: Effort Expectancy

Item	SD	Mean	Interpretation
1. My interaction in teaching 2D geometry topics with the use of technology will be easier to understand.	0.758	5.97	Very high
2. The use of technology makes me easier to be more skilled in teaching 2D geometry topisc.	0.629	6.10	Very high
3. I find that teaching 2D geometry with the use of technology is easy.	0.780	5.97	Very high
Overall mean		**6.01**	**Very high**

Research Question 3 And 4

- Is there a significant difference in mean score for Performance Expectancy between below 20 years of teaching Mathematics experience and above 20 years of teaching Mathematics experience?
- Is there a significant difference in mean score for Effort Expectancy between below 20 years of teaching Mathematics experience and above 20 years of teaching Mathematics experience?

To identify whether there is a significant difference in mean score for Performance Expectancy and Effort Expectancy between those below 20 years of teaching Mathematics experience and those above 20 years of teaching Mathematics experience, t-test is conducted. Table 6 shows the group statistics and the result of the t-test conducted. Findings show that the mean for more than 20 years of teaching experience in both Performance and Effort Expectancy is higher compared to less than 20 years of teaching experience.

Table 6: T-Test Results for Performance Expectancy

	Teaching Mathematics experience	N	Mean	Standard Deviation	p-value	Significant
Performance Expectancy Mean	Less than 20 years	34	5.88	0.678	0.009	Significant
	More than 20 years	26	6.33	0.599		
Effort Expectancy Mean	Less than 20 years	34	5.81	0.652	0.007	Significant
	More than 20 years	26	6.27	0.596		

For performance expectancy, the mean for less than 20 years and more than 20 years of teaching experience is 5.88 (SD=0.678) and 6.33 (SD=0.599) respectively. In addition, the p-value obtained is 0.009 which is less than 0.05. This result shows that there is a significant difference in performance expectancy between teachers with less than 20 years and teachers with more than 20 years of teaching Mathematics experience.

Meanwhile, for effort expectancy, the mean obtained for more than 20 years of teachers is 6.27 (SD=0.596) which is higher compared to 5.81 (SD=0.652) obtained by teachers with less than 20 years of teaching Mathematics experience. However, the 0.007 p-value obtained also shows that there is a significant difference in mean score for effort expectancy between teachers with less than 20 years and teachers with more than 20 years of teaching Mathematics experience.

These findings are in contrast with an overseas study on teachers' technology acceptance which shows that there is no difference in performance and effort expectancy between experienced and inexperienced teachers (Dindar, Suorsa, Hermes, Karppinen & Naykki, 2021). Despite that, other studies on teachers' acceptance of ICT have revealed that performance and effort expectancy play an important role in teachers' behavior and intention to implement ICT in education (Yee & Abdullah, 2021).

CONCLUSION

The purpose of this study is to determine the need for technology-based pedagogical module development for students' geometry thinking level in 2D geometry topics based on teachers' perceptions. Findings show that teachers do need a technology-based module for teaching 2D geometry topics. Moreover, their performance and effort expectancy levels are very high, thus indicating that they have positive expectations towards the use of technology in teaching 2D geometric topics. Findings also show that teaching experience plays a significant role in teachers' performance and effort expectancy. These findings will be used later for the researcher to continue on phase two of DDR which gathers experts' opinions to develop the module and phase three of DDR which is the evaluation of the module. Therefore, based on this study, other researchers and the education system will gain some insight and information regarding the need for technology in the teaching and learning process. Teachers may also gain other benefits as the module that will be developed later can be a reference for teachers to make technology-based modules for other topics while students can experience an interesting learning environment aligned with the current technologies era.

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