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# E-CONSTRUCTION SAFETY EDUCATION IN AUGMENTED REALITY (ECONS)

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## ABSTRACT

*This study mainly focuses on creating a safety module using Augmented Reality (AR) for the employees at the construction site known as ECONS. AR is an enhanced version of the physical world achieved using digital visual elements, sound or other sensory stimuli transmitted through technology. Amid increasing data collection and analysis, one of the primary goals of AR is to highlight specific features of the physical world, improve understanding of those features and obtain intelligent and accessible observations that can be applied to real-world applications. This project aims to explore AR in safety construction education complying with IR4.0 by designing an interactive way of learning safety at the workplace, developing an AR system and testing the efficiency and workability of AR technology. The safety module was designed and developed using Blippar apps. There are four main elements in ECONS: hazard, personal protective equipment (PPE), safety training and OSH basic law. Based on the analysis, ECONS is a simple interactive module for users to learn and understand about safety in construction. It offers a lot of information that is necessary for construction site personnel. Moreover, the ECONS can effectively guide people with legal duties under sections 15 and 17 of the Occupational Safety and Health Act (OSHA) 1994.*

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## 1. Introduction

The construction industry has the highest number of deaths, making it the most critical sector that requires efficient OSH management to reduce the significant number of fatalities at construction sites. The construction industry plays a vital role in contributing to economic performance. The number of accidents and deaths occurring in the industry affects not only the families of victims but also employers who will suffer the loss of experienced workers and be forced to pay incidental costs due to disruption of project activities, increased insurance premiums and medical expenses.

Frequent injuries and health problems related to construction indicate that this industry is the most dangerous occupation due to the unique nature of the construction industry, where workers face a greater risk of work-related death. In addition, workers working in the construction industry are more likely to be killed in their workplace. According to

Abukhashabah E. et. al (2020), the leading causes of the high number of injuries and deaths in construction industry are:

- i. Lack of awareness and experience
- ii. Machinery defects and errors
- iii. Lack of training
- iv. Lack of personal protective equipment PPE
- v. No safety and health officer or supervisor and unsafe work environment

Employers must manage safety management to ensure that a safety culture can be created among construction workers. The employer must implement a written safety policy, accident investigation and reporting, safety records, safety manuals, safety checklists, accident statistical analysis and formal organizational structure.

In architecture and construction education, Hajirasouli, A. and Banihashemi, S. (2022) stated that integrating AR in curriculum can provide students with more realistic and practical learning experience, adaptable to real and physical jobsite. AR allows students to adapt their design to the real scale of construction, within the site. It also provides with unlimited access, to otherwise limited opportunities, to participate in jobsite experiences. Meanwhile, referring to Saidin, N.F. et. al. (2015), the advantages and beneficial uses of AR features can engage students in learning processes and help improve their visualization skills. The features can also help teachers to explain well and make the students easily understand what they are taught.

The objectives of this study are to design an interactive way of learning safety at the workplace, to develop an Augmented Reality (AR) module in the workplace's safety and to test the efficiency and workability of the technology.

## 2. Materials and Methods

The research process in Figure 1 consists of a series of systematic procedures to generate knowledge that will be considered valuable by the project and focus on the relevant topic. The research design of the study consists of three stages.

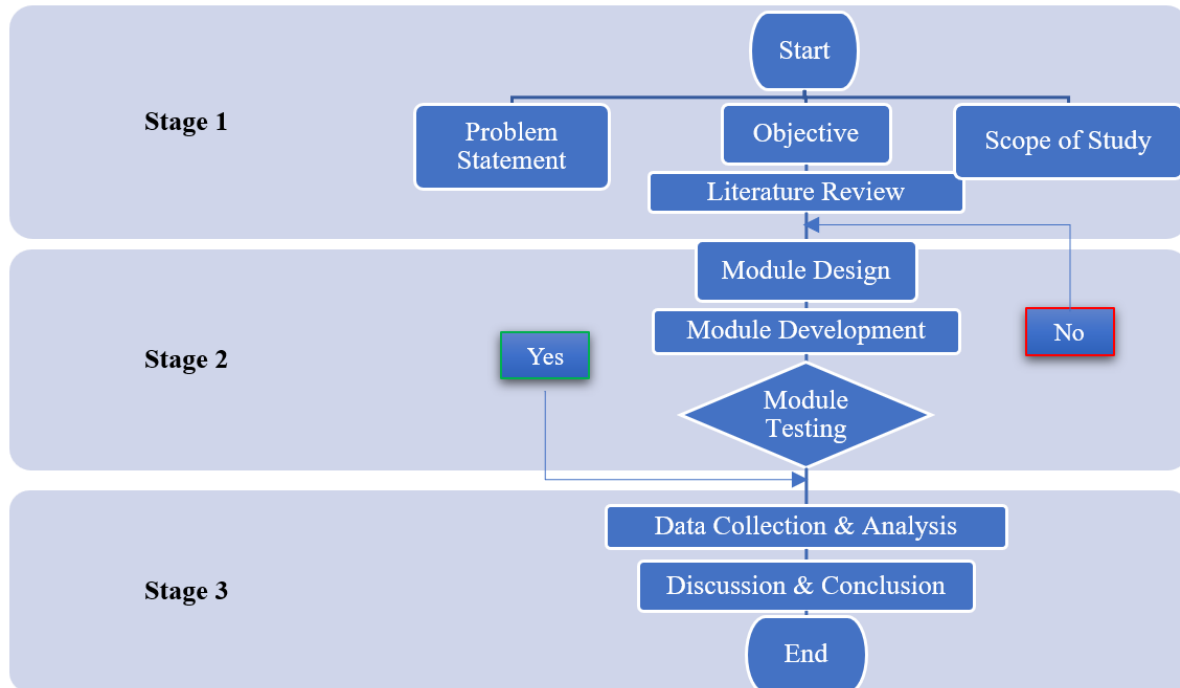


Figure 1. Research Methodology

Stage 1 involves identifying the problem statements, stating the objectives and aims, and planning the scope of study and expectations to be achieved. A well-defined research problem guided all stages of the research process, from setting objectives to choosing a technique. Literature reviews allow for gaining familiarity with the current knowledge and field chosen, as well as the boundaries and limitations. It also helps to understand the theory driving the area, allowing the researcher to contextualize the research question.

In Stage 2, it involves the process of designing, developing and testing the safety module. The module was developed using Blippar apps. It was designed and developed using Blippar apps. Blippar app (Figure 2) is a leading technology content company specialising in Augmented Reality, with the vision of making AR accessible for all. With Blippbuilder, the AR for all creation platforms can easily create and publish augmented reality. In ECONS, four main elements are included: hazard, personal protective equipment (PPE), safety training and OSH basic law. It also comprises the module testing process to verify whether this module can be developed and function as planned.

Kharchenko, Y. V. et. al. (2021) reported the Blippar app has been determined to have great benefits where it is free, the interface is simple and user-friendliness, the possibility of using different file types, the possibility of combining a large amount of information and logically structuring it, loading different types of information of video, images, 3D models, links to sites etc.



Figure 2. Blippar app

Meanwhile, in Stage 3, the discussion and conclusion were made based on the data analysis. Data collection is essential in obtaining the knowledge or information required to answer the research issue. Data was collected among the construction personnel using quantitative research methods through surveys, interviews and observation. These sources provided the primary data.

The safety module will alert construction site workers on what they are doing and what action to take if something happens. The module includes OSH fundamental law, safety, personal protective equipment, and safety training to help construction site workers. The data sampling was chosen among people involved in the architectural, engineering and construction industry (AEC), such as engineers, site supervisors, labour and lecturers and students of Polytechnics of Ungku Omar.

The data collection is taken through:

- i. Surveys (Google forms)- do questionnaires and distribute them to AEC personnel.
- ii. Interview - Interview the professionals to seek opinions, ideas or feedback.
- iii. Observation - Observed by the through-app testing.

### 3. Results

The primary data collection method was using Google Forms to distribute a questionnaire. The questions on the Google form contain some basic questions and opinions to obtain the data and information required through the questionnaire that has been prepared. This question's findings have also offered outcome data to be studied and improvements on application to increase the application facilities' effectiveness further. Statistics obtained from the respondents by Google Forms showed satisfaction with trying the application built in ECONS. The following data has been received.

The information in the tables and graphs is based on the completed Google Forms Survey questionnaire results. Data were evaluated using tables and bar charts, each with full descriptions and explanations. The answers given in response to the questionnaire are critical to the project's success. The questionnaire was separated into two parts to achieve the project objectives: respondent information and assessment of respondent satisfaction with the project. The results of the survey help explain the effectiveness of the module.

### 3.1 Demographic Information

A total of 104 respondents completed the questionnaire about the safety education module. Table 1 shows the findings on demographic information of respondents on genders, age, nationality and occupation. About 57% of the respondents are male and aged above 18 years. Most respondents are Malaysian, including students, employers and retired from the AEC industry.

Table 1. Demographic Information

		Frequency	%
Gender	Male	60	57
	Female	44	43
Age	18-30	67	64.4
	31-40	4	3.8
	41-50	26	25
	>50	7	6.8
Nationality	Malaysian	102	98
	Non-Malaysian	2	2
Occupation	Student	37	35.6
	Employed	56	53.8
	Retired	11	10.6

Table 2 shows the result of respondent's satisfaction with ECONS. There are five elements measured in satisfaction: effectiveness, user-friendliness, time consumption, suitability and awareness. Most respondents strongly agree on the aspects which are evaluated in the questionnaire. 51% of respondents strongly agree on the effectiveness of ECONS. Around 94.2% strongly agree on user-friendliness, and 61.5% strongly agree on time consumption. Meanwhile, regarding the suitability of ECONS for construction safety, 48.1% strongly agree with the respondents, and 38.5% strongly agree on ECONS as an awareness spreader to the AEC industry. However, 2.9% of respondents disagree with the awareness element.

### 3.2 Respondent's Satisfaction on ECONS

Table 2 shows the result of respondent's satisfaction with ECONS. There are five elements measured in satisfaction: effectiveness, user-friendliness, time consumption, suitability, and awareness. Most respondents strongly agree on the aspects which are evaluated in the questionnaire. 51% of respondents strongly agree on the effectiveness of ECONS.

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Table 2. Satisfaction on ECONS

		Frequency	%
Effectiveness	Strongly Disagree	0	0
	Disagree	0	0
	Fair	9	8.6
	Agree	42	40.4
	Strongly Agree	53	51
User Friendliness	Strongly Disagree	0	0
	Disagree	0	0
	Fair	2	1.9
	Agree	4	3.8
	Strongly Agree	98	94.2
Time Consumption	Strongly Disagree	0	0
	Disagree	0	0
	Fair	2	1.9
	Agree	38	36.5
	Strongly Agree	64	61.5
Suitability	Strongly Disagree	0	0
	Disagree	0	0
	Fair	15	14.4
	Agree	39	37.5
	Strongly Agree	50	48.1
Awareness	Strongly Disagree	0	0
	Disagree	3	2.9
	Fair	23	22.1
	Agree	38	36.5
	Strongly Agree	40	38.5

#### 4. Discussion

Based on data analysis, ECONS is an effective way to learn about safety in construction sites because ECONS contains many elements and information that people in construction sites need to know. Thus, the only things people need to have to use ECONS are smartphones and the internet, which has become necessary these days. Improvement can be made if many construction companies use ECONS.

The limitations in this project have indicated the following areas as recommendations for further work as follows:

- i. Upgrade the module from 2D to 3D view to make it more interesting. 3D is preferable as it is eye-catching, attractive, and more realistic.
- ii. Insert more languages so more people can understand the module more, and it will make them use the module more easily.
- iii. Design ECONS to make it more user-friendly so everyone can easily understand how to use the module.
- iv. Focus on the safety training element because understanding safety in construction starts from safety training. Accidents can be prevented even more.
- v. Add more information in ECONS to cover most safety education aspects.

## 5. Conclusion

In conclusion, ECONS can be an effective way to learn about safety in construction because ECONS contains many elements and information that construction site personnel need to know. Thus, the only thing people need to have to use ECONS is a smartphone and internet, which have become necessary. Improvement can be made if ECONS is widely used in many construction companies.

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