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Fuzzy Delphi method for A-level mathematics technological pedagogical and content knowledge module

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ABSTRACT

This study sought to identify the elements for designing and developing the A-level mathematics technological, pedagogical, and content knowledge (TPACK) teaching module. The aim of the module was to incorporate various pedagogies and technological tools for helping mathematics teachers to trigger, maintain, as well as sustain students' interest in learning mathematics. This study used the Fuzzy Delphi method to determine the consensus on how A-level mathematics instruction should be designed. A semi-structured interview had first been conducted to develop a questionnaire. Then, a group of 16 experts was consulted together to discuss their ratings and reach a consensus. The group of experts included educational technology and subject matter experts. Data analysis results showed that the experts accepted all these elements through the expert consensus value above 75%, the threshold value (d)≤0.2, and the Fuzzy score (A)≥α-cut value of 0.5. This research provides implication to A-level mathematics teachers to systematically create an environment that is more conducive to learning and that will ultimately lead to an increase level of students' interest towards learning.

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1. INTRODUCTION

Interest is essential to the learning process. A student's interest in a topic is what drives him or her to put forth extra effort in obtaining knowledge for that particular subject [1], [2]. In education, interest is defined as a psychological state characterized by a high level of attention and prolonged engagement with an activity, accompanied by positive feelings [3], [4]. Being in high state of interest is an event which learners' attention and engagement is high and sustained, which is also identified as one of the key components of effective learning in educational setting [2], [3].

In mathematics study, a positive correlation between students' interest level and mathematics performance was found to be existed, especially among the weaker students [5]. Based on one study conducted in New Zealand, students' attitudes towards mathematics showed a trend of decline, from primary to secondary school education [6]. With higher level of abstraction, such as calculus and statistics, mathematics could be perceived as a more difficult subject, especially to students with weaker academic performance [7].

Learning mathematics will require students to understand things in an abstract manner, rather than just by memorizing definitions or superficial learning [7]. To improve students' self-efficacy in learning mathematics, sufficient efforts must be made by the students. To encourage students to put in effort, it is important to improve students' interest in mathematics learning or doing mathematics-related tasks [7]. In other words, mathematics instructors teaching in the higher learning institutions should teach upper-level mathematics lessons in a manner that would enable students to learn certain abstract mathematical ideas without losing the interest or being bored by the details involved in the learning process [8]. However, as today's methods of teaching have been dominated by a combination of drill-and-practices along with note-taking, passive learning and standardized tests, it needs a greater effort to create an engaging educational environment and to make better use of technology.

This is especially important in the teaching and learning of the A-level program. Chua *et al*. [9] conducted a study to examine how A-level mathematics teachers used instructional strategies and technological tools, and it was discovered that traditional teaching methods are used as the dominant teaching approaches when compared to other teaching approaches. Furthermore, it is clear that exam-oriented teaching was chosen as the primary teaching approach by A-level teachers due to students' preferred learning styles. This discovery also suggests that A-level students' interest in learning may be suppressed as a result of a heavy emphasis on traditional teaching and learning strategies [10].

The significance of knowledge provision in ensuring students have sufficient knowledge to perform well in exams cannot be overstated. Nonetheless, it is critical that students interact and also have fun while learning in order to achieve meaningful and authentic learning wherever possible. It is critical to review the teaching strategies that teachers have used in a science or mathematics class in order to minimize the unwelcome consequences of high-stakes exams and attract more students to have an interest or even aspiration in science and mathematics.

Many researchers advocated various theories to study the impact between intervention and students' interest in learning. In this study, the interest-driven creator (IDC) theory was referred as the theoretical foundation that supports the designing of interest-arousing activities [8]. The IDC theory is a design theory that suggests that students can be motivated to engage in knowledge creation through their interests. This theory is based on three main concepts: interest, creation, and habit. The interest loop consists of three components: triggering, immersing, and extending. The creation loop consists of imitating, combining, and staging. The habit loop consists of a cuing environment, routine, and harmony. These three loops are interconnected and the design process is guided by the IDC theory. The hypothesis is that by designing technology-supported learning activities that align with the IDC theory, students will develop an interest in learning [8], [11], [12].

On the other hand, due to COVID-19, governments around the world imposed the closure of schools to control the widespread of the epidemic. In Malaysia's context, movement control order (MCO) was implemented and schools were ordered to close, online learning or e-learning took place to replace the face-to-face teachings at all levels, ranging from pre-school, primary, secondary, as well as higher learning institutions [13]. As the only teaching and learning option available during trying times, online learning has provided flexibility with the study hours and environment as some of its advantages [13]. On the other hand, online learning might alleviate the motivation of learning, which further limits students-teachers engagement and promotes anxiety experienced by students [13], [14]. A study to investigate challenges of home learning during MCO among Universiti Teknologi MARA Pahang students by Mohamed *et al*. [15] discovered a similar finding in which home learning led to loss of interest towards the subject.

Several studies also suggested that teachers lack of online teaching skills and technical skills hindered the process of effective online learning. Farah *et al*. [16] is covered that teachers' lack of competence in conducting online lessons was reported as one of the main challenges faced by the students. In another study conducted in India, Verma and Priyamvada [17] surveyed 100 school teachers to gain the opinions of these teachers for using online teaching tools during the period when the schools were closed. 37% of teachers expressed their unpreparedness in using the variety of online applications to utilize them to their full extent.

While many schools have reopened, technology is still being used widely in class for various reasons. Though technology is a great aid in the teaching and learning of students, poor use of technology can also be harmful. While teachers may use technology in their classes, they often utilize it in a monotonous way. Derakhshan *et al*. [18] reported that teachers' monotonous and long monologues during the delivery of online instructions also contributed to another source of students' low engagement and boredom. In the discussion of the characteristics of effective teachers, subject matter knowledge is often turned out to be one of the highlights [19]. It is crucial for teachers to have good command of content knowledge so the teachers could provide clarity and explanation in establishing a positive classroom setting [20]. However, having good subject matter knowledge is not enough to make the learning session engaging and deliver to content in an interesting manner [21].

Pompea and Walker used the following analogy to describe content knowledge and pedagogical knowledge, content knowledge is "what is being taught" while pedagogical knowledge is "how it is being taught" [22]. If the teacher may know everything but does not know how to convey it, then it is just a matter of time when the students will start to lose interest in learning. Furthermore, addressing to the current transition in between face-to-face and online learning, the 4th industry revolution, as well as the expectation of the digital natives, the generation Z, it is also important for teachers to equip themselves with the suitable technology to carry out effective instruction. From the previous parts of this article, we know where we are now in the context of preparedness to integrate technology into teaching, our teachers still face challenges and difficulties in utilizing technology to deliver content in an interactive and engaging manner that will stimulate students' interest. To reach where we want to be, which is to deliver the content of a subject while incorporating the effective use of technology and pedagogy, there is still a considerable discrepancy that can be filled.

The mismatch of competency in utilizing technology and pedagogy adversely influences the delivery of quality lessons to their students [23]. This gap in the field of technology integration framework and practices of mathematics teachers' pedagogical skills is evident. To address the gap, a technology integration framework for effective instruction of mathematics content is required [24]. In this study, technological, pedagogical, and content knowledge (TPACK), was used as the framework to present the set of knowledge and skills the teachers need to equip in order to be able to teach effectively using technology in the classroom [25].

This paper describes the design and development process of a guidance module to prepare instructors to use instructional strategies and technologies to teach mathematics. This study anticipates answering the following research questions: i) What are the experts' collective views on the elements to be included in the TPACK module?; (ii) What are the learning strategies to be included in the TPACK module to raise or sustain students' interest in learning mathematics? The module is developed using TPACK as its framework. This module is aimed to help the instructors by providing a range of technologies and instructional strategies for mathematics teachers to teach general certificate of education (GCE) A-level mathematics. Through learning and preparing instructional strategies on how to deliver lessons during mathematics lessons, this module is hoped to raise students' interest in learning mathematics, which eventually leads to an increase in students' performance in mathematics.

2. RESEARCH METHOD

To validate instructional strategies and technological tools for teaching GCE A-level mathematics, a panel of experts was convened. In addition, the Fuzzy Delphi method (FDM) was employed to obtain consensus. The FDM helped to ensure that the opinions of each expert were taken into account and a group consensus was reached on the most effective elements and sub-elements of these strategies and tools.

2.1. Fuzzy Delphi method

The Fuzzy Delphi method is an improved version of the traditional Delphi method for obtaining consensus. As shown in Table 1, FDM is both faster and more effective by reducing the experts' time spent on answering each question and ensuring the completeness and consistency of opinions [26]. Similar to the traditional Delphi method, the first two steps of Fuzzy Delphi method involve the construction of Fuzzy Delphi questionnaire and the selection of a group of experts. This group of experts should have experience in the subject matter being examined. Then, the experts were asked to state the level of agreement on each item whether strongly agree, agree, slightly agree, disagree, and strongly disagree. At the same time, the experts also provided their feedback in a qualitative manner on the items in the questionnaire. Experts' level of agreement given in the form of Likert Scale were then being interpreted into Fuzzy number and analyzed using Microsoft Excel software. The threshold value and defuzzification process involved along with the Fuzzy number theory made this data analysis technique as the FDM [26].

Table 1. Comparison of the traditional Delphi and the Fuzzy Delphi method

Feature	Traditional Delphi method	Fuzzy Delphi method
Iteration	Usually more than two rounds	One round
Time	More time is spent collating expert opinions	Reduces survey time
Incorporation of uncertainty	Misinterpretation of expert opinions can occur, leading to difficulties in reaching consensus.	Experts can better express their opinions, ensuring the completeness and consistency of the group opinions as it takes into account the fuzziness that cannot be avoided during the survey process
Sample	Requires only a large number of samples.	Requires only a small number of samples.

2.2. Construction of the FDM instrument

In order to construct a questionnaire, a semi-structured interview had firstly to be conducted to gather experts' opinion on the pedagogical activities, technological tools, and instructional strategies to stimulate or maintain students' interest in learning mathematics. Combining with the findings from the literature review, the questionnaire for the conduct of Fuzzy Delphi Method was developed to obtain experts' consensus to answer the research questions. The steps involved in the different phases of Fuzzy Delphi Method are illustrated as in Figure 1.

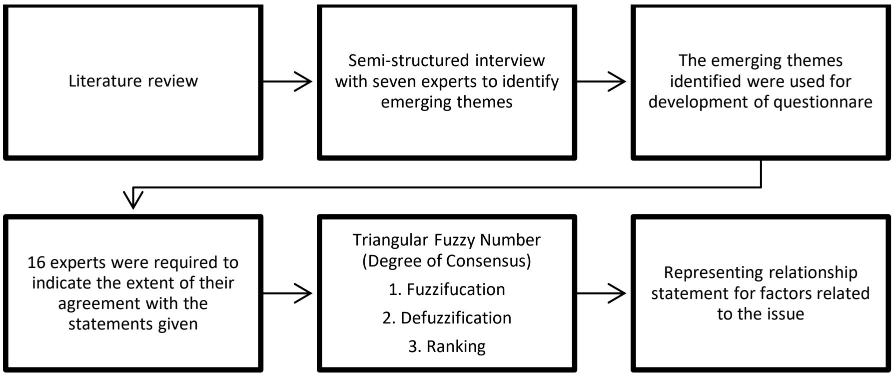

Figure 1. Illustration of different phases of Fuzzy Delphi method

Based on previous studies, it was suggested that literature review, pilot studies, or self-experience could be used as the basis to construct the questionnaire [27]–[29]. In a study to examine how A-level mathematics teachers used instructional strategies and technological tools conducted by Chua *et al*. [9], it was revealed that with the proliferation of new devices and software, it can be difficult for teachers to keep up with the latest trends. However, by emphasizing instructional strategies and providing a reference guideline for technological tools in a teaching module, teachers can feel confident that they are using the best possible tools for their students.

Developing on the results also obtained from the qualitative research conducted by Chua *et al*. [9], seven A-level mathematics lecturers were interview and four main themes were determined to be the essential inclusions for the TPACK teaching module. These themes were: i) The suitable elements to be included in the TPACK teaching module; ii) The instructional strategies to stimulate students' interest; iii) The learning activities to maintain students' interest; and iv) The learning condition to sustain students' interest. These four main themes were identified to accommodate Interest-Driven Creator theory and TPACK. These topics were consistent with the TPACK and IDC theories. The first theme, which emphasizes the inclusion of suitable elements in the TPACK teaching module, ensures that students acquire knowledge that is relevant and meaningful. The second theme, on the other hand, fits with the interest loop of IDC theory, which focuses on the components of instructional tactics aimed at stimulating interest. In addition, the third theme corresponds with the creation loop of IDC theory, which outlines the components of learning activities that emphasize creation, which could be in the form of demonstration of knowledge, in order to maintain students' interest. The fourth component correlates with the habit loop of IDC theory, which emphasizes the environment that might aid to sustain students' motivation in learning. These themes were also referred as the domains. In the further breakdown of these domains, 5 items were categorized under domain 1, 8 items were categorized under domain 2, 5 items were categorized under domain 3, and 5 items were categorized under domain 4.

In this study case, the questionnaire was sent to the field experts for feedback after it had been constructed. To test for reliability, the Cronbach's alpha values were also computed. In particular, the Cronbach's alpha value for domain 1 is 0.935, for domain 2 is 0.886, for domain 3 is 0.858, and for domain 4 is 0.875. Three educational technology experts and three subject matter experts were referred to validate the instrument. The questionnaire had a 7-point Likert scale and comprised the following sections: section 1 on the experts' details; section 2 (Domain 1) on the experts' collective views on the elements to be included in the TPACK module; section 3 (Domain 2) on the instructional strategies to stimulate students' interest through triggering, immersing, and extending.; section 4 (Domain 3) the learning activities to maintain/ raise students' interest through imitating, combining, and staging; section 5 (Domain 4) on the learning condition to sustain students' interest through cuing environment, routine and harmony. Detailed descriptions of the items included in each domain can be seen in Tables 2 to 5.

Table 2. Items included in domain 1, the suitable elements to be included in the TPACK module

Item	Descriptions
D1Q1	The module should be organized according to the content of the curriculum.
D1Q2	Technology applications relevant to the content should be introduced in the module to facilitate teaching & learning activities.
D1Q3	Instructional strategies should be introduced or demonstrated to facilitate teaching & learning of the subject knowledge.
D1Q4	The module should provide opportunities to reflect on one's own practices on how to implement TPACK to stimulate or maintain students' interest.
D1Q5	The module should provide explanations on the theories involved, such as TPACK and Interest Driven Creator theories

Table 3. Items included in domain 2, the instructional strategies to stimulate students' interest through triggering, immersing, and extending (IDC theory)

Item	Descriptions
D2Q1	To present a concept using direct instruction and chalk-and-talk.
D2Q2	To present a concept using direct instruction with the help of interactive tools, animation, simulation, or other display media.
D2Q3	To prepare notes for the students and deliver the lessons using the notes.
D2Q4	To allow students to investigate a concept, with the aid of the technological tools.
D2Q5	To let students to verify a concept that the teacher has introduced, with the help of the technological tools.
D2Q6	To promote collaborative learning opportunities, such as playing the games as a team, during introduction or reinforcement of a concept, with the aid of the technological tools.
D2Q7	To add the elements of Game Based Learning into the procedural drilled practices, with the aid of the technological tools.
D2Q8	To integrate real life context with the concept introduced, with the help of the technological tools.

Table 4. Items included in domain 3, the learning activities to maintain/raise students' interest through imitating, combining, and staging (IDC theory)

Item	Descriptions
D3Q1	To give students the opportunities for them to demonstrate their workings during the class time or the consultation hour, individual, or as a team.
D3Q2	To encourage students to create conceptual maps or procedural steps to demonstrate the strategies to solve mathematical problems.
D3Q3	To allow students to develop or deliver a lesson/ sharing session to explain or demonstrate a certain concept or problem-solving strategy.
D3Q4	To let students to make quizzes as an individual or collective manner, to be played by others to assess their understanding of the concept, with the help of the technological tools.
D3Q5	To hold pre-lesson or post-lesson discussion, with the help of the technological tools.

Table 5. Items included in domain 4, the learning condition to sustain students' interest through cuing environment, routine, and harmony (IDC theory)

Item	Descriptions
D4Q1	To set up a homework routine that students can finish and will finish, with the help of technological tools.
D4Q2	To constantly support students before, during, and after class, with the help of the technological tools.
D4Q3	To maintain constant communication with students, with the help of the technological tools.
D4Q4	To collect regular feedback from the students about their views and their needs, with the help of the technological tools.
D4Q5	To promote students to work together, collectively, on the questions they are asked to do.

2.3. Selection of a group of experts

At this stage, a group of 16 panels comprising the subject matter experts and the technology experts are selected through purposive sampling method to evaluate the module. In the Fuzzy Delphi method, the output of the study relies on the selection of experts. When selecting the experts, the researcher should ensure that their expertise is relevant to the subject at hand and that their opinion is trusted.

The selection criteria for this study include subject lecturers with more than five years of teaching experience [27]. In addition, as one of the objectives of this study is to develop a module that shares technological tools aiming to stimulate or maintain students' interests, the opinion of a group of technology experts was also sought. This group of experts comprised educational technology experts who possessed practical experience on the use of emerging educational technologies in today's classroom. In a related vein, research indicates that in investigation utilizing Fuzzy Delphi method, a minimum of 10 experts are required to establish a high level of agreement among them [27]. Taking these criteria into consideration, we chose 16 participants to evaluate and validate the model in this study. Table 6 provides more details regarding the specialists.

Table 6. Summary of the details among the experts

Number of experts	Position	Area of expertise	Years of teaching experience
3	Senior lecturers	Educational technology experts	10–25 years
1	Lecturers	Educational technology experts	7 years
5	Senior lecturers	Subject matter experts	5–25 years
7	Lecturers	Subject matter experts	5–10 years

2.4. Data analysis

A 7-point linguistic scale as shown in Table 7 was used to convert the experts' responses from a Likert scale to Fuzzy numbers. The Fuzzy Delphi method, unlike the traditional Delphi method, incorporates elements of fuzzy logic, allowing for the consideration of uncertainty and subjectivity during the decision-making process. These fuzzy values provide a more inclusive representation of the experts' opinions and account for the subjectivity and uncertainty of their answers. Based on the responses of the experts in the first round of the survey, the minimum value (n1), the most reasonable value (n2), and the maximum value (n3) are calculated and used to determine the difference between the individual value and the mean value of the group. The use of fuzzy values in the Fuzzy Delphi method facilitates a reduction in survey duration, an increase in questionnaire recovery rate, and a more precise expression of expert opinion.

The 7-point linguistic scale has three different values, namely the minimum value (n1), the most reasonable value (n2), and the maximum value (n3), as shown in Table 7. For an instance, when a rating of 5 from a Likert scale is turned into Fuzzy value, it is corresponded to the Fuzzy values of 0.5, 0.7, and 0.9. This signifies that the minimum value (n1) of experts agree to the particular element is 0.5 (50%), the most reasonable value (n2) is 0.7 (70%), and the maximum value (n3) is 0.9 (90%) [30].

Table 7. 7-point linguistic scale to convert the experts' responses from a Likert scale to Fuzzy numbers

7-Point linguistic scale	The minimum value (n1)	The most reasonable value (n2)	The maximum value (n3)
Extremely strongly agree	0.90	1.00	1.00
Strongly agree	0.70	0.90	1.00
Agree	0.50	0.70	0.90
Moderately agree	0.30	0.50	0.70
Disagree	0.10	0.30	0.50
Strongly disagree	0.00	0.10	0.30
Extremely strongly disagree	0.00	0.00	0.10

In this case, we used a 7-point linguistic scale to assess respondents' answers to a question. The idea behind using this particular scale is that the higher the number on the scale, the more accurate the analysis of the responses will be [30]. The average fuzzy values, m1, m2, and m3, on the other hand, represent the average minimum, average most reasonable, and average maximum values of the experts' individual responses, respectively. These average fuzzy values are determined by averaging the n1, n2, and n3 values contributed by each expert in each round of the Fuzzy Delphi technique. In order to ensure experts' consensus on each item, the threshold value d must not exceed 0.2 The threshold value is the minimum level of acceptance must agree upon by the experts. The threshold value should be smaller than or equal to 0.2 (≤0.2) while the overall agreement should exceed 75% of the deal for each item [27]. The formula (1) is used to calculate the threshold value. Last but not least, the process of defuzzification or the process of ranking the items is to prioritize the importance of each element. This study employs the (2) to calculate the defuzzification value.

$$d(\widetilde{m},\bar{n}) = \sqrt{\frac{1}{3}[(m_1-n_1)^2+(m_2-n_2)^2+(m_3-n_3)^2]} \tag{1}$$

$$A = \frac{1}{3}(m1+m2+m3) \tag{2}$$

For the element to be considered as accepted by the experts' consensus, the defuzzification values have to be more than the α-cut value of 0.5, otherwise the element has to be rejected. In a nutshell, for an item to be considered as accepted by experts' consensus, that item should have i) A value of threshold, d ≤ 0.2; ii) The overall agreement are above 75%; and (ii) All defuzzification values (A) are more than the α-cut value of 0.5.

3. RESULTS

The results of the analysis are presented in the following section. The threshold values, percentage of experts' consensus, as well as the fuzzy score of all items of different domains were presented, followed by the items position by ranking. The results showed that there was a high degree of agreement among experts on the importance of most items. Table 8 shows the findings of experts' consensus on domain 1, the suitable elements to be included in the TPACK module.

Table 8. Findings of experts' consensus on domain 1, the suitable elements to be included in the TPACK module

Item	Condition of triangular Fuzzy numbers		Condition of defuzzification process	Position	Experts' consensus
	Threshold value (d)	Percentage of experts group consensus (%)	Fuzzy score (A)		
D1Q1	0.148	81	0.813	4	Accepted
D1Q2	0.120	88	0.819	3	Accepted
D1Q3	0.161	81	0.794	5	Accepted
D1Q4	0.105	81	0.867	1	Accepted
D1Q5	0.105	81	0.867	1	Accepted

Conditions: Triangular Fuzzy numbers
i) Threshold value (d) ≤ 0.2
ii) Percentage of experts' consensus > 75%

Defuzzification process
iii) Fuzzy score (A) ≥ α-cut value of 0.5

From the data in Table 8, it can be seen that all items in domain 1 have percentage of experts group consensus to be more than 75%, fuzzy score to be more than or equal to 0.5, as well as threshold values (d) smaller than or equal to 0.2. In other words, the experts agreed that these items to be included in the TPACK module. The rank suggests in terms of opinion by the experts that D1Q4 and D1Q5 are the most and equally important elements to be included in the TPACK module, followed by D1Q2, D1Q1, and D1Q3. Table 9 shows the sorted list of the items of domain 1.

Table 9. Items position by priority of domain 1, the suitable elements to be included in the TPACK module

Position	Items	Item number
1	The module should provide opportunities to reflect on one's own practices on how to implement TPACK to stimulate or maintain students' interest	D1Q4
1	The module should provide explanation on the theories involved, such as TPACK and Interest Creator Driven theories.	D1Q5
3	Technology applications relevant to the content should be introduced in the module to facilitate teaching & learning activities	D1Q2
4	The module should be organized according to the content of the curriculum, so that based on a chapter-by-chapter basis	D1Q1
5	Instructional strategies should be introduced or demonstrated to facilitate teaching & learning of the subject knowledge	D1Q3

For the items in domain 1, Table 9 shows that the element stated in as items D1Q4 "The module should provide opportunities to reflect on one's own practices on how to implement TPACK to stimulate or maintain students' interest" and D1Q5 "The module should provide explanation on the theories involved, such as TPACK and Interest Creator Driven theories" are ranked the highest. This is followed by item D1Q2 "Technology applications relevant to the content should be introduced in the module to facilitate teaching & learning activities", thus ranked the second. The item D1Q1 "The module should be organized according to the content of the curriculum, so that based on a chapter-by-chapter basis, which ranked the third. Finally, item D1Q3 "Instructional strategies should be introduced or demonstrated to facilitate teaching & learning of the subject knowledge" is in the 4th rank. On the other hand, Table 10 shows the findings of experts' consensus on domain 2, the instructional strategies to stimulate students' interest through triggering, immersing, and extending (IDC theory).

Table 10. Findings of experts' consensus on domain 2, the instructional strategies to stimulate students' interest through triggering, immersing, and extending (IDC theory)

Item	Condition of triangular Fuzzy numbers		Condition of defuzzification process	Position	Experts' consensus
	Threshold value (d)	Percentage of experts group consensus (%)	Fuzzy score (A)		
D2Q1	0.120	81	0.842	6	Accepted
D2Q2	0.119	81	0.879	2	Accepted
D2Q3	0.089	88	0.877	3	Accepted
D2Q4	0.119	81	0.879	2	Accepted
D2Q5	0.140	88	0.806	7	Accepted
D2Q6	0.110	81	0.867	5	Accepted
D2Q7	0.114	81	0.873	4	Accepted
D2Q8	0.109	88	0.896	1	Accepted

Conditions: Triangular Fuzzy numbers
i) Threshold value (d) ≤ 0.2
ii) Percentage of experts' consensus > 75%

Defuzzification process
iii) Fuzzy score (A) ≥ α-cut value of 0.5

From the data in Table 10, it can be seen that all items in domain 2 have percentage of experts group consensus to be more than 75%, fuzzy score to be more than or equal to 0.5, as well as threshold values (d) smaller than or equal to 0.2. In other words, the experts agreed that these items to be included in the TPACK module. The rank suggests in terms of opinion by the experts the most relevant and effective ways to stimulate students' interest through triggering, immersing, and extending. Table 11 shows the sorted list of the items of domain 2.

Table 11. Items position by priority of domain 2, the instructional strategies to stimulate students' interest through triggering, immersing, and extending (IDC theory)

Position	Items	Item number
1	To integrate real-life context with the concept introduced, with the help of the technological tools	D2Q8
2	To allow students to investigate a concept, with the aid of the technological tools.	D2Q4
2	To present a concept using direct instruction with the help of interactive tool, animation, simulation, or other display media	D2Q2
3	To prepare notes for the students and deliver the lessons using the notes.	D2Q3
4	To add the elements of Game Based Learning into the procedural drilled practices, with the aid of the technological tools	D2Q7
5	To promote collaborative learning opportunities, such as playing the games as a team, during introduction or reinforcement of a concept, with the aid of the technological tools	D2Q6
6	To present a concept using direct instruction and chalk-and-talk.	D2Q1
7	To let students to verify a concept that the teacher has introduced, with the help of the technological tools	D2Q5

For the items in domain 2, Table 11 shows that the element stated as item D2Q8 "To integrate real-life context with the concept introduced, with the help of the technological tools" is ranked the highest. The is followed by items D2Q4 "To allow students to investigate a concept, with the aid of the technological tools" and D2Q2 "To present a concept using direct instruction with the help of interactive tool, animation, simulation, or other display media", which ranked in the second place. Next, item D2Q3 "To prepare notes for the students and deliver the lessons using the notes" rank in the third place. This is followed by item D2Q7 "To add the elements of Game Based Learning into the procedural drilled practices, with the aid of the technological tools, which is ranked fourth in the domain. In the fifth place, there was the item D2Q6 "To promote collaborative learning opportunities, such as playing the games as a team, during introduction or reinforcement of a concept, with the aid of the technological tools.". After that, item D2Q1 "To present a concept using direct instruction and chalk-and-talk" ranked the sixth place. Last but not least, item D2Q5 "To let students to verify a concept that the teacher has introduced with the help of the technological tools" ranked in the seventh place. On the other hand, Table 12 shows the findings of experts' consensus on domain 3, learning activities to maintain/raise students' interest through imitating, combining, and staging (IDC theory).

Table 12. Findings of experts' consensus on domain 3, learning activities to maintain/raise students' interest through imitating, combining, and staging (IDC theory)

Item	Condition of triangular Fuzzy numbers		Condition of defuzzification process	Position	Experts' consensus
	Threshold value (d)	Percentage of experts group consensus (%)	Fuzzy score (A)		
D3Q1	0.114	94	0.906	1	Accepted
D3Q2	0.097	81	0.860	4	Accepted
D3Q3	0.108	88	0.896	3	Accepted
D3Q4	0.137	81	0.860	4	Accepted
D3Q5	0.089	94	0.900	2	Accepted

Conditions: Triangular Fuzzy numbers
i) Threshold value (d) ≤ 0.2
ii) Percentage of experts' consensus > 75%

Defuzzification process
iii) Fuzzy score (A) ≥ α-cut value of 0.5

From the data in Table 12, it can be seen that all items have percentage of experts group consensus to be more than 75%, fuzzy score to be more than or equal to 0.5, as well as threshold values (d) smaller than or equal to 0.2. In other words, the experts agreed that these items to be included in the TPACK module. The rank suggests in terms of opinion by the experts the most relevant and effective ways to maintain/raise students' interest through imitating, combining, and staging. Table 13 shows the sorted list of the items of domain 3.

Table 13. Items position by priority of domain 3, learning activities to maintain/raise students' interest through imitating, combining, and staging (IDC theory)

Position	Items	Item number
1	To give students the opportunities for them to demonstrate their workings during the class time or the consultation hour, individually or as a team.	D3Q1
2	To hold pre-lesson or post-lesson discussion, with the help of the technological tools	D3Q5
3	To allow students to develop or deliver a lesson/sharing session to explain or demonstrate a certain concept or problem-solving strategy.	D3Q3
4	To encourage students to create conceptual maps or procedural steps to demonstrate the strategies to solve mathematical problems.	D3Q2
4	To let students to make quizzes as an individual or collective manner, to be played by others to assess their understanding of the concept, with the help of the technological tools	D3Q4

For the items in domain 3, Table 13 shows that the element stated as item D3Q1 "To give students the opportunities for them to demonstrate their workings during the class time or the consultation hour, individually or as a team" is ranked the first. This is followed by item D3Q5 "To hold pre-lesson or post-lesson discussion, with the help of the technological tools", which was in the second place. In the third place, we could see item D3Q3 "To allow students to develop or deliver a lesson/sharing session to explain or demonstrate a certain concept or problem-solving strategy". Both items D3Q2 "To encourage students to create conceptual maps or procedural steps to demonstrate the strategies to solve mathematical problems" and D3Q4 "To let students to make quizzes as an individual or collective manner, to be played by others to assess their understanding of the concept, with the help of the technological tools" are ranked in the fourth place. On the other hand, Table 14 shows the findings of experts' consensus on domain 4, the learning condition to sustain students' interest through cuing environment, routine, and harmony (IDC theory).

Table 14. Findings of experts' consensus on domain 4, the learning condition to sustain students' interest through cuing environment, routine, and harmony (IDC theory)

Item	Condition of Triangular Fuzzy numbers		Condition of defuzzification process	Position	Experts' consensus
	Threshold value (d)	Percentage of experts group consensus (%)	Fuzzy score (A)		
D4Q1	0.137	81	0.860	5	Accepted
D4Q2	0.119	81	0.879	4	Accepted
D4Q3	0.124	81	0.885	3	Accepted
D4Q4	0.128	81	0.892	2	Accepted
D4Q5	0.086	94	0.925	1	Accepted

Conditions: Triangular Fuzzy numbers
i) Threshold value (d) ≤ 0.2
ii) Percentage of experts' consensus > 75%
Defuzzification process
iii) Fuzzy score (A) ≥ α-cut value of 0.5

From the data in Table 14, it can be seen that all items in domain 4 have percentage of experts group consensus to be more than 75%, fuzzy score to be more than or equal to 0.5, as well as threshold values (d) smaller than or equal to 0.2. In other words, the experts agreed that these items to be included in the TPACK module. The rank suggests in terms of opinion by the experts the most relevant and effective ways to sustain students' interest through cuing environment, routine, and harmony. Table 15 shows the sorted list of the items of domain 4.

Table 15. Items position by priority of domain 4, the learning condition to sustain students' interest through cuing environment, routine, and harmony (IDC theory)

Position	Items	Item number
1	To promote students to work together, collectively, on the questions they are asked to do.	D4Q5
2	To collect regular feedback from the students about their views and their needs, with the help of the technological tools.	D4Q4
3	To maintain constant communication with students, with the help of the technological tools.	D4Q3
4	To constantly support students before, during, and after class, with the help of the technological tools.	D4Q2
5	To set up a homework routine that students can finish and will finish, with the help of technological tools.	D4Q1

For the domain of "The learning condition to sustain students' interest", Table 15 shows that the element stated as item D4Q5 "To promote students to work together, collectively, on the questions they are asked to do" ranked the first. This is followed by item D4Q4 "To collect regular feedback from the students about their views and their needs, with the help of the technological tools", which could be found in the second place. In the third place, item D4Q3 "To maintain constant communication with students, with the help of the technological tools" was seen. In the fourth place, item D4Q2 "To constantly support students before, during, and after class, with the help of the technological tools" was seen. Last but not least, item D4Q1 "To set up a homework routine that students can finish and will finish, with the help of technological tools" is ranked in the fifth place.

4. DISCUSSION

After analyzing the results of the study using the Fuzzy Delphi method, the researchers identified the consensus of the experts on the elements as content and instructional strategies to be included in the TPACK module. The elements of each construct were further ranked in descending order of importance by the experts. These findings are also used to answer the research questions. The first research question of this study is, what are the experts' collective views on the elements to be included in the TPACK module? Based on the results, presented as Domain 1, to ensure producing an effective guide in assisting teachers to stimulate and maintain students' interest in learning mathematics, experts agreed that the TPACK module should: provide opportunities for users to reflect on one's practices, provide explanation on the theories involved, introduce the technologies and instructional strategies, and the content should be organized based on the content of the curriculum on a chapter-by-chapter basis.

These items indicate that the reflection component of teaching should be provided in the module as it helps teachers to have a greater understanding of their teaching styles. The experts' view aligns with revelation made by Körkkö *et al*. [31] in which they stated reflection allows teachers to think about what they do and learn from their past experiences and mistakes to become better teachers. In terms of the content of the module, the experts recommended the content organization of the module, the technological knowledge, and pedagogical knowledge involved in the module, be aligned with the A-level curriculum and subject matter knowledge, on a chapter-by-chapter basis. It is important for the module to be constructively aligned so that the instructional strategies can meet the learning outcomes criteria [32].

To answer the second research question, the IDC theory served as the theoretical basis. According to the IDC theory, instructional activities planned in accordance with the IDC theory are expected to boost students' interest in learning. Consequently, learning approaches are given by referencing the three components of the IDC theory in order to find the aspects that effectively stimulate, maintain, and sustain students' interest in learning. More specifically, to stimulate students' interest, experts recommended the following aspects, presented as Domain 2 to be focused on: relate mathematics to real life, student-centered learning, game-based learning, collaborative learning, and direct instruction with the aid of technological tools. The experts' recommendation to include learning strategies that relate mathematics to real life aligns with findings discovered by Velani and Retnawati [33], in which they found the application of contextual teaching and learning could improve students' interest in mathematics and produce students with better achievement.

Meanwhile, for the aspect of student-centered learning, Fadilah and Alwi [34] presented that student-centered active learning increased students' concepts and students' interest in learning. The suggested active learning approaches such as game-based learning and collaborative learning were also supported by the experts to be included as the learning strategies to stimulate students' interest. In the aspect of game-based learning, various researchers have noted the positive effect of game-based learning to stimulate students' interest in learning [35], [36]. In a similar vein, research revealed that students who were taught utilizing a collaborative learning technique were more engaged than those who got instruction only from their teacher [37]. While student-centered approaches are recommended in many fields including higher education, the experts agreed that direct instructional methods should still be reserved for some lessons for imparting knowledge to their students. According to a study conducted in Indonesia, explicit teaching was found to be effective in promoting interest among students [38].

On the other hand, to maintain students' interest, experts recommended the following aspects, presented as domain 3 to be focused on: mathematics demonstration, pre-lesson/post-lesson discussion, conceptual maps, and cooperative quizzes. In terms of mathematics demonstration, having students show their work promotes mathematical understanding and transmission of ideas [39]. Through the right amount of encouragement, students could be really engaged in the process especially when they enjoyed showing their work. Pre-teaching discussion for mathematics was also found to contribute positive feelings toward students' confidence and able to let students transform the way they see themselves, especially for the students who are struggling with mathematics [40]. On the other hand, in an investigation to discuss the effect of mind maps on students' interest and achievement, it was that mind maps help in organizing students' thought on the concepts used and the connection to be drawn, which eventually helped raising students' interest towards mathematics [41]. Last but not least, to sustain students' interest, aspects to be focused on, presented as domain 4 include: promote students to work together, collect regular feedback from the students, maintain constant communication with students, provide support with the help of the technological tools, and set up a homework routine. Sustained and meaningful tasks, as well as personal involvements help students to develop stable and sustainable interest towards the learning subject [3].

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5. CONCLUSION

Teachers are the pillars of schools, colleges, and universities. They are endowed with the responsibility to transfer knowledge from one generation to another. However, a well-trained teacher does not only rely on their teaching skills but is always up-to-date in their subject matter knowledge as well as skill sets that would enable to impart knowledge effectively through the incorporation of technological knowledge, pedagogical knowledge, and content knowledge (TPACK). The attainment of TPACK knowledge would enable teachers to plan effective educational activities. On top of that, an educator should also be aware of the interest level of students and always in the quest in searching for more interesting teaching methods to maintain or stimulate students' interest in learning. To achieve a desirable learning outcome, interest is a key ingredient for all learners. The educator has the obligation to maintain and stimulate students' level of interest for the subject so as not to discourage the learners. This can be achieved by ensuring that most if not all materials presented are meant to spark the interest of the students and that the students are continuously involved in exemplary activities.

In this study, the experts gave consensus on the items that should be incorporated in the TPACK teaching module so that teachers can use it as a guide to maintain and stimulate students' interest over time, which will lead to a more successful education. The study showed that the experts concurred to the use of technology in the classroom to be able to greatly benefit students' learning. Teachers should thus be encouraged to use appropriate technologies in their teaching to achieve these desired outcomes. Some examples of such technologies include but are not limited to multimedia, simulations, and gaming. Furthermore, the research revealed that it is essential for teachers to have knowledge of their content and pedagogy in order to create successful learning experiences for their students. The TPACK teaching module should therefore include content on how best to combine technology with effective teaching practices. This will help teachers to design lessons that are engaging and meet the needs of all learners. In conclusion, the TPACK teaching module should be designed to promote reflection, effective use of technology, and content knowledge in order to create successful learning experiences for all students.

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