Application of Fuzzy Delphi Technique to Identify the Elements for Designing and Developing the e-PBM PI-Poli Module

Ahmad Fkrudin Mohamed Yusoff[1*], Azmil Hashim[2], Norhisham Muhamad[3], Wan Norina Wan Hamat[4]

[1 2 3]Faculty of Human Sciences, Universiti Pendidikan Sultan Idris,
35900 Tanjong Malim, Perak Darul Ridzuan, Malaysia
a.fkrudin@gmail.com
azmil@fsk.upsi.edu.my
nhisham@fsk.upsi.edu.my
[4]General Studies Department, Politeknik Ungku Omar,
Jalan Raja Musa Mahadi, 31400 Ipoh, Perak Darul Ridzuan, Malaysia
wnnorina@gmail.com
[*]Corresponding Author

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Abstract : Along with the wave of the Industrial Revolution 4.0 era, shifts in the aspects of approach in teaching and the integration of learning technology should always be given careful research and planning. Therefore, this study aims to see the elements needed to integrate technology and delivery strategies to design and develop an online problem-based learning module for the Islamic Studies course (e-PBM PI-Poli) in a polytechnic. The design of this study is a quantitative study using the Fuzzy Delphi technique. A questionnaire instrument was used to collect research data. Seventeen experts in educational technology, problem-based learning, Islamic studies, and curriculum participated in the study. 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) $\geq \alpha$ - cut value = 0.5. Therefore, it shows that these elements have gained expert consensus and are needed to design and develop the e-PBM PI-Poli module in Polytechnic. This research provides tremendous implications to the lecturers and students, and references Malaysia's education system to transform education through technology-based active learning.

Keywords: Technology, Problem-based learning, Fuzzy Delphi, Islamic studies

1. Introduction

The use of creative and innovative teaching methods enables educators to monitor activities, increase motivation, provide understanding to students (Tamuri & Nor, 2015) and give implications to student achievement (Seenbruk, 2015; Fazleen & Siti Noor, 2018). Therefore, lecturers play a significant role and responsibility in achieving educational goals. This matter requires the lecturers' wisdom to create a positive and conducive learning environment in line with the wave of the industrial revolution 4.0 era in education that focuses more on the latest technology and practical learning.

2. Literature Review

Islamic Studies courses are considered general studies (translated as *Mata Pelajaran Pengajian Umum,* MPU) offered in polytechnics. MPU is an undergraduate education programme that aims to provide students with the knowledge of preparing them for life in modern society. In realising this matter, the Department of Higher Education has designed an integrated, holistic curriculum by combining 21st-century skills with MPU courses with the hope of producing graduates who have knowledge and morality, and are equipped with appropriate mindset, good behaviour and ethics (High Impact Education Practices in General Subjects, 2019). The onus is on lecturers to ensure that students' learning experience are relevant and that they are equipped to face current demands (KPM Shift Bulletin, 2015; Nurmalinda, 2011) in line with 4.0 industrial revolution. Therefore, lecturers themselves need to be prepared to master course content (Sulaiman, 2012) and strengthen their teaching methods and strategies. However, the present scenario shows that the pedagogical competence of lecturers in higher education institutions (HEIs) is still at a moderate (emergent) level Lu (2013).

The reality is, lecturers' teaching methods in HEIs still relies on lectures or speeches as the primary teaching techniques (Wan Mahmud et al. 2012; Tengku Kasim et al. 2017; Mohamed Yusoff et al. 2019). Amin et al. (2012) showed that 38.4% of HEIs polytechnics, and community college lecturers felt that they were not proficient with student-centred learning. A research report conducted in 2010 by the Ministry of Higher Education found that students were indifferent towards the MPU courses because managing these courses was less effective. Therefore, the students became less motivated and felt not interested to learn these courses.

Lecturers need to adapt to technology applications to improve teaching and learning (Domingo & Garganté, 2016). However, Mohd Burhan and Tamuri (2013), and Mohd Burhan et al. (2013) found that students believed their lecturers were unsuccessful at utilising ICT and diversifying their teaching methods. The respondents expected their lecturers to apply diversified teaching methods, to use technology to motivate, attract attention, energise, and comprehend the lesson content. Ahmad Kasim (2015) found that discussion through PowerPoint caused students to be "bored, drowsy, and uninterested" in learning.

The Malaysian Education Development Plan (Higher Education) 2015-2025 suggests that the curriculum should emphasise 21st-century learning mastery such as creativity and innovation, collaborative, critical thinking, and communication to enable students to compete globally. Al-Ghazali (1983) states that in teaching and learning, their minds need to be stimulated, mobilised and given attention; even if one's mind has "vision" there are many more things that the mind cannot reach. In line with that, Anita et al. (2020) and Mohd Hawari & Mohd Nor (2020) suggested that thinking and critical values, and problem-solving skills, should be applied in the curriculum of education. Hence using the latest technology should attract students to explore knowledge and make learning more meaningful. Therefore, this study aimed to produce elements for designing and developing online problem-based learning modules for the Islamic Studies course (*e-PBM PI-Poli*) at the Polytechnic based on expert views.

3. Research Design

This study used the Fuzzy Delphi technique. The selection of this technique is made following the study's purpose to obtain expert consensus on the elements used in designing module development. According to Mohd Jamil et al. (2017), this Fuzzy Delphi technique can be adopted to gain expert consensus on a problem. The rationale for applying the Fuzzy Delphi technique compared to the Delphi technique is that it saves time and cost in handling questionnaires. It also allows experts to consistently provide their views (Mohd. Jamil et al., 2013).

The minimum sample of experts in the Fuzzy Delphi studies is 10 to obtain high uniformity among experts (Adler & Ziglio, 1996; Jones & Twiss, 1978). Therefore, 17 experts were selected in this study using purposive sampling technique. They consisted of experts in Islamic studies, technology, problem-based learning and curriculum selected via purposive sampling technique (Chua, 2010). The experts had (i) at least a bachelor's degree as a academic qualification, and (ii) minimum of ten years of experience in the field. Expert selection criteria was in line with Berliner (2004) who stated that an

individual is considered skilled in a field if he has had more than five years of experience in that field; Gambatese et al. (2008) claimed experts must have high academic qualifications.

4. Questionnaire for Experts

The researchers used the literature review to develop the research questionnaire for the Fuzzy Delphi method. The development of questionnaire items can be done based on literature review, pilot studies, and experiences (Skulmowski et al. 2007). Okoli and Pawlowski (2004) agree that the construction of items and content elements of a study should be done through a literature review within the study's scope. After adapting the questionnaire from literature, it was given to three experts for their feedback. Then, modifications were made to the questionnaire based on their feedback. It was also tested for reliability. As a result, every construct achieved an excellent Cronbach alpha value of 0.891 for learning strategy design, 0.871 for presentation interface design, and 0.911 for interactivity interface design. To answer the research question, a seven-point questionnaire, as stated in Table 1, was distributed to the experts to obtain consensus on the items.

Table 1. 7-point Fuzzy Scale

Scale	Level of Agreement	Fuzzy Scale
1	Extremely Strongly Agree	(0.9,1.0,1.0)
2	Strongly Agree	(0.7,0.9,1.0)
3	Agree	(0.5,0.7,0.9)
4	Moderately Agree	(0.3,0.5,0.7)
5	Disagree	(0.1,0.3,0.5)
6	Strongly Disagree	(0.0,0.1,0.3)
7	Extremely Strongly Disagree	(0.0,0.0,0.1)

Source: Mohd Jamil and Mat Noh (2020)

5. Data Analysis Questionnaire

Data analysis was done systematically. The experts' views were carefully analysed using Microsoft Excel software as suggested by Ramlie et al. (2014), Mohd Jamil et al. (2017) and Mohd Jamil and Mat Noh (2020). The two main prerequisites that must be followed in the Fuzzy Delphi technique are the Triangular Fuzzy Number and the Defuzzification Process. Triangular Fuzzy Number has two conditions, first the value of Threshold (d) ≤ 0.2. The expert agreement is reached when the resulting value is smaller or equal to 0.2 (Cheng & Lin, 2002; Chen, 2000). The following formula is used:

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

The second condition for the Triangular Fuzzy Number is to involve a percentage of expert agreement. The traditional Delphi technique stated that if the expert group agreement exceeds 75%, it is accepted (Chu & Hwang, 2008; Murray & Hammons, 1995). Defuzzification Process, on the other hand, is the determination of the fuzzy (A) score value based on the α-cut value of 0.5 (Tang & Wu, 2010; Bodjonava, 2006). If the fuzzy score value (A) is equal to or greater than 0.5, then the measured item is accepted, and if less than 0.5, then the measured item is rejected. The determination of fuzzy (A) score value was made based on the following formula:

A= (1/3)*(m1 + m2 + m3)

6. Research Findings

6.1 Experts Demographic Information

Expert demographic information is shown in Table 2. The majority of them possessed a PhD in the field of expertise. In terms of work experience, all the experts have more than ten years of experience. The selected specialists are experts in Islamic Studies, problem-based learning, educational technology and curriculum.

Table 2. Experts Demographic Information

Level of Education	
Level	**Frequency**
PhD	11
Master Degree	3
Bachelor Degree	3
Total	**17**
Work Experience	
Year	**Frequency**
Less than ten years	0
11 to 15 years	10
16 to 20 years	4
More than 20 years	3
Total	**17**
Field of Experts	
Field	**Frequency**
Islamic Studies	5
Problem-Based Learning	5
Educational Technology	5
Curriculum	2
Total	**17**

6.2 Analysis of Expert Consensus on Learning Strategy Design

In this learning strategy design construct, the items given to the experts are stated in Table 3.

Table 3. Items for the Aspect of Learning Strategy Design Construct

	Items
A1	Provide problem-solving activities (scenarios) that challenge thinking
A2	Provide problem-solving activities (scenarios) in stages from easy to difficult
A3	Provide problem-solving activities (scenarios) similar to real life
A4	Provide active learning activities
A5	Provide learning activities that can assist current and future life practices
A6	Provide an opportunity to evaluate personal progress
A7	Provide discussion space with friends
A8	Provide learning activities that allow working with friends in groups
A9	Provides additional facilities (search button or glossary) for searching for additional information
A10	Provides additional facilities and related links
A11	Provide facilities to organise information

The threshold value (d), expert consensus percentage, defuzzification and item position for the above items are shown in Table 4.

Table 4. Findings of Expert Consensus on Learning Strategy Design

Item	Condition of Triangular Fuzzy Numbers		Condition of Defuzzification Process	Position	Experts Consensus
	Threshold Value, d	Percentage of Experts Group Consensus, %	Fuzzy Score (A)		
A1	0.108	88.2%	0.906	10	Accepted
A2	0.083	94.1%	0.927	4	Accepted
A3	0.076	94.1%	0.933	2	Accepted
A4	0.063	100.00%	0.937	1	Accepted
A5	0.076	94.12%	0.933	2	Accepted
A6	0.111	94.12%	0.910	9	Accepted
A7	0.102	94.12%	0.922	5	Accepted
A8	0.088	94.12%	0.922	6	Accepted
A9	0.091	94.12%	0.916	7	Accepted
A10	0.107	88.24%	0.912	8	Accepted
A11	0.123	100.00%	0.890	11	Accepted

Condition:

Triangular Fuzzy Numbers

1) Threshold Value (d) ≤ 0.2

2) Percentage of Experts Consensus > 75%

Defuzzification Process

3) Fuzzy Score (A) $\geq \alpha$ – cut value = 0.5

Based on the findings in Table 4 above, all items recorded a value of Threshold (d) ≤ 0.2. This result indicates that all of these items have gained an expert consensus (Chen & Lin, 2002). The expert agreement percentage shows that all items are above 75% and all defuzzification values for items also exceed the value of α - cut = 0.5. The result shows that the items in learning strategies design have gained consensus from the experts. The items are sorted by priority as shown in Table 5.

Table 5. Items Position by Priority

Sort by priority	Items	Item Number
1	Provide active learning activities	A4
2	Provide problem-solving activities (scenarios) similar to real life	A3
2	Provide learning activities that can assist current and future life practices	A5
4	Provide problem-solving activities (scenarios) in stages from easy to difficult	A2
5	Provide discussion space with friends	A7
6	Provide learning activities that allow working with friends in groups	A8
7	Provides additional facilities (search button or glossary) for searching for additional information	A9
8	Provides additional facilities and related links	A10
9	Provide problem-solving activities (scenarios) that challenge thinking	A1
10	Provide facilities to organise information	A11
11	Provide an opportunity to evaluate personal progress	A6

Items in Table 5 are the aspects of learning strategy design arranged based on the priorities in developing the application of *e-PBM PI-Poli* module.

6.3 Analysis of Expert Consensus on Presentation Interface Design

The following Table 6 illustrates the experts' evaluation of the items of the presentation interface design construct.

Table 6. Items for the Aspect of Presentation Interface Design Construct

	Items
B1	The screen design of the application should be simple, attractive and consistent
B2	The use of text should be straightforward and easy to read
B3	The integration of graphics, images, colours and icon buttons should be attractive and appropriate
B4	The arrangement and structure of the content should be organised and engaging
B5	Using real images (realistic) to apply a concept
B6	Using graphic elements to convey scenarios
B7	Using audio elements to convey scenarios
B8	Using video elements to convey scenarios
B9	The response time in the application must be appropriate
B10	Has a smooth transition from one display to another
B11	The language used should be appropriate and easy to understand
B12	No technical glitches occurred during application and presentation
B13	The navigation icons are user friendly
B14	The main menu system is simple and easy to use

The threshold values (d), expert consensus percentage, defuzzification and item position for the above items are shown in table 7.

Table 7. Findings of Expert Consensus on Presentation Interface Design

Item	**Condition of Triangular Fuzzy Numbers**		**Condition of Defuzzification Process**	**Position**	**Experts Consensus**
	Threshold Value, d	**Percentage of Experts Group Consensus, %**	**Threshold Value, d**		
B1	0.120	82.4%	0.914	9	Accepted
B2	0.076	94.1%	0.933	2	Accepted
B3	0.083	94.1%	0.927	4	Accepted
B4	0.076	94.12%	0.933	2	Accepted
B5	0.063	100.00%	0.937	1	Accepted
B6	0.192	88.24%	0.822	13	Accepted
B7	0.177	88.24%	0.806	14	Accepted
B8	0.130	94.12%	0.900	11	Accepted
B9	0.130	94.12%	0.894	12	Accepted
B10	0.111	94.12%	0.910	10	Accepted
B11	0.083	94.12%	0.927	4	Accepted
B12	0.083	94.12%	0.927	4	Accepted
B13	0.107	94.12%	0.916	8	Accepted
B14	0.083	94.12%	0.927	4	Accepted

Condition:

Triangular Fuzzy Numbers

1) Threshold Value (d) ≤ 0.2

2) Percentage of Experts Consensus > 75%

Defuzzification Process

3) Fuzzy Score (A) ≥ α – cut value = 0.5

Based on the findings in Table 7 above, all items for this construct recorded a value of Threshold (d) ≤ 0.2, which means that all items have obtained expert consensus (Chen & Lin, 2002). Meanwhile, expert consensus shows that all items are above the value of 75%, and all defuzzification values for each item exceed the value of α - cut = 0.5. This result shows that the items for presentation interface design have gained consensus from the experts. Items are sorted by priority, as shown in Table 8.

Table 8. Items Position by Priority

Sort by priority	Items	Item Number
1	Using real images (realistic) to apply a concept	B5
2	The use of text should be clear and easy to read	B2
2	The arrangement and structure of the content should be organised and interesting	B4
4	The integration of graphics, images, colours and icon buttons should be attractive and appropriate	B3
4	The language used should be appropriate and easy to understand	B11
4	No technical glitches occurred during application and presentation	B12
4	The main menu system is simple and easy to use	B14
8	The navigation icons are user friendly	B13
9	The screen design of the application should be simple, attractive and consistent	B1
10	Has a smooth transition from one display to another	B10
11	Using video elements to convey scenarios	B8
12	The response time in the application must be appropriate	B9
13	Using graphic elements to convey scenarios	B6
14	Using audio elements to convey scenarios	B7

Based on Table 8, the application of presentation interface design items is arranged based on priority when developing and designing the *e-PBM PI-Poli* module.

6.4 Analysis of Expert Consensus on Interactivity Interface Design

The following Table 9 illustrates the analysis of the experts' evaluation on the items of the interactivity interface design construct.

Table 9. Items for the Aspect of the Interactivity Interface Design Construct

	Items
C1	Encouraging feedback
C2	Different forms of feedback (typing answers, clicking options, others.)
C3	Provide links to other related websites
C4	Scenarios and activities focus on intended achievement in the learning process.
C5	Provides a systematic navigation structure to avoid confusion or lost while exploring it
C6	Provides an easy-to-follow direction for the presentation of information in this software
C7	Provides more than one form of information access
C8	Eases the access to information needed
C9	Provides opportunities to interact through Web 2.0 applications (blog, interactive online wall, interactive whiteboard, forum, WhatsApp group and Facebook)
C10	Provides facilities to download the material provided
C11	Provides online evaluation or online reinforcement activities
C12	Provides user guides to facilitate navigation

The threshold value (d), the percentage of expert consensus, defuzzification and item position for the above items are shown in Table 10.

Table 10. Findings of Expert Consensus on Interactivity Interface Design

Item	Condition of Triangular Fuzzy Numbers		Condition of Defuzzification Process	Position	Experts Consensus
	Threshold Value, d	Percentage of Experts Group Consensus, %	Threshold Value, d		
C1	0.083	94.1%	0.927	6	Accepted
C2	0.088	94.1%	0.922	9	Accepted
C3	0.076	94.1%	0.933	2	Accepted
C4	0.076	94.12%	0.933	2	Accepted
C5	0.098	88.24%	0.924	8	Accepted
C6	0.063	100.00%	0.937	1	Accepted
C7	0.107	94.12%	0.916	11	Accepted
C8	0.076	94.12%	0.933	2	Accepted
C9	0.076	94.12%	0.933	2	Accepted
C10	0.083	94.12%	0.927	6	Accepted
C11	0.091	94.12%	0.916	11	Accepted
C12	0.088	94.12%	0.922	9	Accepted

Condition:

Triangular Fuzzy Numbers

1) Threshold Value (d) ≤ 0.2

2) Percentage of Experts Consensus > 75%

Defuzzification Process

3) Fuzzy Score (A) ≥ α – cut value = 0.5

Based on the findings in Table 10 above, all items recorded a value of Threshold (d) ≤ 0.2. It means that all of these items have gained expert consensus (Chen & Lin, 2002). The expert agreement percentage shows that all items are above 75% and all defuzzification values for items also exceed the value of α - cut = 0.5. It shows that the items in the aspect of learning strategies design have gained consensus from experts. Items are sorted by priority as shown in Table 11.

Table 11. Items Position by Priority

Sort by priority	Items	Item Number
1	Provides an easy-to-follow direction for the presentation of information in this software	C6
2	Provide links to other related websites	C3
2	Scenarios and activities focus on intended achievement in the learning process	C4
2	Eases the access to information needed	C8
2	Provides opportunities to interact through Web 2.0 applications (blog, interactive online wall, forum, WhatsApp group and Facebook)	C9
6	Encouraging feedback	C1
6	Provides facilities to download the material provided	C10
8	Provides a systematic navigation structure to avoid confusion or lost while exploring it	C5
9	Different forms of feedback (typing answers, clicking options, others.)	C2
9	Provides user guides to facilitate navigation	C12
11	Provides more than one form of information access	C7
11	Provides online evaluation or online reinforcement activities	C11

The items in Table 11 consists of the items for the aspects of interactivity interface design that need to be emphasised according to priority by the researcher in developing the *e-PBM PI-Poli* module on the presentation interface design.

7. Discussion

From the findings of the analysis using the fuzzy Delphi technique carried out, the researchers identified the elements as agreed by the experts. The elements were prioritised by the experts in each construct. The results showed that all the elements need to be applied in designing the development of the *e-PBM PI-Poli* module. On the aspects of learning strategy design, the experts agreed that these should include: active learning activities, problem-solving activities similar to real life, learning activities supportive of current and future life practices, and problem-solving activities ranging from easy to difficult ones. These items indicate that active learning strategies which incorporate thinking skills should be focused in module development. Lecturing with students' active involvement will result in meaningful learning (Juperi, 2011; Tamuri & Nor, 2015). Problem-based learning (PBM) is one of the student-centred active learning methods related to group learning, controlling and guiding student activities, and students' world (Othman et al. 2013; Yusof et al. 2016; Mohamed Yusoff et al. 2020; Sariya & Muazzan 2020).

In the implementation of PBM, the diversity of students' academic level is taken into account when dividing students into small groups. It aims to provide a balance of learning process in each group (Masek 2015), which is concerned with human nature differentiated through abilities and intelligence (Ibn Khaldun, 2002). Muhammad Qutb (2001) stated that the intellect's potential should be continuously nurtured by emphasising the importance of observing by utilising the five senses as channels to achieve confidence. Thus, PBM strategies can help students transfer the experience of critically analysing learning activities to daily life activities, especially when facing critical moments to make decisions or solve problems (Baba 2009; Mohd Hawari & Mohd Noor 2020).

Moreover, the presentation interface design findings show that the main focus in designing the module is to use realistic images, exact text, organised structure, and multimedia elements that are interesting, simple, consistent and appropriate. Each integrated object should have specific functions and roles according to the purpose of learning. According to Muslimin et al. (2017), interconnected content design can guide students in the learning process and ensure the information reaches students at right. The technical aspect is also emphasised so that interruptions during the learning process can be reduced because it can affect students' motivation to continue exploring this module. Nawi et al. (2014) explained that the development of users' acceptance of an application depends on convenience and the ability to use it. Mohamed Yusoff & Romli (2018) also stated that users felt happy and enjoyed using applications that had convenient usability features.

The experts also recommended using multimedia with text, video, graphics and audio forms, compatible with mobile technology for module design and development. The application of multimedia elements in a mobile learning environment can improve memory retention (Huffman & Hahn, 2015), attract learning (Nordin, 2019) and create excitement (Wieman & Perkins 2005). These elements are acknowledged by Doyle (2007) and Yahaya (2009) that stated that learning using multimedia is more effective and suitable to be applied in any subject. It can also be easily used to explain learning content. Additionally, the experts emphasised the use of appropriate and simple language. Che Hassan and Abd Rahman (2011) stated that language in the teaching and learning process must be according to students' level to have a meaningful impact.

Meanwhile, for the aspect of interactivity interface design, the experts emphasised developing directions for information presentations that are easy to follow. It means that the multi-touch content access design should be easy to navigate and explore students' learning content. Secondly, they focused on the weblinks and communication tools using web 2.0. The use of technology allows students to explore, collaborate and create new experiences. These findings support Ibn Khaldun's (2002) theory which uses existing experience and current knowledge to relate to a problem learned. The learning resources provided can control the information obtained by students. This approach is seen as necessary as information displayed on the Internet may be incorrect. Thus students need to evaluate the information online before using it as a reference (Aris et al., 2003).

The ease to download materials, feedback, user guide, and reinforcement activities are positioned at the sixth to eleventh priority. Students should be given space to use technology in support of teamwork (Mat Noh, 2019). Reinforcement activities, face-to-face or online, can retest the objectives of teaching and learning content that has been done. In the context of online reinforcement, Mohamed Yusoff et al. (2019) recommends using web 2.0 applications, as it offers a variety of applications that allow lecturers to select applications based on the topic taught. The use of technology in consolidation is in line with the study's target, which consists of generations Y and Z, who on average are digitally literate.

8. Conclusion

Educators need to be knowledgeable and equipped with teaching skills that include planning, management, delivery, guidance and evaluation activities to impart knowledge or skills to students effectively through teaching approaches, strategies, methods and techniques based on teaching and learning theory. It can be concluded that active learning is a student-centred strategy involving various activities inside and outside the classroom. Active management of the teaching and learning process of Islamic studies can improve the quality of teaching. Besides, students will be attracted and interested to get engaged throughout the lecturing. As a result, the teaching and learning process becomes more meaningful and fun.

Based on experts' consensus, technology plays a vital role in implementing problem-based learning. According to Wells (2012), the most effective element that can be provided in integrating technology is thinking critically and creatively. In today's world of global competition, having high knowledge and intelligence is not enough. Such knowledge and intelligence must be accompanied by creativity to compete worldwide when they graduate later. However, nurturing students' creativity will be stunted if the barriers to nurturing creativity are not overcome.

Thinking skill is an essential element that students need to have. It includes thinking creatively, critically, innovatively, and applying understanding and knowledge in various fields. The current wave of changes requires modifications in the teaching and learning system to apply creative and critical thinking skills. This skill can protect an individual from the onslaught of negative thoughts, ideologies and elements. Therefore, the researcher will integrate the expert consensus elements' findings in designing the *e-PBM PI-Poli* module in Polytechnic.

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