

The development of augmented reality framework to enhance students' motivation

Farah Mohamad Zain, Marini Kasim, Faizahani Ab Rahman, Mohd Faiz Mohd Yaakob
School of Education, Universiti Utara Malaysia, Sintok, Malaysia

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ABSTRACT

Previous studies have shown that augmented reality (AR) is an interactive teaching aids that can improve students' learning motivation. Many studies have discussed AR technology but there are scarce studies on developing AR framework and guideline for teachers. Therefore, the objective of this research is to study the need to develop an AR framework to enhance motivation among students based on Gagne's nine events of instruction and self-determination theory (SDT). This research employs the design and development research (DDR) method with a blend of quantitative and qualitative in which data was collected via a closed and open questionnaire. The respondents of this research are 35 teachers who are teaching technology course in Kedah, chosen through purposive sampling. The findings revealed the need to develop an AR framework by taking into consideration five main constructs, namely motivation, technology skills, instructional design, AR development tools and types of AR applications. Hence, AR developed using this framework has the potential to enhance student motivation and create effective AR learning experiences for students.

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Corresponding Author:

Farah Mohamad Zain
School of Education, Universiti Utara Malaysia
Sintok, Bukit Kayu Hitam, Kedah, Malaysia
Email: mz.farah@uum.edu.my

1. INTRODUCTION

In the education system, some students face challenges in mastering study skills, primarily due to limited retention capacity and difficulties in effectively grasping the core content of lessons. Therefore, a variety of learning applications, multimedia and advanced technologies such as video-based learning, [1] massive open online courses (MOOCs), [2] digital teaching and learning [3] and the usage of Web 2.0 [4]. have been introduced as a tool to enhance the students' understanding. Nevertheless, most of these learning applications have not been focusing on immersive learning experience and augmented reality (AR) which hold the potential of marking up students' motivation, eliciting a positive impact on the learning experience for the weaker learners [5]. The existing AR underlines the outcomes of its usage on the achievements and the perception of the students, regardless of the elements that should be inculcated such as learning theories and designing principles in the process of developing AR. The well-designed AR can encourage, stimulate, motivate and enhance the engagement of the students [6]. Nevertheless, the usage of AR is still new among teachers particularly in Malaysia and requires appropriate guideline to assist them in integrating it into teaching and learning process [7]. In light of this, the researcher has suggested the development of the AR framework acts as a guideline for the educators, the lecturers, the teaching designers as well as the designers in creating AR. This framework would consider relevant learning theories while developing AR experiences. However, the needs analysis has to be carried out prior to this effort in order to survey the need to develop the framework and the requirements of constructs and elements in the framework.

2. LITERATURE REVIEW

2.1. Augmented reality

AR is a technology that incorporates virtual objects into reality and users can interact with the virtual object in real-time [8], [9]. It is very different from virtual reality technology which ‘isolates’ users into a virtual new world. For example, users who wish to experience adventure in space, AR technology will take them into the ‘true feeling’ of being in space by fully equipping and dressing them as astronaut. Thus, the users are able to fully interact in such atmosphere although in reality, he is placed either in a room or virtual lab. AR enriches the learning experience by seamlessly blending two-dimensional and three-dimensional animated visual in a more authentic way [10]. It has a capability to offer a new perspective and approach of learning, positioning it as a promising tool in the educational landscape.

The findings of previous studies show that the use of AR can enhance creative thinking and improve student’s comprehension [11]. Moreover, AR can provide a fun immersive learning experience and encourage students to do self-exploration [12], [13]. The utilization of AR also yields beneficial impacts on self-efficacy of students with special needs [14]. For teaching that require students to describe an object that difficult to visualize, AR can help students’ cognitive to visualize the object through 3D or 2D AR [15]. According to Richardo *et al.* [16], incorporating AR into mathematics subject can streamline the teacher’s role in delivering content, reduce time constraints and foster a heightened level of interactive learning. AR also has the potential to encourage, stimulate, motivate and increase student engagement by viewing and manipulating learning materials from a variety of different angles [17]. Moreover, AR has the potential to encourage collaboration between students and teacher or fellow students [18], by sharpening students’ creativity and imagination [19], allowing students to organize and control their own learning [20] and therefore, build an authentic learning environment appropriate to various student learning styles.

2.2. Augmented reality framework

AR can also help students in visualizing an abstract concept and escalating their understanding at once. Therefore, this advantage of the AR has been applied extensively in the field of education. In fact, this technology has been employed as a teaching aid in a myriad of educational fields, especially in subjects like science [21], [22], mathematics [23], [24], language [25], [26], and engineering [27]. However, prior research has predominantly focused on the development of AR applications, often neglecting to integrate relevant learning theories and design principles.

Successively, there is a need in proving holistic models and design principles for AR learning [28]. The framework is essential to enable a teacher to use AR as a teaching aid more effectively to achieve teaching and learning objectives. This is in line with the opinion of Gagne *et al.* [29], that each technology has its respective advantages in representing objects, facts, ideas, processes, human activities, character models, spatial relationships or in motor skill development. According to Gagne *et al.* [29] again, in most cases, the combination of several strategies in the use of teaching technology is very helpful in attaining the objectives of effective teaching and learning. This opinion is also advocated by Billingham and Duenser [18], where they found that it is better to identify how AR-based applications are best suited to be used in educational environments. This framework will help educators in choosing the appropriate design in the use of AR in teaching and learning, but also assist AR developers in creating educational-based applications that suit the needs of an educator and student.

There are several AR frameworks in education that have been identified including: i) the experience of using AR in science, technology, engineering, and mathematics (STEM) education with exploring dimensions of tangibility, simulation, and interaction [30]; ii) a conceptual model of AR for science textbooks that is user friendly, engaging and fun so as to determine the effectiveness of AR in science learning [4]; iii) an AR-sci framework consisting of nine elements namely interactive, creative, collaborative, situation-based learning, inquiry-based science, augmentation, 3D visuals, adapting different perspectives and data [31]; iv) enhanced science textbook using AR (e-STAR) model consists of three components namely design for information, design for interaction and design for presentation [32]; and v) AR for learning muscular system (ARMS) model consists of three components namely requirement to implement AR in classroom, experiential learning model and high-level prototyping [33].

However, the existing AR framework does not emphasize the learning theory which is the lifeblood of education. Therefore, this study proposes the development of a holistic AR framework and includes learning theory in ensuring that the AR meets the criteria in terms of content, presentation, human-computer interaction, teaching and learning theory and immersive learning experience. However, before an AR framework is developed, a needs analysis needs to be conducted to i) identify the constructs and elements in designing the AR framework and ii) explore the need to develop an AR framework.

2.3. AR and motivation

The findings of previous studies indicate that the use of AR increases student motivation in a more effective way [34]–[37]. Creating learning environment with AR can increase students' motivation and interest, resulting in more effective and deeper understanding of content learning [38]. Motivation can be defined as having a sense of belongingness [39]. Students driven by motivation engage more activities in tasks completion compared to unmotivated students.

In this regard, Maslow [40] found that utilization of AR can enhance students' motivation by improving the visualization of course material for better understanding. AR provides innovative and interactive ways of learning a specific concepts and has an edge over the traditional styles of teaching and learning in classroom setting. Its notable advantage lies in its ability to enhance student motivation during task execution. Kaur *et al.* [41] mentioned that in contrast to traditional textbooks, AR not only facilitates learning but also amplifies students' motivation to engage in the learning process. Furthermore, students felt motivated when using AR because it is attractive [42] and enjoyable [43], [44] discovered that university students possessed stronger motivation in learning with AR presentation as opposed to using traditional class notes with static images.

Several AR studies have investigated students' motivation based on Keller's ARCS model [45] which includes four factors: attention, relevance, confidence, and satisfaction [40], [46]. The model outlines a sequence of four steps for sustaining motivation in the learning process: i) attention: capturing students' attention and sparking interest in learning materials; ii) relevance: delivering pertinent information that aligns with students' individual goals; iii) confidence: nurturing positive expectations for achieving success among students; and iv) satisfaction: feeling satisfied with learning experiences. Theoretically, each factor of the ARCS model plays a critical role in motivating students throughout the learning process. However, according to the studies, it may be argued that learners did not significantly utilize all motivational factors of the ARCS model when involved in different instructional design of the AR learning context. In this context, self-determination theory (SDT) is more relevant with the use of AR in enhancing student's motivation.

2.4. The use of need analysis

The need analysis is vital in identifying and evaluating the significance of the subject which is being studied and this eventually led to determining the conclusion and the subsequent actions to be taken [47]. Besides that, the need analysis is also important in identifying the problem before the researcher embarks on the objective of the study, the contents of the research, execution of the study, the targeted-population, and the intervention outputs [48], [49] analysed the need for students to use AR as a learning medium in primary schools and the results of the study was used in developing AR that met the needs of students and teachers' skills. Johar [50] also performed a needs analysis to develop AR-based geometry teaching instruments in secondary schools. The results explicated the necessity in planning and designing before developing AR so that students' understanding of mathematical concepts and skills could be improved. Subsequently, Saforrudin *et al.* [51] surveyed teachers' readiness in developing AR by considering basic technology skills as well as skills in using AR authoring tools. The study found that teachers prefer to use software that are not too technical and less time consuming during the preparation of teaching materials. Overall, it is pivotal to carry out needs analysis before developing an AR framework to ensure that the AR developed meets the needs of users. In addition, the findings and information obtained from the need analysis phase will assist researchers to design and develop an AR framework.

3. THEORETICAL FRAMEWORK

It is essential to integrate multiple learning theories to create an effective and meaningful learning experience. Therefore, this study combines Gagne's nine events of instruction with SDT to develop a more comprehensive AR framework. By blending these theories, the framework aims to address various aspects of instructional design and student motivation, ensuring a more holistic approach to learning.

3.1. Gagne's nine events of instruction

Gagne *et al.* [29] has underlined the nine-events instruction to arrange the sequence of a comprehensive teaching, initiating from grabbing attention until improving retention and consequently, learning transfer. This systematic sequence ensures that the educators supervise the student-learning effectively in each event before shifting to the subsequent event, without neglecting any of the important process in learning [52]. The string of nine events which have been highlighted comprises of gaining learner's attention, informing learners of the objective, stimulating recall of prior learning, presenting the stimulus, providing learning guidance, eliciting performance, providing feedback, assessing performance and enhancing retention and transfer. Nevertheless, it is not necessary for the educators to parallel teaching with this sequence, instead the educators could modify the teaching process based on the needed contents, students' ability and any variables which could contribute to the quality of teaching and learning [53].

In relation to that, Abdelmagid [52] proposed an AR model based on Gagne's nine events of instruction by focusing on five phases namely planning, introduction, content, assessment, and summary. The planning phase is to plan the use of AR in accordance with the learning activity and then the introduction phase is to attract the attention and interest of students by using AR animation and allowing students to interact. Next, in the content phase, teachers use AR authoring tools to develop teaching materials creatively and meet the needs of students. Subsequently, in the assessment phase, teachers give the opportunity to the students to trigger their curiosity as well as master the content. The final phase is the summary in which the teachers ensure that their teaching is able to enhance retention and transfer knowledge through the training given to the students.

On another note, Vate-U-Lan [54] emphasizes the first sequence of Gagne's nine events of instruction which is used to gain attention in all levels of AR 3D pop-up book learning. This is because the AR 3D pop-up book is an educational innovation that can increase student's motivation. Therefore, it is important for this study to focus on scenes that attract student's attention.

3.2. Self-determination theory

SDT discusses three primary elements of internal motivation specifically autonomy, competence and also relatedness [55]. Based on the SDT, individual motivation develops if they obtain the power of autonomy to perform a task. Individuals with autonomous powers will also function optimally. According to Deci and Ryan [56], self-determined learning engagement requires satisfaction from the individual himself. For example, students who can determine the topics they want to study are autonomous. Without freedom and self-choice, students will not be successful in self-learning. The internal motivation of educators when implementing teaching and learning creates autonomous power to educators specifically to achieve the learning objectives that have been set. In the context of teaching and learning, this element is in line with Gagne's nine events of instruction which states that educators do not necessarily apply teaching in this order, but can modify it based on the needs and students' abilities that can contribute to the quality of teaching and learning [53].

The next element found in SDT is competence, which is the ability and confidence to successfully perform a task. Competence refers to a person's ability to master learning and is a motivating factor in the cognitive engagement of students. It also helps students to feel capable in learning a skill, creating high satisfaction and understanding among students. In addition, competence can also provide motivation in engaging behavior and emotions that encourage students to learn and create positive feelings throughout the learning process [57]. Thus, this element can be linked to educators' ability and confidence to incorporate AR technology in teaching and learning.

Meanwhile, relatedness refers to the individual's feelings to connect with other people [56]. In the teaching and learning process, students need to connect and share their information with their peers. This can increase knowledge and generate student motivation in understanding a certain learning content. In conclusion, SDT describes support from the point of view of autonomy in the form of educators' freedom to utilize appropriate teaching methods in the classroom which in turn can produce meaningful learning [55]. SDT at the same time works in tandem to support the competent aspects that educators should possess while implementing AR technology-based teaching and learning.

4. METHOD

This research has been conducted based on the design and development research (DDR) by employing a mixed approach, which is a blend of the qualitative and the quantitative data collection via open as well as closed questionnaires. According to Richey and Klein [58], DDR consists of three systematic phases, namely the need analysis phase, the design and development phase as well as the evaluation phase. However, this article merely underlines the outputs of the initial stage of the research, which is the need analysis. The initial phase is recognized as a pivotal one because in this phase, the research questions which would be utilized in forming a model development, would be rectified. Besides that, this phase also plays a vital role in identifying the problems that arise among the selected population [48]. As quoted by Witkin and Altschuld [59], this phase also involves the process of selecting the most appropriate solution, which could be exercised by the researcher. In this research, the need analysis phase serves the purpose of gathering information pertaining to the need to develop the AR framework and its constructs, along with the apt elements in the framework. Thus, the quantitative approach has been executed to answer the first research question, whereas the second research question was answered employing the qualitative research approach.

4.1. Research sampling

In this study, purposive sampling technique has been utilized, in which the respondents were chosen based on certain criteria. Tongco [60] has stated that this methodology refers to a non-random technique which neither require an underlying theory, nor the setting of the number of respondents. Hence, it is the researcher

who decides on identifying the respondents who are able to provide information based on their knowledge and experience. The criteria have been finalized during the selection of the respondents, is teachers who have taught information technology (IT) courses, teachers from the education background related to the field of IT or even teachers who have been utilizing the AR in their teaching and learning. In all, the most evident criteria are none other than reassuring that the shortlisted respondents are really qualified when applying purposive sampling technique. Henceforth, about 35 respondents, comprising of teachers from various schools in Kedah, Malaysia who have fulfilled all the criteria were chosen for this research.

4.2. Research instrument

Questionnaires are used to collect the data which is needed to answer the research questions. The researcher has prepared a set of questionnaires, which consists of instructions and simplified explanations pertaining to this study along with the ways to complete each part of the questionnaires. The questionnaires have been bifurcated into three parts, which is Part 1, comprising of the respondents' backgrounds with five items which have been developed by the researcher. The respondents were to provide information about their gender, age, teaching experience, the highest qualification as well as the types of mobile technology equipment owned by them. In Part 2, the items are used to answer the first research question, in which the respondents were needed to identify the constructs and elements in designing the AR framework. Part 2 comprises questions related to the five main constructs in the AR framework.

To measure respondents' interpretation of elements in the five main constructs, a questionnaire adapted from [51], [53], [55], [61], [62], was used with a number 38 items, Table 1. Teachers responded to the items in a Likert scale from 1-5 with 5 indicating 'strongly agree' and scale 1 indicating 'strongly disagree'. If a respondent chooses a higher scale, it means that the respondent has a much stronger feeling compared to the selection of a lower scale. Thus, a higher scale score indicates a positive perception of the stated element. In Part 3, the open-ended questionnaires are used to answer the second research question, in which the respondents gave their opinions about the need to develop the AR framework. This part also provides space for respondents to give answers other than the options given by the researcher. Among the questions are teachers' views on the need to develop an AR framework, views on the proposed constructs, and other relevant construct suggestions in this framework.

Table 1. Items

Elements	Number of items	Sources
Technology skills	10	[51]
Instructional design	6	[53]
AR development tools	9	[61]
Types of AR applications	6	[62]
Motivation	7	[55]
Total of items	38	

4.3. Data collection

Initially, a pilot study was conducted with 10 respondents who would not be involved in the actual study but possessed the same criteria as the actual respondents' who had knowledge of IT. The pilot study was conducted to assess the understanding of each item of the questionnaire, the format and the duration required to complete the questionnaire. Next, for the actual study, the researchers collected information from respondents who met the criteria. The selected respondents, namely teachers, were guaranteed confidentiality and their answers would only be used for research purposes only. Next, the researchers developed a set of questionnaires using Google Form and distributed these questionnaires via email and Whatsapp application to the 35 selected respondents.

4.4. Data analysis

The focus of this study is to identify the need to develop an AR framework and the appropriate elements to be used as constructs in the AR framework. As such, quantitative data analysis was used to obtain the demographics of respondents and also components in the AR framework, namely technology skills, instructional design, AR development tools, types of AR applications and motivation. The respondents in this study were teachers. The questionnaires received were screened initially and it was found that all 35 respondents managed to answer the questionnaire.

Therefore, all 35 answers were collected and analysed using statistical package for social science (SPSS) version 22. On the other hand, the open-ended questions in Part 2 of the questionnaire set were analysed qualitatively. Qualitative methods were able to answer questions that cannot be explained quantitatively. Therefore, the researchers used open-ended questions to gain clearer and in-depth information on the need to develop an AR framework for educators.

5. RESULTS

5.1. Reliability and validity

A reliability analysis was conducted to check the internal validity and the consistency of the items in the questionnaire. The Cronbach's alpha was used and the values of the Cronbach's alpha, which is less than 0.5 (<0.5) is unaccepted, in which the value of 0.6 is still considered as being questionable. Table 2 shows the Cronbach's alpha values for these constructs are all above 0.9, indicating a high level of reliability. Specifically, the Cronbach's alpha values range from 0.934 for AR development tools to 0.977 for instructional design. The total reliability score for all constructs combined is 0.981, which further emphasizes the strong internal consistency of the measurement instrument used in this study.

Table 2. The cronbach alpha for each construct

Constructs	Cronbach's alpha
Technology skills	0.965
Instructional design	0.977
AR development tools	0.934
Types of AR applications	0.964
Motivation	0.966
Total	0.981

5.2. Demographic

In line with this demographic factor, 35 teachers answered the questionnaires which have been distributed online. The respondents have been selected via purposive sampling, in which the teachers who have expertise, experience as well as knowledge in the utilization of AR technology were chosen. The findings of profiles of the teachers who have been shortlisted as the respondents comprises of gender, age, the teaching experiences, and the highest qualification. The overall findings are being demonstrated in Table 3.

Table 3 displays the number of male and female respondents. There are about 14 male respondents, covering 40% and 21 female respondents, encompassing the remaining 60%. To sum up, about 35 respondents have been engaged in this need analysis research. Out of the total number of respondents that is 35, about 2.9% of them fall under the range of 26-30 years old, 20% of them fall within the range of 31-35 years old, 31.4% in the range of 36-40 years old, 28.6% under the range of 41-45 years old and the remaining 17.1% have been 46 years old and above. Considering the levels of teaching experiences, the researcher has bifurcated this into four parts as a measure to lubricate the analysis process. The findings of the research establish that most of the experienced teachers have been teaching for about 16 years and above, which is 17 respondents, covering 48.6%. The percentages of the teachers who have been teaching within 1-5 years, is 2.9%, 6-10 years, with 8.6%, and 11-15 years is 40%.

Table 3. Respondents' demography

Aspects	Labels	Percentages (%)
Gender	Male	40 (N=14)
	Female	60 (N=21)
Age	26-30	2.9 (N=1)
	31-35	20 (N=7)
	36-40	31.4 (N=11)
	41-45	28.6 (N=10)
	46 and above	17.1 (N=6)
The teaching experiences (in years)	1-5	2.9 (N=1)
	6-10	8.6 (N=3)
	11-15	40 (N=14)
	16 and above	48.6 (N=17)
The highest qualification	Bachelor's degree	34.3 (N=12)
	Master's degree	60 (N=21)
	Doctor of Philosophy	5.7 (N=2)

5.3. The construct of the AR framework

A quantitative approach has been employed via the questionnaire forms. The data analysis adapts a set of descriptive data, including percentages, mean and the standard deviation. Table 4 demonstrates the interpretation of the mean which has been used by the researcher, with reference to Kane [63].

Reflecting from the literature review, five constructs in the AR framework were proposed namely technology skills, instructional design, AR development tools, types of AR applications and motivation,

Table 5. All construct proposals showed a high level of mean interpretation value. These findings indicated that all constructs were accepted in the AR framework (M=4.39; SP=0.886).

Table 4. Interpretation of the mean score

Mean score	Interpretation
1.00-2.00	Low
2.01-3.00	Average low
3.01-4.00	Average high
4.01-5.00	High

Table 5. Constructs of AR

Constructs	Mean	Standard deviation	Interpretation
Technology skills	4.43	0.884	High
Instructional design	4.46	0.886	High
AR development tools	4.37	0.877	High
The types of AR	4.40	0.881	High
Motivation	4.31	0.900	High
Average	4.39	0.886	High

5.4. Technology skills construct

Table 6 shows the suggested elements found in the technology skills construct. Technology skills refer to the basic skills required by every teacher in developing AR. Table 6 showed a mean score of values (M=4.24; SP=0.821). All elements in the technology skills construct showed an interpretation value at a high level except for the skilled elements in programming (e. g., C, C++, java, flash) that is, the interpretation value was at a moderately high level. This indicates that all the suggestions on the elements are well received by the respondents.

Technological skills such as proficiency in programming were too technical and difficult to be learned and used by teachers who did not have IT background which might cause their interpretation to be at a modest stage. However, if teachers do not master these skills, it is likely that they will face difficulties in developing AR-based teaching materials [51]. He added that these technology skills are important because no AR authoring tool can be easily used by teachers if there are no skills such as video, audio, graphics and animation. AR can incorporate all types of digital objects such as graphics, video, animation, multimedia and 3D objects [54]. Therefore, it is imperative for teachers to master these elements of technology skills to develop AR.

Table 6. Elements of the technology skills construct

Constructs	Mean	Standard deviation	Interpretation
Video editing skills	4.31	0.796	High
Video creating skills	4.29	0.789	High
Graphic editing skills	4.26	0.780	High
Graphic creating skills	4.26	0.780	High
Animation editing skills	4.31	0.758	High
Animation creation skills	4.26	0.780	High
Audio editing skills	4.37	0.770	High
Audio creating skills	4.31	0.758	High
Programming skills (examples: C, C++, Java, Flash)	3.94	0.998	Average high
3D model creation skills	4.06	0.998	High
Average	4.24	0.821	High

5.5. Instructional design construct

Instructional design is a systematic process for designing, constructing, implementing and evaluating instruction. The instructional design element refers to AR-based instructional planning. The proposed instructional design element is based on Gagne's nine events. Table 7 shows the mean score values (M=4.54; SP=0.719) for the proposed elements in the instructional design construct. All element showed a high level of interpretation. Accordingly, the findings showed that the proposed content delivery element had the highest mean value of 4.63 (SP=0.690). This explains that respondents agreed and accepted the elements listed for the instructional design construct. This element in the design of development is crucial for every teacher to plan the production of teaching and learning materials based on AR more systematically to increase learning effectiveness and student motivation while avoiding confusion among students.

Table 7. Elements of the instructional design construct

Constructs	Mean	Standard deviation	Interpretation
Set induction	4.49	0.742	High
Learning objectives	4.49	0.742	High
Prior knowledge	4.46	0.741	High
Contents delivery	4.63	0.690	High
Preparation of learning guidelines	4.57	0.698	High
Preparation of feedback and evaluate performance	4.57	0.698	High
Average	4.54	0.719	High

5.6. AR development tools construct

Table 8 shows nine elements for AR development tools. ARToolkit had the highest mean value for the element in the AR development tools construct which is 4.09 (SP=0.887). Previous research elucidated that AR was developed using software or applications that were complex and tailored to the content and designed according to a robust instructional design [64]. However, this finding differed from Mundy *et al.* [61] where most educators preferred to develop AR using ready-made AR apps such as Aurasma/HP Reveal, Merge Cube, and Metaverse. Although they used a ready-made AR platform, the findings revealed high level of student's engagement and interest. The other element suggestions had mean values of interpretation at moderately high level. The mean score for the AR development tools element was 3.83 (SP=0.886). These findings provided an initial insight to teachers in selecting AR development tools that are able to achieve their teaching objectives. For new educators, they are encouraged to use ready-made AR apps while for educators who are already experienced in producing AR, they can use more complex platforms.

Table 8. Elements of the AR development tools construct

Constructs	Mean	Standard deviation	Interpretation
Metaverse	3.60	0.976	Average high
Vuforia	3.97	0.857	Average high
Unity	3.91	0.853	Average high
AR toolkit	4.09	0.887	High
Flar tool kit	3.60	0.881	Average high
Qualcomm AR	3.63	0.843	Average high
Aurasma	3.91	0.887	Average high
Blippar	3.86	0.944	Average high
Augmented class	3.86	0.845	Average high
Average	3.83	0.886	Average high

5.7. Types of AR application construct

Table 9 demonstrates the researcher's proposition for the types of AR application, which embeds the outputs that could be derived from the AR. The AR gameboard element and the AR-based game applications score the highest mean value, which is 4.37 (SP=0.843). Parallel to these outcomes, Tutunea [62] also concluded that the type of AR application which is widely being utilized is the AR gamification, covering a percentage of 26.12%. Thus, the AR-based game applications have been proven to be rather useful in the learning atmosphere as the application holds the potential of enhancing problem-solving, exploration as well as the students' conduct. The entire mean value of interpretation touches on a high level. With that, the findings which have been combed could be helpful for the educators to select the suitable types of AR applications in the process of developing the AR in future.

Table 9. Elements of the AR application construct

Constructs	Mean	Standard deviation	Interpretation
AR-based game applications	4.37	0.843	High
AR book	4.23	0.731	High
AR flashcard	4.17	0.822	High
AR poster	4.26	0.817	High
AR gameboard	4.37	0.843	High
AR comics	4.26	0.780	High
Average	4.28	0.806	High

5.8. Motivation construct

Table 10 illustrates the suggestion of elements for the motivation construct in creating the AR application. The entire mean value of interpretation lies on a high level with an average score of mean value

of 4.413 (SP=0.697). Hence, the findings which have been obtained expound that the motivation construct plays a consequential role in the formation of the AR framework.

Table 10. Elements of the motivation construct

Constructs	Mean	Standard deviation	Interpretation
Moulding the students to self-identify objectives/comprehension of the lesson to be learnt	4.34	0.838	High
Assist the students to express their views and ideas respectively	4.46	0.817	High
Aids the students to feel competent	4.43	0.815	High
Enables the students to learn a new skill	4.51	0.781	High
Raise a high sense of satisfaction and comprehension among the students	4.40	0.812	High
Stimulate the students to develop likings towards the contents of the lessons being learnt	4.46	0.741	High
Comprehension and contents of the lessons being learnt help the students to relate to their routine lives	4.29	0.893	High
Average	4.413	0.697	High

5.9. Insights on the need to develop AR framework

Most of the respondents has agreed on the call to develop an AR framework because they view this development framework as a large contributor to the field of education in terms of:

- Guideline to educators

The respondents are of the opinion that the AR framework needs develop to be molded into a set of guidelines for the educators, paralleled to the production of the AR -based learning aids with a guaranteed quality.

“Yes, as a guideline for the educators in terms of producing the teaching materials, resting assured that the materials being produced meet the appropriate criteria.” (R2)

“Yes, acting as a guide to construct an interactive learning based on the AR.” (R22)

“It’s needed this framework is capable of gearing the enhancement of the augmented reality application in various subjects or topics.” (R35)

- Novel fields that need to be explored by educators

Since AR is a novel field in Malaysia, it is pivotal for the educators to have a specified framework that meets the students’ features in Malaysia. The design of the AR framework plays an undeniably essential role in uplifting the quality of the learning aids as well as keeping the teaching aids abreast for the educators’ utilization [50].

“Yes, it is required as augmented reality being a new field, needs a specified base which has been developed in accordance with the framework as well as the culture of the teaching and learning in Malaysia.” (R4)

Needless to say, the respondents have opined that the AR framework is indeed needed not merely to ease the students to be adapted in the real world but also to enable the students to get to know and remember things in-depth.

“In my opinion, it is needed. This is because the pupils or the students will be able to easily feel that they are in the real world, even though they are unable to get there. They will also be able to be well-acquainted as well as have an elevated retention capacity of a certain knowledge.” (R14)

“Yes, due to the current technology circulation, which is rather sophisticated, in line with the competency level of the pupils and the students of today towards the latest and the apparent technology.” (R32)

- Contemporary teaching and learning aids

The use of AR can make teaching and learning sessions more interesting and produce an interactive learning session. In addition, AR is used as learning aids in accordance with the advancement of innovative technology in line with the level of competence of students on the latest technology.

“To ensure the teaching activities are interesting.” (R15)

“Need it if want to have interactive learning using AR.” (R18)

“Yes, because it is an innovation in the education that is towards IR 4.0.” (R19)

Overall, the opinion expressed by the respondents explained that the development of AR framework is crucial as a guide to educators in producing a more effective AR.

6. DISCUSSION

This study identifies the constructs in AR framework and the need to develop an AR framework. While earlier studies have investigated the use of AR in teaching and learning, they have not explicitly addressed the important component in developing a quality AR for teaching and learning. We found that there are five main constructs in the AR framework which are technology skills, instructional design, AR development tools, the types of AR and motivation. In addition, findings also showed that the need to develop an AR framework as a guideline to educators. Our study suggests that a lack of technology skills will prevent educators from creating AR-based teaching and learning materials [51]. Meanwhile, instructional design based on Gagne's nine events will assist educators in organising AR content systematically. However, educators can modify the sequence of the teaching process based on the application of AR [53]. As for the third construct which is AR development tools that enlist nine relevant and appropriate tools to develop AR, either ready-made AR apps to more complex apps. The choice of AR development tool also depends on the technological skills of the educators. AR application construct will give insightful ideas to educators in producing output such as AR gameboard, AR-based game applications and so on. Finally, motivational constructs focus on autonomy, competence and relatedness. It is hoped that AR framework developed from this needs analysis will assist educators in designing and creating instructional materials using AR to facilitate effective teaching and learning. Besides, this alternative feature could help to enhance the students' ability in learning [65]. In addition to this, reference Budiman [66] showed that students' understanding about the usage of AR did improve and increase their motivation in learning.

7. CONCLUSION

This preliminary research has drawn some conclusions as follows. Firstly, there is a need to develop a framework for the instructional design of educational AR in education, especially to enhance students' motivation. As highlighted by the respondents, AR is quite a novel field for most of the educators in Malaysia. Therefore, the framework is needed as a guide for the teachers in developing instructional materials that fulfil the current requirements of IR 4.0. Secondly, the elements of the AR framework have been identified from the following main constructs, technology skills, instructional design, the AR development tools, types of AR applications and motivation. These constructs are derived from the literature and further confirmed by the respondents to this study based on their expertise in the field of IT and their experiences using AR applications.

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AUTHOR CONTRIBUTIONS STATEMENT

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Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Farah Mohamad Zain	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	
Marini Kasim		✓				✓		✓	✓	✓		✓		
Faizahani Ab Rahman	✓		✓	✓		✓	✓			✓	✓		✓	
Mohd Faiz Mohd Yaakob		✓	✓	✓	✓					✓			✓	

C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest in this paper's publishing.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee; or: The research related to animal use has been complied with all the relevant national regulations and institutional policies for the care and use of animals.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [FMZ], upon reasonable request.

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BIOGRAPHIES OF AUTHORS



Farah Mohamad Zain    is a senior lecturer in educational technology and deputy dean (research and innovation) at School of Education, Universiti Utara Malaysia. She has served Universiti Utara Malaysia as an academician since 2017. She has extensive experience in digital content development (video production, editing, narrating, and interactive content) and has produced works and written books on these areas. Her research areas and interest include digital content development, instructional technology, scholarship of teaching and learning and technology enhanced learning. She can be contacted at email: mz.farah@uum.edu.my.



Marini Kasim    is a lecturer at School of Education, College of Arts and Science, Universiti Utara Malaysia. Previously she had an experience as a general manager and a trainer of a company. Besides that, she also had experience in the educational sector as she had been a school teacher for 10 years. Her interests include but not limited to research on management and psychological factors that supports learning. She can be contacted at email: marini@uum.edu.my.



Faizahani Ab Rahman    background is on teaching of English as a second language but she also has a qualification in corporate communication. Apart from looking at teaching and learning processes that take place in and outside of classrooms, her areas of interest have recently developed into gender studies and issues, focusing more on women in higher learning institutions. She can be contacted at email: faizahani@uum.edu.my.



Mohd Faiz Mohd Yaakob    is an associate professor in the School of Education at Universiti Utara Malaysia, Malaysia. With a specialization in educational management and administration, he possesses extensive knowledge and expertise in various education-related areas. His dedication to research and scholarly activities has been recognized through his appointment as the deputy dean for research and innovation. He opens the collaboration to researchers worldwide, inviting them to engage in research projects such as Erasmus, MSCA, or other international collaborations. He can be contacted at email: mohd.faiz@uum.edu.my.