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

SITI AZWANEE ABDULLAH, MUHAMMAD SUKRI SAUD, MOHD HIZWAN MOHD HISHAM, NUR HUSNA ABD WAHID, MAHYUDDIN ARSAT, NORNARZIRA SUHAIROM, AND MUHAMAD AFZAMIMAN ARIPIN

Faculty of Social Science and Humanities, School of Education, Universiti Teknologi Malaysia, Skudai, 81310 Johor, Malaysia
Corresponding author: Siti Azwanee Abdullah (waneeabdullah@gmail.com)

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 \( \leq 0.2 \), 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
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).

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:

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.

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.

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.
### Step 3: Calculating Average Value

Average values of the data were calculated using Microsoft Excel. The distances of two fuzzy numbers, \( m = (m_1, m_2, m_3) \) and \( n = (n_1, n_2, n_3) \) were computed using the following formula:

\[
\text{Step 4: Determining Threshold Value (d)}
\]

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].

### Step 6: Defuzzification Process

The defuzzification process was used to determine the scores and rankings for each item. The symbol for defuzzification is ‘\( A_{max} \)’. The Fuzzy score was \( \geq 0.5 \). The formula used is as follows:

### Table 3. Expert demographic.

| Experts | Status            | Institution                                                                 | 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 Instruction in TVET |
| 9       | Deputy Director   | Department Skills Development                                             | Competency-based Education            |
| 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 |
FIGURE 1. Procedure for fuzzy Delphi method.

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

FIGURE 2. Average fuzzy value.

i. \(A_{\text{max}} = \frac{1}{3} (m_1 + m_2 + m_3)\)
ii. \(A_{\text{max}} = \frac{1}{4} (m_1 + 2m_2 + m_3)\)
iii. \(A_{\text{max}} = \frac{1}{6} (m_1 + 4m_2 + m_3)\)

Source: [15]

TABLE 5. Elements found from interviewed respondents.

| Expert | 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

TABLE 4. Seven-point likert scale to fuzzy 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 |

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.

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%.

TABLE 6. Consensus reached among experts regarding mobile learning elements.

| Element | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---------|---|---|---|---|---|---|---|---|
| Learning Activity | / | / | / | / | / | / |   |   |
| Technology | / | / | / | / | / | / |   |   |
| Teachers | / | / | / | / | / | / |   |   |
| Content | / | / | / | / | / | / |   |   |
| Learning Strategy | / | / | / | / | / | / |   |   |
| Students | / | / | / | / | / | / |   |   |
| Assessment | / | / | / | / | / | / |   |   |
| Learning Environment | / | / | / | / | / | / |   |   |

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...
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 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 discreetly 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 quizzies, 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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SITI AZWANEE ABDULLAH received the bachelor’s degree in technology with education (electrical engineering) and the master’s degree in technical and vocational education from Universiti Teknologi Malaysia, Skudai, Malaysia, in 2009 and 2015, respectively, where she is currently pursuing the Ph.D. degree in technical and vocational education. Her research interests include TVET education, mobile learning, and competency-based education.

MUHAMMAD SUKRI SAUD received the master’s degree from the University of Winsconsin, USA, in 1998, and the Ph.D. degree from Ohio State University, Columbus, OH, USA, in 2004. He is currently a Professor with the Department of Technical and Engineering Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, Johor.
MOHD HIZWAN MOHD HISHAM received the bachelor’s degree in technology with education (electrical engineering), the master’s degree in technical and vocational education, and the Ph.D. degree in education (technical and vocational) from Universiti Teknologi Malaysia, Johor, in 2010, 2014, and 2019, respectively. He is currently a Senior Lecturer with the Department of Technical and Engineering Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia.

NUR HUSNA ABD WAHID received the bachelor’s degree in science majoring in microbiology and the master’s degree in technical and vocational education (agriculture education) from University Putra Malaysia (previously known as Malaysian Agriculture University), Johor, in 2005 and 2010, respectively, and the Ph.D. degree in workforce education & development from Pennsylvania State University, in 2016. She is currently a Senior Lecturer with the Department of Technical and Engineering Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia.

MAHYUDDIN ARSAT received the master’s degree from Universiti Teknologi Malaysia, Johor, and the Ph.D. degree from Aalborg University, Denmark. He is currently a Senior Lecturer with the Department of Technical and Engineering Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia.

NORNAZIRA SUHAIROM received the Master of Science degree in technical and vocational education from University Putra Malaysia, and the Ph.D. degree in technical and vocational education from Universiti Teknologi Malaysia, Johor. She is currently a Senior Lecturer with the Department of Technical and Engineering Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia.

MUHAMAD AFZAMIMAN ARIPIN received the Ph.D. degree in the field of technical and vocational education from Universiti Teknologi Malaysia (UTM), Johor. He had work in several education institutions as an Administrator and an Academic Staff. He is currently working as a Senior Lecturer with the Faculty of Social Sciences and Humanities, School of Education, UTM.