Developing an Augmented Reality Immersive Learning Design (AILeaD) Framework: A Fuzzy Delphi Approach

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Abstract—The use of augmented reality as a teaching aid among teachers is becoming more widespread. So, it is a must to create a holistic framework of augmented reality in order to enhance the teaching and learning context. Therefore, the purpose of this study is to develop an augmented reality immersive learning design (AILeaD) framework by using the Fuzzy Delphi Technique. The objective of this research is to gain experts' consensus in building and identifying constructs and elements as well as their place in the AILeaD framework. The Fuzzy Delphi Technique is used as a systematic method to evaluate, verify as well as to make a decision in modifying all needed constructs and elements in order to create the AILeaD framework through the consensus of the experts. The research questionnaire is divided into three sections which are technology skills, instructional designs and type of augmented reality applications in a total of 36 items and using the Likert-7 point scale. The sample of this research consists of 10 experts from educational technology, teaching technology, augmented reality and model development. The finding showed that the experts agreed and approved all of the constructs and elements where the three conditions were fulfilled which are the item value is less than or same with the threshold value (d) < 0.2, experts' consensus percentage exceeded 75% and defuzzification value per item exceeded α-cut = 0.5. This study could contribute to the educational policy that focuses on the development of teaching quality with the improvement of existing skills among educators through the innovation and utilization of technology in the teaching and learning context. This is in line with Malaysia Education Blueprint known as Shift 7 (2013–2025) where it leverages the utilization of ICT to enhance the quality of education in Malaysia. The implication of this study is to make the AILeaD framework as a guideline for teachers, lecturers and instructional designers in producing the teaching aids in accordance with augmented reality and taking Gagne Nine Events, Cognitive Theory of Multimedia Learning dan Revised Bloom Taxonomy into account.

Keywords—augmented reality, Fuzzy Delphi, immersive learning experiences, instructional design

1 Introduction

An immersive learning experience is a meaningful learning environment where students are involved actively and acknowledge the content studied either in a simulation context or real-life situation [1]. Immersive learning could be implemented through online learning or the combination of online and face to face learning supported by the technology [2]. For instance, the usage of MOOC, simulation, augmented reality, virtual reality, live classroom, digital gamification and many more could give a huge impact on the students' experience, knowledge and skill [3]. It is in line with the Education 4.0 in Malaysia, a new learning system that enables students to develop lifelong learning and skills [4]. Therefore, educators need to be prepared to innovate in teaching and strengthen their teaching methods and strategies. However, the current scenario shows that the technological efficiency and innovation of teaching are still at a moderate level.

Augmented reality (AR) is a virtual reality technology that allows users to interact with the virtual object in real life [5]. AR also defined as an interactive tool and medium that connects digital information with the real world [6]. [7] described AR as a technology that overlays an image generated by the computer on a users' view of the real world. Also, AR can be interpreted as a valuable educational tool and has a great potential for future learning in generating students' creative thinking [8]. For instance, AR allows teachers to integrate technology as a teaching aid throughout the teaching and learning process. According to [9], there are seven AR characters that can be used as a guideline for teachers in developing augmented reality which is a substitute for an existing object, assist in explaining the process, simulation aid, gain attention, describe the abstract, explain the concept of space and a replacement for an experiment. The result of his study showed positive feedback and the teachers involved acknowledged that AR is suitable to be used as a teaching medium. Nevertheless, the usage of AR is still new among teachers especially in Malaysia and need some time for them to apply it in the teaching and learning process [3].

The previous studies shown the advantages and benefits of using AR in education. Among them is being able to increase the students' motivation [10]–[12], improve academic performance [13], enhance cognitive development [14], promote student engagement [15], learning experience [16, 17] and as one of the teaching strategies [18]. Moreover, AR could improve the quality of education [12, 19]. According to [20], AR could help students to enhance their focus through fun activities and immersive experiences. However, the production process, guidelines to construct AR as well as the elements that need to be considered during the development of AR which could give benefits in the education field are still not fully explored.

AR could be developed in various materials. Among them is the use of AR application using textbook [10, 11], mobile learning [21, 12, 22, 13, 23, 17], interactive book [14, 16], games application [24, 15]. This is in line with the study conducted by [25], who explained that the type of materials applied in the trend of AR application used between 2016 and 2017 were more to mobile applications, marker-based, AR books as well as gaming applications. A study by [26] also says that the use of marker-based is more frequently applied using AR. Therefore, educators' knowledge of the types of AR applications helps them to adapt to the innovation in teaching and learning.

1.1 Instructional design

Past research on AR seem to emphasise the Cognitive Theory of Multimedia Learning (CTML) as a design element, Gagne Nine Events as systematic planning and Revised Bloom Taxonomy for developing students' HOT skills. However, there is still no study that combines the three instructional designs in developing AR. According to [27], the Gagne Nine Events could give valuable information to educators because the nine steps emphasized by Gagne are the best way to produce a systematic, structured and holistic teaching and learning context. Furthermore, Gagne Nine Events is flexible because educators can modify the order of the events in accordance with the needs of their respective subjects to achieve the learning objectives [28]. These events could also be applied in both synchronous and asynchronous ways [29] and is suitable for activities that stimulate the visual, auditory, verbal and kinesthetic [30]. However, there is limited research on the usage of Gagne Nine Events during the development of AR. By combining these events, educators could produce an AR that is designed in accordance with the accurate teaching arrangement to retain the learning experience for students. Table 1 shows Gagne's Nine Events of Instruction.

Table 1. Gagne's nine events of instruction

Instructional Event	Description
Gain Attention	Provide stimulus to ensure reception of coming instruction.
Inform learners of objectives	Telling learners what they will be able to do following the lesson.
Stimulate recall of prior learning	Asking for recall of existing prior knowledge.
Present the stimulus	Provide and displaying the content.
Provide learning guidance	Supplying information relevance to enhance understanding.
Elicit performance	Asking to respond to the demonstrating learning.
Provide feedback	Providing immediate feedback on learner's performance.
Assess performance	Giving feedback to learner's additional performance for reinforcement.
Enhance retention and transfer	Providing various practice to generalize the capability.

There are 12 principles suggested by CTML to create the effective multimedia instruction [31]. Previous researchers pointed out that a well planned and developed AR that incorporated with the principles in CTML will produce effective AR content for the students and reduce the students' cognitive load. [32] focused on four CTML principles in developing AR which are (a) multimedia principle (overlaying printed texts with virtual pictorial content or, vice versa, by augmenting physical objects with virtual texts), (b) spatial and temporal contiguity (superimposing virtual content onto physical objects in real-time and thereby spatially and temporally aligning related physical and virtual information), (c) modality principle (playing spoken text, instead of displaying printed text, when recognizing a trigger event), (d) signalling principle (AR can implement signalling by directing and guiding people through learning environments using geographic location information and visual triggers). The result showed that the use of AR-based on CTML produces a lower cognitive effort towards the students compared to the use of traditional computer technology. [33] also applied CTML in building the Augmented Reality Learning Environment (ARLE) where two principles were used, multimedia principle (Real object replaces the picture) and spatial and temporal contiguity (Virtual text and symbol replace the words). CTML provides a learning theory of how real-world annotation by AR can help students learn better based on human cognition and related processes in the brain. [34] only used the principle of modality in CTML as a foundation in cultivating the AR because this principle influences the students' cognition where auditory and visual could be used at the same time.

[10] on the other hand, used CTML as a basis in designing a presentation to deliver e-STAR content to students. The five principles emphasized in developing e-STAR are spatial contiguity principle, temporal contiguity principle, coherence principle, modality principle and redundancy principle. [35] used CTML in the content design where two principles were highlighted which are the Spatial Contiguity Principle dan the Coherence Principle. This showed the importance of CTML in developing AR especially in designing AR content to ensure that students' cognitive is not burdened as well as certifying that the AR design is more effective and has a great impact on students. However, not all principles in CTML can be applied in developing AR as shown in previous studies. The use of CTML principles in developing AR depends on learning objectives, learning outcomes, learning content and the suitability of multimedia materials [36]. Table 2 shows a summary of the use of CTML in developing AR.

Table 2. Summary of the use of CTML in developing AR

Authors	Cognitive Theory of Multimedia Learning
[32]	multimedia principle spatial and temporal contiguity modality principle signaling principle
[33]	multimedia principle spatial contiguity
[34]	prinsip modality
[10]	spatial contiguity principle temporal contiguity principle coherence principle modality principle redundancy principle
[35]	Spatial Contiguity Principle Coherence Principle

Revised Bloom Taxonomy [37] combines two dimensions which are knowledge dimensions (factual, conceptual, procedural, meta-cognitive) with cognitive dimensions (remember, understand, apply, analyze, evaluate, create). It is widely used to classify learning activities according to learning objectives, analyze the syllabus, the relationship between assessment and learning activities or review teaching materials [38]. [39] in their study on playful and interactive environment-based augmented reality used five domains in Bloom Taxonomy which are knowledge, comprehension, application, analysis and synthesis while developing AR and performing self-evaluation for the content.

1.2 Research objectives

The purpose of this study is to build an AILeaD framework using the Fuzzy Delphi Technique. Therefore, the objectives of this study are (a) to validate the constructs and elements of the AILeaD framework based on experts' consensus, (b) to identify the position of construct and element of the AILeaD framework based on expert agreement.

2 Research methodology

In this study, the Fuzzy Delphi Technique was used as a systematic method to decide on the constructs and elements required in developing the AILeaD framework through the experts' consensus.

2.1 Sample of the study

The number of experts for the Fuzzy Delphi Technique is between 10 to 15 experts [40]. Hence, there are 10 experts for the sample of this study which consists of 4 educational technology experts, 2 teaching technology experts, 3 AR experts and 1 model development expert. The criteria of selecting the experts are very important because the experts are responsible for viewing, evaluating and validating the constructs and elements used in the AILeaD framework. The constructs and elements are very important for the improvement based on the consensus of the experienced experts before they can be used. Ergo, the selection criterias for the experts in this study are the experts in the field of AR, the experts in the field of teaching technology, the experts in the field of educational technology and the experts in model development with five years of experience in the field of education. According to [41], those who have served between five to ten years are categorized as specialists because they have undergone a continuous process of teaching and administrative management. Table 3 shows the selected panel of experts who are involved in providing recommendations and validations of constructs and elements in the AILeaD framework.

Table 3. List of expert

Category	Item	Frequency
Gender	Male	7
	Female	3
Teaching Experience	5–8 years	2
	9–12 years	3
	13–16 years	1
	More than 16 years	4
Expertise	Educational technology	4
	Teaching technology	2
	Augmented reality	3
	Model development	1
Institution	Universiti Utara Malaysia	4
	Universiti Kebangsaan Malaysia	2
	Universiti Sains Malaysia	3
	Universiti Sultan Zainal Abidin	1

2.2 Research instrument

The questionnaire was used in this study to get the quantitative data. The utilization of questionnaires fulfils the condition and criteria of the Fuzzy Delphi Technique which is involving the usage of mathematical formulas to get the experts' consensus. The instrument of this study was developed based on the previous study, namely technology skill instrument, adapted and modified by [42] that consists of 10 items while instructional design instrument adapted and modified by [43, 31] that consists of 20 items. As for the types of AR application instrument, it was adapted and modified by [44] that consists of 6 items. This study used Likert-7 Point Scale and it was divided into 2 parts which are construct and element. In the first part, the experts were asked whether they agreed with the constructs in developing AILeaD (technology skills, instructional design and types of augmented reality applications). In the second part, the experts were asked whether they agreed with the elements in each construct. For example, in technology skills constructs, the elements listed and submitted to the experts are the skills of developing video, animation, graphics, programming, 3D models and audio.

2.3 Validity and reliability of the instrument

Four experts were appointed to validate the research instruments which are two senior lecturers from Universiti Sains Malaysia and two senior lecturers from Universiti Utara Malaysia. During this process, comments, suggestions and corrections were advised by the experts in revising the puzzling words, some content items and certain sentences.

2.4 Design and development procedure of AILeaD framework

Figure 1 shows the design and development procedures of the AILeaD framework. The first step is to develop and build the constructs and elements of the AILeaD framework based on the literature review. There are three existing theories that underlies this study which are CTML [31], Gagne's Nine Events of Instruction [43] and Revised Bloom Taxonomy [37]. Based on the literature review, 8 out of 9 Gagne events were adapted in this framework namely gain attention, inform learners of objectives, stimulate recall of prior learning, present the stimulus, provide learning guidance, elicit performance, provide feedback and assess performance. As for the CTML, this study takes five principles into account, namely signalling principle, coherence principle, redundancy principle, contiguity principle and pre-training principle to reduce extraneous processing and manage essential processing while developing AR. Finally, this study also refers to the Revised Bloom Taxonomy when developing AR to ensure that the task/assessment given are in line with the objectives/learning outcomes and the learning materials presented are designed according to low-level thinking (remember, understand, apply) to high-level thinking (analyze, evaluate, create). The second step is the validation of constructs and elements based on experts' consensus through the Fuzzy Delphi Technique. This method is based on the consensus of qualified experts in the field to ensure the validity of the information obtained [45]. The finding from Step 2 will form the AILeAD framework that can be used as a guideline in developing quality and effective AR for teaching and learning aids.

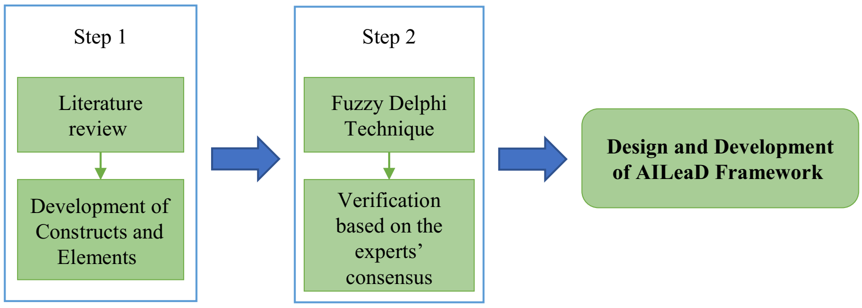


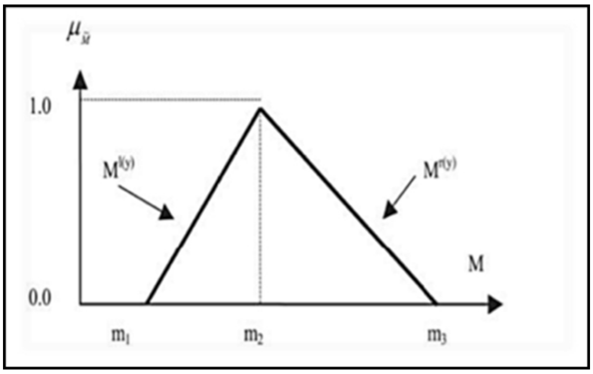
Fig. 1. Design and development of AILeaD framework

2.5 Fuzzy Delphi Technique

This study analysis uses the Fuzzy Delphi Technique which is based on the threshold value (d) measured must be less than or equal to 0.2 [46, 47], the percentage of experts' consensus must be more than or equal to 75% [48, 49] and defuzzification value exceeded alpha-cut = 0.5. The analysis was performed according to the following steps:

<table>
<tr><th>Step</th><th>Process</th></tr>
<tr><td>Step 1</td><td>Selection of linguistic scale. This study chooses a seven-point linguistic scale and Table 4 shows the conversion of the linguistic scale to fuzzy number.

Table 4. Seven-point Linguistic scale
<table>
<tr><th>Linguistic Scale</th><th colspan="3">Fuzzy Number</th></tr>
<tr><td></td><td>m1</td><td>m2</td><td>m3</td></tr>
<tr><td>Strongly agree</td><td>0.90</td><td>1.00</td><td>1.00</td></tr>
<tr><td>Agree</td><td>0.70</td><td>0.90</td><td>1.00</td></tr>
<tr><td>Moderately agree</td><td>0.50</td><td>0.70</td><td>0.90</td></tr>
<tr><td>Slightly agree</td><td>0.30</td><td>0.50</td><td>0.70</td></tr>
<tr><td>Slightly disagree</td><td>0.10</td><td>0.30</td><td>0.50</td></tr>
<tr><td>Disagree</td><td>0.00</td><td>0.10</td><td>0.30</td></tr>
<tr><td>Strongly disagree</td><td>0.00</td><td>0.00</td><td>0.10</td></tr>
</table>
</td></tr>
</table>

Step 2	To overcome the issue of fuzziness among experts, three fuzzy values are given to form a triangular fuzzy number where m1 is the minimum value, m2 is the medium value and m3 is the maximum value. These three values can be seen in Figure 2 which is a mean triangle graph against triangular value.  **Fig. 2.** Mean triangle graph against triangular value
Step 3	Calculate and obtain the average value of a fuzzy number by identifying the average response for each fuzzy number [50].
Step 4	Identify the threshold value (d). To measure the consensus of the expert groups, the result of threshold value (d) must be less than or equal to the value of 0.2 [47]. The determination of this threshold value (d) is based on the following formula: $d(\bar{M},\bar{m}) = \sqrt{\frac{1}{3}(M1-m_1)^2+(M2-m_2)^2+(M3-m_3)^2}.$
Step 5	Identify the percentage of experts' agreement. The percentage value of experts' agreement must be more than or equal to 75% [51].
Step 6	Identify alpha-cut levels. The value of α—cut is equal to 0.5 because the fuzzy number range is between 0 and 1 [52]. If the value of α—cut is less than 0.5, then the measured item is rejected based on expert agreement. If the value of α—cut is equal to 0.5 and above, then it is accepted based on expert agreement.
Step 7	The defuzzification process is the process of determining the position or priority of each item or determining the position of each construct or element [53]. The determination of this value is based on the following formula: $A = (1/3)^{*}(m_1 + m_2 + m_3)$ The element that obtained the highest score value was considered to be in the first position [54].

The researchers use the coded Microsoft Excel Program to get the threshold value (d), percentage of experts' consensus and defuzzification value. The Likert Scale data gained from the experts were keyed in the Excel template and the step 1 until step 7 gained using the Microsoft Excel program (Figure 3).

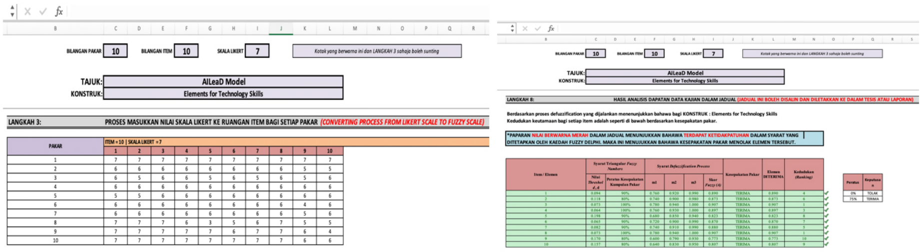


Fig. 3. Microsoft excel program

3 Finding

3.1 Construct for AILeaD

The acceptance of construct for AILeaD must meet three conditions which are threshold value (d) is smaller than or equal to 0.2, experts' consensus percentage exceeds 75% and alpha-cut value is equal to or greater than 0.5. The analysis shows that the threshold value (d) for constructs A1, A2 and A3 is smaller than 0.2. According to [55], the average value and expert rating are less than the threshold value of 0.2, so the item has obtained expert approval. The percentage of experts' consensus on each item also exceeds 75%, namely A1 (90%), A2 (90%) and A3 (90%). According to [48], each item is considered to reach expert agreement when its percentage is equal to or higher than 75%. All defuzzification values for each item also exceeded the α-cut = 0.5 value. Overall, items A1, A2 and A3 in the AILeaD construct meet the above three conditions and are agreed and accepted by the experts. Table 5 shows the overall finding.

Table 5. Construct for AILeaD

Expert	Construct		
	A1	A2	A3
Expert 1 (Educational Technology)	0.084	0.099	0.114
Expert 2 (Educational Technology)	0.084	0.099	0.114
Expert 3 (Educational Technology)	0.071	0.056	0.041
Expert 4 (Educational Technology)	0.071	0.056	0.041
Expert 5 (Instructional Technology)	0.084	0.056	0.041
Expert 6 (Instructional Technology)	0.309	0.295	0.281
Expert 7 (Augmented Reality)	0.071	0.056	0.041
Expert 8 (Augmented Reality)	0.084	0.099	0.114
Expert 9 (Augmented Reality)	0.084	0.099	0.114
Expert 10 (Model Development)	0.084	0.099	0.114
d value of each item	0.103	0.101	0.094
Threshold value (d) of construct	0.129		

(Continued)

Table 5. Construct for AILeaD *(Continued)*

Expert	Construct		
	A1	A2	A3
Percentage of experts' consensus on each item	90%	90%	90%
Average experts' consensus percentage of all items	82%		
Percentage of all items defuzzification (alpha-cut)	0.910	0.900	0.890
Ranking	1	2	3

The items agreed upon by the experts were rearranged according to the rank, from highest to lowest as shown in Table 6. A1 refers to the basic skills required by each teacher in developing augmented reality. Meanwhile, A2 refers to the instructional design that needs to be applied while developing augmented reality. The last item in the AILeaD construct is A3 which is the Types of AR Application.

Table 6. Ranking of construct for AILeaD

Contruct	Rank
A1: Technology skills	1
A2: Instructional design	2
A3: Types of AR Application	3

3.2 Elements for technology skills

The finding from the technology skills elements meets all three conditions where the item value is less than or equal to the threshold value (d) <0.2, experts' consensus percentage exceeded 75% and defuzzification value per item exceeded α-cut = 0.5. The first condition indicates that all of the items in the technology skills elements are (d) <0.2. While the average value is 0.110 (d <0.2) and this shows the consensus of the experts in evaluating and accepting all elements for technology skills. The second condition also has been fulfilled where the average of the experts' consensus of all items marked at 90%, exceeding the required percentage of 75%. The third condition is all alpha—cut values for each item exceed α = 0.5. This indicates that the elements of technology skills have reached expert consensus (Table 7).

Table 7. Elements for technology skills

Expert	Element									
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
Expert 1 (Educational Technology)	0.114	0.138	0.092	0.107	0.206	0.145	0.129	0.092	0.281	0.161
Expert 2 (Educational Technology)	0.041	0.031	0.061	0.046	0.079	0.015	0.027	0.061	0.111	0.093
Expert 3 (Educational Technology)	0.041	0.256	0.061	0.046	0.187	0.015	0.267	0.061	0.111	0.093

(Continued)

Table 7. Elements for technology skills *(Continued)*

Expert	Element									
	B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**
Expert 4 (Educational Technology)	0.041	0.031	0.061	0.046	0.079	0.015	0.027	0.061	0.143	0.093
Expert 5 (Instructional Technology)	0.281	0.256	0.061	0.046	0.079	0.015	0.027	0.061	0.143	0.093
Expert 6 (Instructional Technology)	0.041	0.031	0.061	0.046	0.079	0.015	0.027	0.061	0.409	0.093
Expert 7 (Augmented Reality)	0.041	0.031	0.061	0.046	0.079	0.015	0.027	0.061	0.111	0.093
Expert 8 (Augmented Reality)	0.114	0.138	0.092	0.046	0.780	0.253	0.027	0.092	0.111	0.161
Expert 9 (Augmented Reality)	0.114	0.138	0.092	0.107	0.206	0.015	0.129	0.092	0.143	0.458
Expert 10 (Model Development)	0.114	0.138	0.092	0.107	0.206	0.145	0.129	0.092	0.143	0.093
d value of each item	0.094	0.118	0.073	0.064	0.198	0.065	0.082	0.073	0.170	0.157
Threshold value (d) of construct	0.110									
Percentage of experts' consensus	90%	80%	100%	100%	90%	90%	90%	100%	80%	80%
Average experts' consensus percentage of all items	90%									
Percentage of all items defuzzification (alpha-cut)	0.890	0.873	0.907	0.897	0.823	0.870	0.880	0.907	0.773	0.807
Ranking	4	6	1	3	8	7	5	1	10	9

All of the elements that have been agreed upon by the experts are rearranged according to the order as in Table 8. B3, B8, B4, B1, B7, B2, B6, B5, B10 and B9 are arranged from the highest to the lowest rating.

Table 8. Ranking of elements for technology skills

Element	Rank
B1: Skilled in video editing	4
B2: Skilled in making a video	6
B3: Skilled in graphic editing	1
B4: Skilled in producing graphic	3
B5: Skilled in animation editing	8
B6: Skilled in making animation	7
B7: Skilled in audio editing	5
B8: Skilled in producing audio	1
B9: Skilled in programming (Example; C, C++, Java, Flash)	10
B10: Skilled in producing 3D models	9

3.3 Instructional design (introduction)

The instructional design elements were divided into three aspects, C1-introduction, C2-content delivery and C3-assessment. Table 9 shows the overall of the experts' consensus for the instructional design elements (introduction). It was found that all of the three conditions were met, first, the item value was less than or equal to the threshold value (d) <0.2. C1a, C1b, C1c and C1d each of the items showed a threshold value (d) <0.2 and a threshold value (d) of the construct is 0.104. The second condition also reached the experts' consensus where it exceeded 75%. It was found that the average experts 'consensus percentage of all items was 88%. The last condition was the defuzzification value per item exceeded α-cut = 0.5 where Table 7 shows the percentage of all defuzzification items (alpha-cut) exceeding 0.5. Therefore, all of the elements in the instructional design (introduction) were accepted and reached experts' consensus.

Table 9. Elements for instructional design (introduction)

Expert	Element			
	C1a	C1b	C1c	C1d
Expert 1 (Educational Technology)	0.114	0.099	0.138	0.099
Expert 2 (Educational Technology)	0.041	0.099	0.031	0.056
Expert 3 (Educational Technology)	0.041	0.056	0.031	0.056
Expert 4 (Educational Technology)	0.041	0.056	0.256	0.295
Expert 5 (Instructional Technology)	0.281	0.295	0.256	0.056
Expert 6 (Instructional Technology)	0.114	0.099	0.031	0.099
Expert 7 (Augmented Reality)	0.041	0.056	0.031	0.056
Expert 8 (Augmented Reality)	0.114	0.099	0.138	0.099
Expert 9 (Augmented Reality)	0.114	0.099	0.138	0.099
Expert 10 (Model Development)	0.041	0.056	0.138	0.099

(Continued)

Table 9. Elements for instructional design (introduction) *(Continued)*

Expert	Element			
	C1a	**C1b**	**C1c**	**C1d**
d value of each item	0.094	0.101	0.118	0.101
Threshold value (d) of construct	0.104			
Percentage of experts' consensus	90%	90%	80%	90%
Average experts' consensus percentage of all items	88%			
Percentage of all items defuzzification (alpha-cut)	0.890	0.900	0.873	0.900
Ranking	3	1	4	1

All the elements that have been agreed upon by the experts are rearranged according to the order as in Table 10. C1b, C1d, C1a and C1c are rearranged from the highest rating to the lowest rating.

Table 10. Ranking of elements for instructional design (introduction)

	Element	Rank
C1a	It starts with an induction set that is able to attract the students' attention such as the use of image, video, music, animation and interesting gamification.	3
C1b	Each learning objective should be stated.	1
C1c	Enabling the students to recall what they have learned by using an audio or visual signals (signaling principle) to emphasize the important information.	4
C1d	Enabling the students to recall what they have learned with the necessary signals (signaling principle) to facilitate the selection and organization of information, especially to the weak students	1

3.4 Instructional design (content delivery)

Table 11 shows the overall of the experts' consensus for the elements of the Instructional Design (Content Delivery). It was found that all of the three conditions were met, first, the item value was less than or equal to the threshold value (d) <0.2. C2a, C2b, C2c, C2d, C2e, C2f, C2g, C2h, C2i and C2j, each of the items show a threshold value (d) <0.2 and a threshold value (d) of construct is 0.106. The second condition also reached the experts' consensus where it exceeded 75%. It was found that the average of the experts consensus percentage of all items was 91%. The last condition was the defuzzification value per item exceeded α-cut = 0.5 where Table 11 shows the percentage of all defuzzification items (alpha-cut) exceeding 0.5. Therefore, all of the elements in instructional design (content delivery) were accepted and reached the experts' agreement.

Table 11. Elements for instructional design (content delivery)

Expert	Element									
	C2a	**C2b**	**C2c**	**C2d**	**C2e**	**C2f**	**C2g**	**C2h**	**C2i**	**C2j**
Expert 1 (Educational Technology)	0.114	0.092	0.114	0.242	0.114	0.204	0.200	0.114	0.114	0.076
Expert 2 (Educational Technology)	0.114	0.092	0.114	0.153	0.114	0.188	0.058	0.114	0.114	0.076
Expert 3 (Educational Technology)	0.041	0.061	0.041	0.025	0.041	0.064	0.058	0.041	0.041	0.076
Expert 4 (Educational Technology)	0.041	0.061	0.041	0.025	0.041	0.064	0.058	0.041	0.041	0.076
Expert 5 (Instructional Technology)	0.281	0.061	0.281	0.242	0.281	0.495	0.495	0.281	0.281	0.076
Expert 6 (Instructional Technology)	0.041	0.061	0.041	0.025	0.041	0.188	0.058	0.041	0.041	0.076
Expert 7 (Augmented Reality)	0.041	0.061	0.041	0.025	0.041	0.204	0.058	0.041	0.041	0.076
Expert 8 (Augmented Reality)	0.114	0.092	0.114	0.153	0.114	0.188	0.193	0.114	0.114	0.076
Expert 9 (Augmented Reality)	0.114	0.092	0.114	0.153	0.114	0.188	0.193	0.114	0.114	0.076
Expert 10 (Model Development)	0.041	0.061	0.041	0.025	0.041	0.064	0.058	0.041	0.041	0.076
d value of each item	0.094	0.073	0.094	0.107	0.094	0.185	0.143	0.094	0.094	0.076
Threshold value (d) of construct	0.106									
Percentage of experts' consensus	90%	100%	90%	80%	90%	90%	90%	90%	90%	100%
Average experts' consensus percentage of all items	91%									
Percentage of all items defuzzification (alpha-cut)	0.890	0.907	0.890	0.863	0.890	0.837	0.833	0.890	0.890	0.917
Ranking	3	2	3	8	3	9	10	3	3	1

All the elements that have been agreed upon by the experts are rearranged according to the ranking as in Table 12. C2j, C2b, C2a, C2c, C2e, C2h, C2i, C2d, C2f and C2g are rearranged from the highest to the lowest rating. Elements C2a, C2c, C2e, C2h and C2i share the third position of the ranking.

Table 12. Ranking of elements for instructional design (content delivery)

	Element	Rank
C2a	Arrange the content in order of difficulty level (starting with easy to difficult).	3
C2b	Diverse the medium of delivery.	2
C2c	Relate the content to everyday life.	3
C2d	Apply the coherence principle by avoiding the irrelevant material even the material is interesting because it will reduce the cognitive ability of the students.	8
C2e	Apply the redundancy principle with the use of an appropriate combination of multimedia elements.	3
C2f	Apply the redundancy principle which is a combination of graphics with narrative alone is more effective than with additional text.	9
C2g	Apply the redundancy principle by avoiding the background music if there is a narrative.	10
C2h	Apply the contiguity principle by placing the words close to the relevant visuals.	3
C2i	Apply the contiguity principle by supporting the narrative with appropriate visuals.	3
C2j	Should be framed according to Bloom's Taxonomy which is lower-order thinking skill (application, understanding, knowledge) to higher-order thinking skill (evaluation, synthesis, analysis).	1

3.5 Instructional design (assessment)

Table 13 shows the overall of the experts' consensus for the elements for Instructional Design (Assessment). It was found that all three conditions were met, first, the item value was less than or equal to the threshold value (d) <0.2. C3a, C3b, C3c, C3d, C3e and C3f each show a threshold value (d) <0.2 and a threshold value (d) of construct is 0.089. The second condition also reached the experts' consensus where it exceeded 75%. It was found that the average experts' consensus percentage of all items was 93%. The last condition was the defuzzification value per item exceeded α-cut = 0.5 where Table 13 shows the percentage of all defuzzification items (alpha-cut) exceeding 0.5. Therefore, all of the elements for Instructional Design (Assessment) were accepted and reached the experts' agreement.

Table 13. Elements for instructional design (assessment)

Expert	Element					
	C3a	C3b	C3c	C3d	C3e	C3f
Expert 1 (Educational Technology)	0.154	0.154	0.107	0.107	0.129	0.129
Expert 2 (Educational Technology)	0.154	0.154	0.107	0.107	0.129	0.129
Expert 3 (Educational Technology)	0.034	0.034	0.046	0.046	0.027	0.027
Expert 4 (Educational Technology)	0.034	0.034	0.046	0.046	0.027	0.027
Expert 5 (Instructional Technology)	0.034	0.034	0.046	0.046	0.027	0.267
Expert 6 (Instructional Technology)	0.034	0.034	0.046	0.046	0.027	0.027
Expert 7 (Augmented Reality)	0.034	0.034	0.046	0.046	0.267	0.027

(Continued)

Table 13. Elements for instructional design (assessment) *(Continued)*

Expert	Element					
	C3a	C3b	C3c	C3d	C3e	C3f
Expert 8 (Augmented Reality)	0.533	0.533	0.046	0.046	0.027	0.027
Expert 9 (Augmented Reality)	0.154	0.154	0.107	0.107	0.129	0.129
Expert 10 (Model Development)	0.034	0.034	0.046	0.046	0.027	0.027
d value of each item	0.120	0.120	0.064	0.064	0.082	0.082
Threshold value (d) of construct	0.089					
Percentage of experts' consensus	90%	90%	100%	100%	90%	90%
Average experts' consensus percentage of all items	93%					
Percentage of all items defuzzification (alpha-cut)	0.860	0.860	0.897	0.897	0.880	0.880
Ranking	5	5	1	1	3	3

All the elements that have been agreed upon by the experts are rearranged according to the ranking as in Table 14. C3c, C3d, C3e, C3f, C3a and C3b are rearranged according to the highest rating to the lowest rating. C3c and C3d share the same ranking i.e. first ranking.

Table 14. Ranking of elements for instructional design (assessment)

	Element	Rank
C3a	Demonstrate a learning guide by providing hints, clues, info, terminology or problem-solving workflows.	5
C3b	Apply the pre-learning principle by creating a menu to display the main terms as reference and guidance.	5
C3c	Tasks and assessment given are in line with the objectives and outcomes.	1
C3d	Able to provide immediate feedback to students.	1
C3e	Able to provide constructive feedback and justification to students.	3
C3f	Assess student comprehension by performing formative assessment.	3

3.6 Types of AR application

Table 15 shows the overall expert agreement for the elements of the types of AR application. It was found that all three conditions were met, first, the item value was less than or equal to the threshold value (d) <0.2. D1, D2, D3, D4, D5 and D6 each of the items showed a threshold value (d) <0.2 and a threshold value (d) of the construct is 0.111. The second condition also reached experts' consensus where the percentage exceeded 75%. It was found that the average experts' consensus percentage of all items was 88%. The last condition was the defuzzification value per item exceeded α-cut = 0.5 where Table 15 shows the percentage of all defuzzification items (alpha-cut) exceeding 0.5. Therefore, all elements for these types of AR application are accepted and reach experts' agreement.

Table 15. Elements for types of AR application

Expert	Element					
	D1	**D2**	**D3**	**D4**	**D5**	**D6**
Expert 1 (Educational Technology)	0.160	0.208	0.208	0.232	0.160	0.208
Expert 2 (Educational Technology)	0.014	0.068	0.068	0.093	0.014	0.068
Expert 3 (Educational Technology)	0.014	0.068	0.068	0.093	0.014	0.068
Expert 4 (Educational Technology)	0.014	0.068	0.068	0.093	0.014	0.068
Expert 5 (Instructional Technology)	0.240	0.186	0.186	0.161	0.240	0.186
Expert 6 (Instructional Technology)	0.014	0.483	0.483	0.458	0.014	0.483
Expert 7 (Augmented Reality)	0.014	0.068	0.068	0.161	0.014	0.068
Expert 8 (Augmented Reality)	0.014	0.068	0.068	0.093	0.014	0.068
Expert 9 (Augmented Reality)	0.014	0.068	0.068	0.093	0.014	0.068
Expert 10 (Model Development)	0.014	0.068	0.068	0.093	0.014	0.068
d value of each item	0.051	0.135	0.135	0.157	0.051	0.135
Threshold value (d) of construct	0.111					
Percentage of experts' consensus	90%	90%	90%	80%	90%	90%
Average experts' consensus percentage of all items	88%					
Percentage of all items defuzzification (alpha-cut)	0.860	0.823	0.823	0.807	0.860	0.823
Ranking	1	3	3	6	1	3

All of the elements that have been agreed upon by the experts were rearranged according to the ranking as in Table 16. D1, D5, D2, D3, D6 and D4 were rearranged from the highest to the lowest rating. D1 and D5 share the same ranking which was the first ranking. While D2, D3 and D6 share the same ranking which was the third ranking. Last but not least was D4 which was located at the sixth ranking.

Table 16. Types of AR application

	Element	Rank
D1	AR-based Game Application	1
D2	AR Book	3
D3	AR Flashcard	3
D4	AR Poster	6
D5	AR Gameboard	1
D6	AR Comic	3

4 Discussion

The AILeaD framework was developed based on the literature review and combined the CTML [31], Gagne's Nine Events of Instruction [43] and Revised Bloom Taxonomy [37]. The expert agreed that technology skills should be the first construct in the framework. To develop AR, educators should have technical skills and among the skills that were listed by the augmented reality developer are computer programming, animation, 3D modelling and multimedia [56]. Those unskilled educators would face difficulties and hardships while developing the instructional materials based on AR [42]. Those educators who inquire to develop AR should prepare themselves with the basic skills of technology like editing the graphic, audio and video. Nevertheless, if the educators want to produce a complex AR, they should master advanced technical skills like 3D modelling and programming.

Besides, AR development also requires technology skills in multimedia editing like graphics, video, animation and audio depending on the AR tools used. Usually, the ready-made AR template tools only need some basic skills like video, graphic, animation and audio (low-level tool). But the complex AR tools need animation skills, programming and skill to produce 3D modelling (high-level tool). The finding of this study showed that the position of technology skills agreed by the experts is from basic to advance. The first sixth level only involves basic skills such as graphics, audio and video while the seventh to tenth level indicate advanced technology skills like the ability to produce animation, 3D modelling and programming. All of these technology skills are closely related to the selection of AR tools. If the educators do not have programming knowledge, low-level tools are necessary where educators only need to select, edit and upload information [44]. [56] used GUI based AR authoring tool in producing AR where 3D modelling skills are required. [57] also showed the skills of producing 3D objects, animation, audio and video in producing 3D Augmented Reality Arabic. In addition, the skills of producing and editing images, text, and 3D objects are required in producing android mobile augmented reality [34]. Therefore, these technology skills are agreed by the experts as the first construct to be mastered and learned by the educators before they develop AR so that they do not face any difficulties and take a long time while developing AR later. Moreover, these elements for technology skills are also important when educators decide to choose and use AR authoring tools in developing AR.

Next, the experts agreed that instructional design is the second construct in the AILeaD framework. Instructional design is a systematic process to design, build and carry out all the instructional processes. Most of the instructional design model depends on several steps to produce effective learning materials [58] and among the steps are planning, development and evaluation [59]. Thus, this construct aims to ensure the developed AR is based on the systematic instructional design. The ignorance of the instructional design during the AR development process leads to the failure of the objectives.

This second construct is divided into three parts which are the introduction, content delivery and assessment. The initial part is the introduction which focuses on the learning objective, gaining students attention and signalling principle. Gagne's Nine Events of Instruction stated that educators should inform the students about the learning objectives at the beginning of the lesson before delivering the learning content in order to ensure that the students know the direction of instruction, things to achieve and motivate them to complete the lesson [60]. Next, gain the students' attention to give the stimulation in order to make sure the students are ready to accept the order and activate the receptor [61]. Therefore, while developing AR, multimedia elements such as image, video, music, animation or gamification should be applied to ensure that the students are attracted and stay until the end of the lesson. The signalling principle in CTML stated that learners are better when cues that highlight the organization of the essential material are added [31]. During the development of AR, educators should guide the students to focus on the important concept to ease the choice and arrangement of information specific to the low-level students.

The second part focuses on content delivery. When delivering the learning content through AR, educators should draft the content based on the Revised Bloom Taxonomy which is lower-order thinking skills (applying, understanding and knowledge) to higher-order thinking skills (evaluating, synthesis and analysis). Apart from measuring the knowledge of the students, Revised Taxonomy Bloom is also used to schedule instructional activities in a course to enhance students' learning [62]. Educators could diversify the medium of presentation so that students do not easily feel bored. Students are more excited and attracted to presentations that have audio, video and 3D models because they feel as if they are in the real world [63]. The redundancy principle is that students learn better from graphics and narration than from graphics, narration and on-screen text [31]. Therefore, to ensure that there is no cognitive overload, the educators should combine the appropriate multimedia elements, the combination of graphics with narrative alone is more effective than with additional text and avoid background music if there is narrative. While spatial contiguity is students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen [31]. Therefore, when developing AR, the text should be placed close to the graphic to make it easier for students to understand the content and the narrative should be matched with appropriate visuals. While developing AR content, educators should avoid irrelevant material even if it is interesting as it will reduce the cognitive ability of the students.

The third part is assessment, which is an activity implemented to improve and test students' understanding. There are six elements that were agreed upon by the experts to ensure that the assessments carried out were in line with the learning objectives, immediate feedback, formative assessment and providing learning guidance. According to [64], assessment is not only to assess the students' performance but also the retrieval of information performed by the students can maintain their long-term knowledge.

Finally, the experts agreed that type of AR application is the third construct in the AILeaD framework. AR can produce various types of applications such as AR simulation, location-based services, AR applications for tourism and many more. Nevertheless, in the field of education, the development of AR is more focused on teaching objectives and conceptually shaped information [44]. Therefore, the type of AR application which is the output needs to be adapted with the objectives and information desired by the educators.

Table 17. The constructs and elements in an augmented reality immersive learning design

A. Technology Skills	
1. Skilled in producing audio	
2. Skilled in graphic editing	
3. Skilled in producing graphic	
4. Skilled in video editing	
5. Skilled in audio editing	
6. Skilled in making a video	
7. Skilled in making animation	
8. Skilled in animation editing	
9. Skilled in producing 3D models	
10. Skilled in programming (eg. C, C+, java, flash)	
B. Instructional Design	
Introduction	1. Each learning objective should be stated.
	2. Enabling the students to recall what they have learned with the necessary signals (signaling principle) to facilitate the selection and organization of information, especially to the weak students (signaling principle).
	3. It starts with an induction set that is able to attract the students' attention such as the use of image, video, music, animation and interesting gamification.
	4. Enabling the students to recall what they have learned by using an audio or visual signals (signaling principle) to emphasize the important information.
Content Delivery	1. Should be framed according to Bloom's Taxonomy which is lower-order thinking skill (application, understanding, knowledge) to higher-order thinking skill (evaluation, synthesis, analysis).
	2. Diverse the medium of delivery.
	3. Arrange the content in order of difficulty level (starting with easy to difficult).
	4. Relate the content to everyday life.
	5. Apply the redundancy principle with the use of an appropriate combination of multimedia elements.
	6. Apply the contiguity principle by placing the words close to the relevant visuals.
	7. Apply the contiguity principle by supporting the narrative with appropriate visuals.
	8. Apply the coherence principle by avoiding the irrelevant material even the material is interesting because it will reduce the cognitive ability of the students.
	9. Apply the redundancy principle which is a combination of graphics with narrative alone is more effective than with additional text.
	10. Apply the redundancy principle by avoiding the background music if there is a narrative.

(Continued)

Table 17. The constructs and elements in an augmented reality immersive learning design *(Continued)*

Assessment	1. Tasks and assessment given are in line with the objectives and outcomes.
	2. Able to provide immediate feedback to students.
	3. Able to provide a constructive feedback and justification to students.
	4. Assess student comprehension by performing formative assessment.
	5. Demonstrate a learning guide by providing hints, clues, info, terminology or problem-solving workflows.
	6. Apply the Pre-learning principle by creating a menu to display the main terms as reference and guidance.
C. Types of AR Application	
	1. AR-based Game Application
	2. AR Gameboard
	3. AR Book
	4. AR Flashcard
	5. AR Comic
	6. AR Poster

5 Conclusion

This study has discussed the finding of the two objectives of this study which are (a) validate the constructs and elements of the AILeaD framework based on experts' consensus (b) identify the position of constructs and elements of the AILeaD framework based on experts' consensus. The finding of the study shows that overall experts' consensus has been obtained to determine the construct of the framework, namely technology skills, instructional design and types of AR applications. Next, the framework elements for each of these constructs were validated and ranked according to the experts' consensus as shown in Table 17. This study has several contributions especially to the field of instructional technology. Firstly, the occurrence of a new framework that combines three instructional designs which are Gagne Nine Events, Cognitive Theory of Multimedia Learning dan Revised Bloom Taxonomy, thus it is filling the gap in this area of knowledge. The combination of these three theories resulted in the prime framework construct which are instructional design that consists of the introduction, content delivery and assessment. Secondly, the Fuzzy Delphi technique was used to evaluate and confirm the constructs and elements that contain in the AILeaD framework. This process involves a group of experts to achieve the concurrence and agreement to make a decision. Finally, the finding of this study could be used as a guideline for teachers, lecturers, instructional designers and application designers in creating AR. All the elements and constructs demonstrate the crucial of the use of AILeaD in developing the pedagogical resources based on AR and verified by the experts. Despite of that, educators that want to make AR as an aid in teaching using the AILeaD framework need to be aligned with the learning objectives and learning outcomes. Hence, further study is suggested to develop the AR prototype based on this AILeaD framework and tested the effectiveness of students' achievement. The benefit of this study is not only for the educators, students also could gain a meaningful experience through immersive pedagogical. The development of AR based on AILeaD can improve the innovation in teaching as well as improve the quality of education in Malaysia during facing the Education 4.0.

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