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Determining Elements in Mobile Learning Implemention Among Instructors in Vocational Colleges: A Fuzzy Delphi Method

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ABSTRACT This study aims to identify the elements of implementing mobile learning based on Competency-based Education. The confirmation of elements was based on the opinions and consensus of experts. The consensus survey was constructed based on the emergent themes that experts raised during their interview sessions. Sixteen experts in Competency-based Education were included in the survey. The data was analyzed using the Fuzzy Delphi method (FDM). The results indicate that eight elements met the FDM requirements. Its threshold value is ≤ 0.2, the percentage expert consensus is $\geq 75\%$, and the average score of the Fuzzy number is over 0.5. These eight elements are students, teachers, technology, learning environment, content, assessment, learning strategy, and learning activity. The outcomes of this research will be useful for stakeholders within the educational sector to address student competency, including the Ministry of Education Malaysia, the Technical and Vocational Education Division, teachers, students, and developers and designers of mobile learning applications.

INDEX TERMS Competency-based education, Fuzzy Delphi method (FDM), mobile learning, M-learning.

I. INTRODUCTION

The application of mobile devices in teaching and learning is not new. Mobile learning is free of the limitations of time and space, flexible, highly targeted, and has a high absorption rate [1]. 'M-learning' refers to the use of mobile and handheld IT devices, such as PDAs, mobile phones, laptops, and tablet PCs, in teaching and learning [2]. Learners are able to engage with educational activities without being tied to a specific physical location [3]. According to [4], mobile learning is a flexible learning method. This advanced and efficient learning method can reduce investment into training equipment and customize learning solutions for special student groups. Therefore, mobile learning is suitable for all types of students.

For this reason, Technical And Vocational Education Training (TVET) has not been excluded from the increasing use of technology in the teaching and learning process [5]. TVET is a practice-oriented approach which has an emphasis on preparing students to work in real-life conditions through the teaching contents of their curricula [6]. Therefore, to encourage students' active participation in the learning process, the integration of mobile devices in teaching and learning has been extensively investigated [7]. This enhances students' overall competency levels. The effectiveness of using mobile and flexible technology to enhance learning and teaching in TVET, however, remains uncertain [8].

At the same time, students in higher vocational colleges lack of motivation, and cannot maintain a stable interest in certain subjects. This is because their attention is easily affected by their surrounding environments [9]. Moreover, the lack of supplementary content and dependence on textbooks as the sole learning source can cause students to easily forget what has been taught [10]. An initial survey by [11] also states that mobile learning in vocational colleges remains dubious. This is in regards to the effectiveness of mobile learning implemented in the teaching and learning process at vocational colleges. In addition to that, the study demonstrates the absence of specific guidance or frameworks for implementing

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TABLE 1. Fuzzy Delphi technique.

Steps	Total Experts	Instrument	Product
1	6 experts	Interview protocol	Survey instrument
2 (obtain consensus)	16 experts	Survey instrument	Expert consensus on the element

mobile learning. The lack of mobile learning frameworks can cause serious issues in the creation of effective learning designs [12].

Therefore, this study was conducted to identify the elements of mobile learning implementation in Competency-based Education. These elements are required as a guideline for all stakeholders involved in TVET. The elements of implementation of mobile learning were determined by the consensus reached among experts regarding what is required of mobile learning and how it should be implemented. There were three research questions that needed to be answered by this study, which are:

1. What are the elements of mobile learning implementation in Competency-based Education, based on a consensus reached by experts?
2. What are the values of the Fuzzy Delphi method, based on a consensus reached by experts?
3. What are the rankings of these elements?

II. METHODOLOGY

In this study, the researcher used the Fuzzy Delphi method. This method was based on the group thinking of qualified experts, which assured the validity of the collected data for the study as it was based on the agreement of a group of experts on an issue reviewed. The methodology involved two main steps, as listed in Table 1.

As mentioned earlier, the first phase of data collection involved semi-structured interviews with six (6) experts in the field of Competency-based Education from different universities. The researcher developed interview protocol based on the existing literature. The experts involved in the semi-structured interviews are listed in Table 2.

The second step was to obtain a consensus by experts on the elements of implementing mobile learning. From the themes derived, a set of questionnaires was produced and distributed to a further 16 experts. These experts comprised of five associate professors, ten senior lecturers, and one teacher with more than 25 years of teaching experience. The criteria for the experts were as follows:

1. Experts in the field of Competency-based Education.
2. Involved in teaching and TVET for more than five years.
3. Experts in mobile learning.
4. Experts in Information and Communication Technology (ICT).

TABLE 2. Expert demographic.

Experts	Institution	Position	Teaching Experience
1	Public University	Senior Lecturer	21 years
2	Centre for Instructor and Advanced Skill Training (CIAST)	Head of Department Electronic and Multimedia Unit	21 years
3	Public University	Associate Professor	34 years
4	Public University	Associate Professor	21 years
5	Public University	Senior Lecturer	12 years
6	Public University	Associate Professor	22 years

The details of the experts are as listed in Table 3.

The procedure of obtaining a consensus among the experts is detailed in Figure 1.

III. DATA ANALYSIS

As previously mentioned, this study applied the Fuzzy Delphi method, which consisted of two phases. Phase 1 involved semi-structured interviews, followed by survey research. Data from the interviews was analyzed using thematic analysis. Thematic Analysis is a method used for identifying and analyzing patterns of meaning in a dataset. This involves researchers reading transcript repeatedly to familiarize themselves with the data.

Since interviews fall under qualitative data collection, they could be stopped when the data obtained reached a point of saturation. Next, the researcher coded the interview findings in terms of relevance to the research questions. After the interviews were conducted, the themes that emerged were used in a questionnaire. The questionnaire was distributed to the 16 experts to reach a consensus regarding the elements that emerged from the interviews. Next, the data was analyzed using the Fuzzy Delphi analysis. The steps involved in this Fuzzy Delphi method are as follows:

Step 1: Expert Involvement

The researcher searched for experts based on certain criteria. An appointment letter was sent to experts who were willing to participate in the study.

Step 2: Selecting a Scale

In this study, the researcher selected a 7-point Likert scale. This scale was represented by seven types of agreement: very strongly disagree, strongly disagree, disagree, not sure, agree, and very strongly agree (see Table 4). Experts were required to indicate the extent of their agreement with the statements provided.

TABLE 3. Expert demographic.

Experts	Status	Instituition	Field Expertise
1	Senior Lecturer	Research and Innovation Centre, Polytechnic Nilai	Curriculum and Instruction in TVET
2	Associate Professor	Faculty of Technical and Vocational, UPSI	Competency-based Education, Mobile Learning
3	Senior Lecturer	Faculty of Technical and Vocational, UPSI	Competency-based Education, Curriculum and Instruction in TVET
4	Head of Department	Research and Innovation Centre, Institute of Teacher Education Technic Campus	Competency-based Education
5	Head of Department	Research and Innovation Centre, Institute of Teacher Education Darul Aman Campus	Competency-based Education, e-TVET
6	Senior Lecturer	Faculty of Technical and Vocational Education, UTHM	Competency-based Education, Mobile Learning, ICTs
7	Associate Professor	Technical and Engineering Education, UTM	Competency-based Education
8	Associate Professor	Faculty of Technical and Vocational Education, UTHM	Competency-based Education, Curriculum and Teachinng In TVE
9	Deputy Director	Department Skills Development	Competency-based Education, Curriculum and Instruction in TVET
10	Senior Lecturer	Faculty of Technical and Vocational Education, UTHM	Competency-based Education
11	Senior Lecturer	Social Science Department, Institute of Teacher Education Darul Aman Campus	M-Learning, Curriculum and Instruction in TVET
12	Head of Department	Manufacturing Engineering Technology, Leboh Cator Vocational College, Perak	Curriculum and Instruction in TVET
13	Senior Lecturer	Research and Innovation Department, Institute of Teacher Education Darul Aman Campus	Curriculum and Instruction in TVET, Mobile Learning
14	Senior Lecturer	Research and Innovation Department, Institute of Teacher Education Darul Aman Campus	Curriculum and Instruction Mobile Learning, Curriculum and Technology
15	Senior Lecturer	Information and Communication Unit, Department of Technology Education,	Curriculum and Technology, Online Learning, ICTs
16	Senior Lecturer	Department of Communication Technology and Networks, Faculty of Computer Science and Information Technology, Universiti Putra Malaysia	ICTs

Step 3: Calculating Average Value

Average values of the data were calculated using Microsoft Excel. The distances of two fuzzy numbers, m = (m1, m2, m3) and n = (n1, n2, n3) were computed using the following formula:

Step 4: Determining Threshold Value (d)

The threshold value d was the value indicating the experts' agreement for each item. The threshold value d must be less than or equal to 0.2. This shows that experts reached a consensus [14].

Step 5: Percentage Expert Consensus

The percentage of expert consensus must be more than 75%, indicating that the experts have reached an agreement. Any questionnaire item not reaching an agreement was dropped [15].

Steps 6: Defuzzification Process

The defuzzification process was used to determine the scores and rankings for each item. The symbol for defuzzification is 'Amax'. The Fuzzy score was $\geq$0.5. The formula used is as follows:

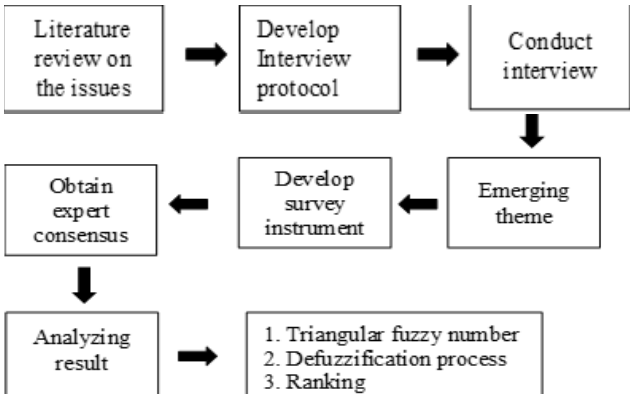

FIGURE 1. Procedure for fuzzy Delphi method.

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

FIGURE 2. Average fuzzy value.

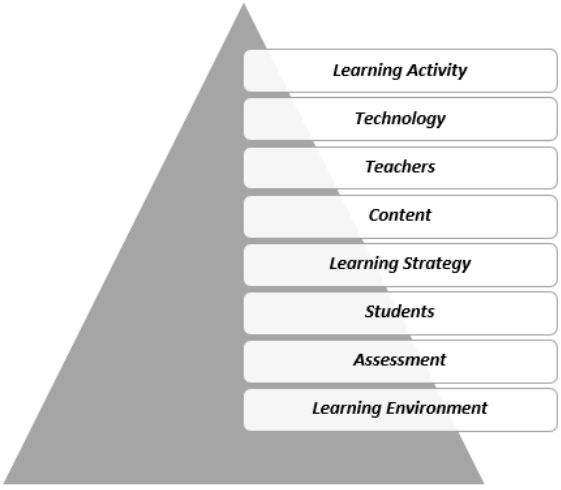

FIGURE 3. The ranking of elements for implementation of M-learning based on competency-based education.

i. Amax = 1/3 * (m1 + m2 + m3)
ii. Amax = 1/4 * (m1+ 2m2 + m3)
iii. Amax = 1/6 * (m1 +4m2 + m3)
Source: [15]

IV. FINDINGS AND RESULTS

A. WHAT ARE THE ELEMENTS OF MOBILE LEARNING IMPLEMENTATION FOR COMPETENCY-BASED EDUCATION, BASED ON A CONSENSUS REACHED BY EXPERTS?

Based on the thematic analysis, the results show that eight themes emerged. The eight elements are (1) students, (2) teachers, (3) content, (4) learning design, (5) learning activities, (6) learning environment, (7) technology, and (8) assessment elements. These eight elements can be used as a guide to improve the quality of teaching and learning process through the integration of mobile technology.

TABLE 4. Seven-point likert scale to fuzzy scale.

Likert Scale	Agreement	Fuzzy Scale		
		m1	m2	m3
1	Extremely disagree	0.0	0.0	0.1
2	Strongly disagree	0.0	0.1	0.3
3	Disagree	0.1	0.3	0.5
4	Slightly agree	0.3	0.5	0.7
5	Agree	0.5	0.7	0.9
6	Strongly agree	0.7	0.9	1.0
7	Extremely agree	0.9	1.0	1.0

TABLE 5. Elements found from interviewed respondents.

Expert	Element							
	1	2	3	4	5	6	7	8
1	/		/	/	/		/	
2		/	/		/		/	/
3	/	/	/	/	/	/	/	/
4	/	/	/	/	/	/	/	/
5	/	/	/		/	/	/	
6	/	/		/	/	/	/	

Indicator:
1 - Student
2 - Teacher
3 - Technology
4 - Learning Environment
5 - Content
6 - Assessment
7 - Learning strategy
8 - Learning activity

B. WHAT ARE THE VALUES OF THE FUZZY DELPHI METHOD, BASED ON A CONSENSUS REACHED BY EXPERTS?

Table 6 shows the consensus reached among experts regarding mobile learning elements, with a threshold value of below 0.2. These findings show that the first requirement, which has a threshold value (d) $\leq$ 0.2, was suitable. The second requirement of the Fuzzy Delphi method was also accepted, and the percentage of experts who agreed on it was more than 75%.

C. WHAT ARE THE RANKINGS OF THE ELEMENTS?

Table 7 shows the ranking of mobile learning elements based on the value of average Fuzzy numbers.

Referring to Table 6, the experts achieved consensus on the eight main elements of the implementation of mobile learning based on Competency-based Education. All elements complied with the first requirement, in which the threshold values, d, of most items were $\leq$ 0.2. Meanwhile, the second requirement was adhered to, as the consensus percentage of experts was more than 75%. Thus, the experts reached a

TABLE 6. Expert consensus on mobile learning elements based on threshold value (d).

Expert	Element							
	1	2	3	4	5	6	7	8
1	0.048	0.029	0.019	0.109	0.029	0.069	0.029	0.010
2	0.048	0.029	0.019	0.109	0.029	0.069	0.029	0.010
3	0.048	0.029	0.019	0.109	0.029	0.069	0.029	0.010
4	0.048	0.029	0.019	0.109	0.029	0.069	0.029	0.010
5	0.048	0.029	0.019	0.109	0.029	0.069	0.029	0.010
6	0.048	0.029	0.019	0.109	0.029	0.069	0.124	0.010
7	0.048	0.029	0.019	0.283	0.029	0.069	0.029	0.010
8	0.105	0.124	0.019	0.283	0.029	**0.907**	0.029	0.010
9	0.105	0.029	0.134	**0.572**	0.124	0.069	0.029	0.010
10	0.048	0.029	0.019	0.109	0.029	0.069	0.029	0.010
11	0.105	0.124	0.134	0.062	0.124	0.099	0.124	0.143
12	0.105	0.029	0.019	0.062	0.124	0.069	0.124	0.010
13	0.105	0.124	0.019	0.109	0.029	0.069	0.029	0.010
14	0.048	0.029	0.019	0.109	0.029	0.069	0.029	0.010
15	0.048	0.029	0.019	0.109	0.029	0.069	0.029	0.010
16	0.048	0.029	0.019	0.109	0.029	0.069	0.029	0.010
Threshold value(d)	**0.066**	**0.047**	**0.033**	**0.154**	**0.047**	**0.123**	**0.047**	**0.018**
Percentage of Expert Consensus (%)	100 %	100 %	100 %	93.8 %	100 %	93.8 %	100 %	100 %
Score Value A	0.935	0.948	0.954	0.892	0.948	0.919	0.948	0.960

good consensus and a second round of Fuzzy Delphi was not required because the data acquisition complied with both conditions for analyzing data using this technique. In addition to that, the defuzzification values of all components exceeded the Fuzzy score value (A) ≥ 0.5. This indicates that the main components obtained the experts' agreement regarding the evaluation of these elements. The agreed elements were sorted according to their priority (ranking)(refer table 7). Overall, these elements have been agreed upon by experts and meet the stipulated requirements.

V. DISCUSSION

Based on the findings, there are eight elements of mobile learning implementation in Competency-based Education, based on the consensus reached by the experts involved. The elements are students, teachers, technology, learning environment, content, assessment, learning strategy, and learning activity. These eight elements fulfilled the requirements of the FDM analysis, which are threshold value (d) and consensus percentage. The threshold value (d) of each element was less than 0.2, which implies that all experts agreed with that particular element. The first prerequisite was fulfilled, whereby all eight constructs obtained a threshold

TABLE 7. Mobile learning elements ranking based on value average fuzzy number.

No.	Element	*Triangular Fuzzy Numbers*		*Defuzzification Process*	Interpretation	Ranking
		Threshold Value, d	Percentage experts consensus, %	*Fuzzy Score (A)*		
1	Students	0.066	100.0%	0.935	Accept	6
2	Teachers	0.047	100.0%	0.948	Accept	3
3	Technology	0.033	100.0%	0.954	Accept	2
4	Learning Environment	0.154	93.75%	0.892	Accept	8
5	Content	0.047	100.00%	0.948	Accept	3
6	Assessment	0.123	93.75%	0.919	Accept	7
7	Learning Strategy	0.047	100.00%	0.948	Accept	3
8	Learning Activity	0.018	100.00%	0.960	Accept	1

value (d) of ≤ 0.2. In addition to that, the expert consensus percentage for this study was in the range of 93.7%, which exceeded the minimum of 75%. This indicates that the experts have reached a consensus in their views for all elements of the mobile learning implementation model based on Competency-based Education.

Next, the elements of mobile learning implementation based on Competency-based Education were ranked based on the Fuzzy score, A. From Table 7, we can rank the elements as learning activity, followed by technology, teachers, content, learning strategy, students, assessment, and learning environment. The elements were ranked according to priority, from the highest priority to the lowest priority.

VI. CONCLUSION

Figure 3 shows the ranking of elements for the implementation of mobile learning based on Competency-based Education. We can conclude that the successful implementation of mobile learning greatly relies on planned activity and technology used to support the learning process. This is because learning activities using a mobile device can make learning more enjoyable [16], enhance the learning experience, and engage learners in different learning situations [17]. In addition to that, mobile devices can be available at any time and place, thus boosting the ability to do things both discretely and openly [18]. Using the Internet removes geographical boundaries so that information can be easily accessible. Technical support also includes access to infrastructure, and is also important to ensure that mobile technology serves the needs of both teachers and students [19]. In addition to that, teachers can optimize learning by using mobile devices as interactivity tools so that students can learn more efficiently [20]. It is important to plan the learning content in detail to be related to the learning objectives, so that it can improve comprehension and advance learning outcomes [21].

On the other hand, vocational teachers can implement learning and teaching strategies to utilize effective learning approaches, such as collaborative learning in the classroom, with teachers playing the role of facilitators [22]. The forms of assessment used by vocational teachers are important to meet the demands of Competency-based Education and authentic assessment [23]. Students can enhance their achievement rates, develop autonomy, and become more confident [24] through M-learning. Assessments that can improve learning experiences are online quizzes, presentations, online projects/assignments, online task assessments, and online exams [25].

The conclusion drawn from this research is that mobile devices are an effective tool in teaching and learning, and can help enhance students' competency levels. The benefits of mobile devices are that they can be used for learning anytime and anywhere. Students can easily access information or learning resources whenever they are free. In this study, a group of experts reached a consensus that there are eight elements related to the implementation of mobile learning based on Competency-based Education.

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