

# Development of Augmented Reality (AR) for Innovative Teaching and Learning in Engineering Education



By: Nur Idawati MdENZai, Norhayati Ahmad, Mohd Amir Hamzah Ab. Ghani,  
Siti Sara Rais & Syazilawati Mohamed

Faculty of Electrical Engineering, Universiti Teknologi MARA Terengganu

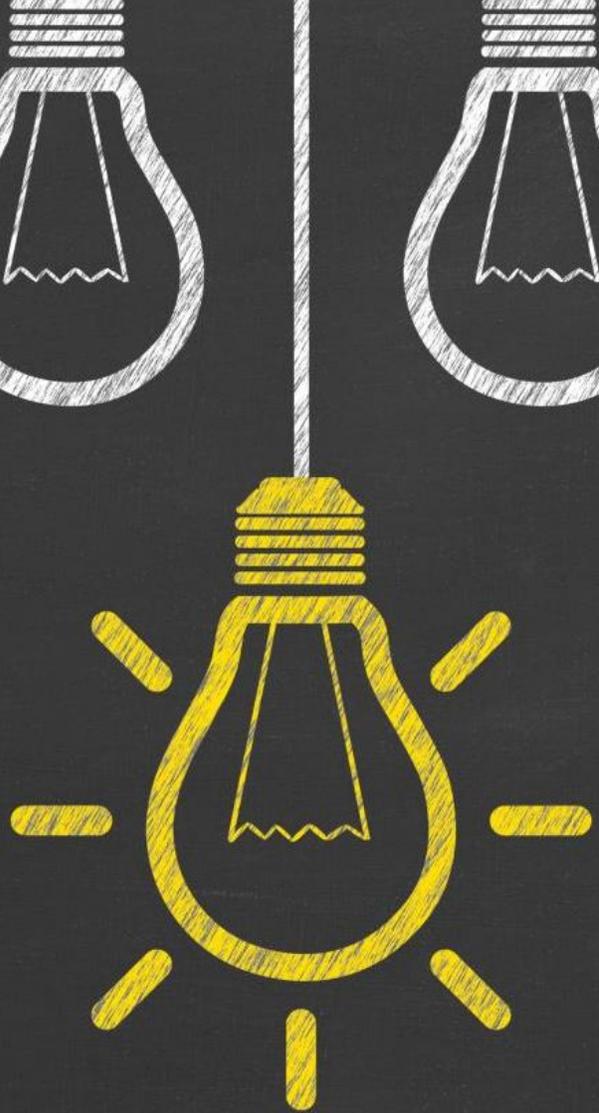
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- Literature Review
- Methodology
- Results and Discussions
- Conclusion and Future Work



# Introduction

# What is Augmented Reality (AR)?

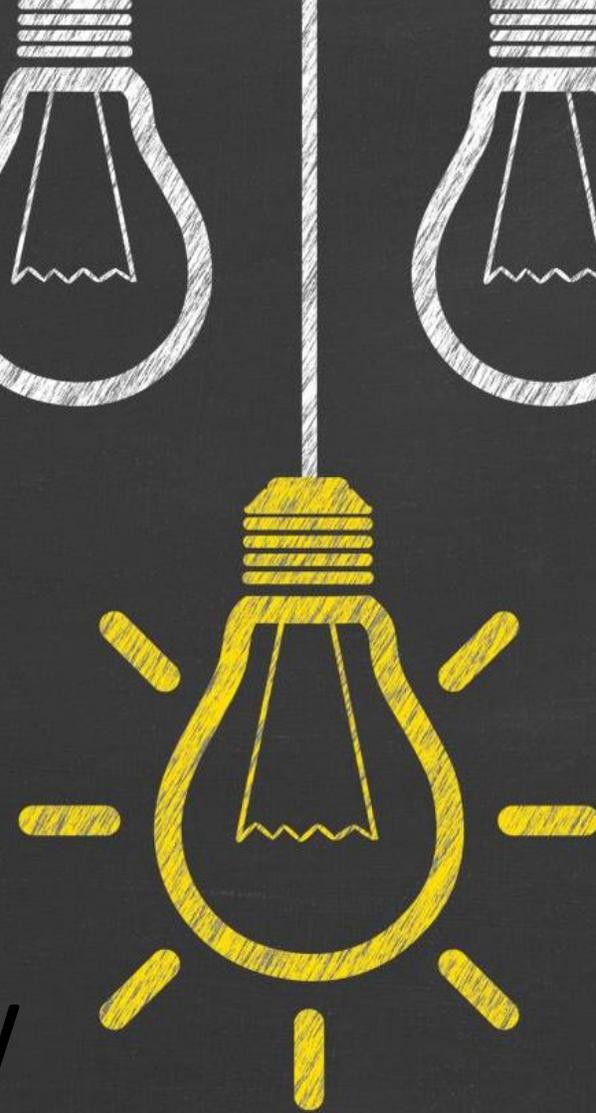
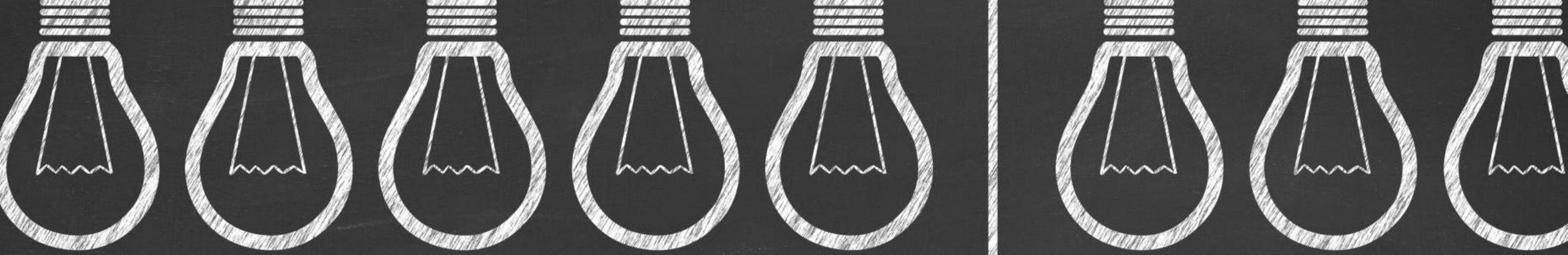
- AR provides an environment where virtual and physical objects can be intertwined
- AR concepts use the real world as its backdrops and added the virtually generated 3-Dimension images to it.
- AR is known for its ability to overlay rich media into the real world by viewing through web-enabled devices such as phones and tablets
- AR is the real-time use of information in the form of text, graphics, audio, and other virtual enhancements integrated with real-world objects

# Augmented Reality in Education

- AR allows rich educational experience for teaching and learning process without requiring existence of physical object by making use of AR application or software on mobile devices (Billinghurst, 2002).
- The features that make AR suitable for learning experience are: interaction with 3D synthetic objects, good utilization of mobile devices and location-tracking, sense of involvement for the learners, as well as virtual realization of invisible concepts or scenarios (Wu, Lee, Chang, & Liang, 2013).
- The application of AR in education has substantial improvement in terms of promoting students to engage, stimulate and motivate in learning
- AR could also address the financial and space constraints pertaining to science and technology laboratory equipment and apparatus.

# Motivation (AR Framework for Engineering Education)

- A well-planned AR is expected to improve learning processes especially for science and engineering subjects as they involve substantial amount of equipment and apparatus.
- In addition to ability to address the issue of lack of resources due to financial and space constraints, safety of students can also be assured through minimal practice of dangerous experiments (Martín-Gutiérrez, Fabiani, Benesova, Meneses, & Mora, 2015).



Literature Review

# Literature Review

-Reviewed 14 pieces of literature.

-Ranged from 2002-2019

Key Emerging Themes	Most Common Methodologies	Limitations
Professional Development	Classroom observations	Limitation of technology
Diverse Learners	Surveys	Lack of Expertise/Training
Motivation	Qualitative research	
Improvement/Learning Enhancement		

# Literature Review

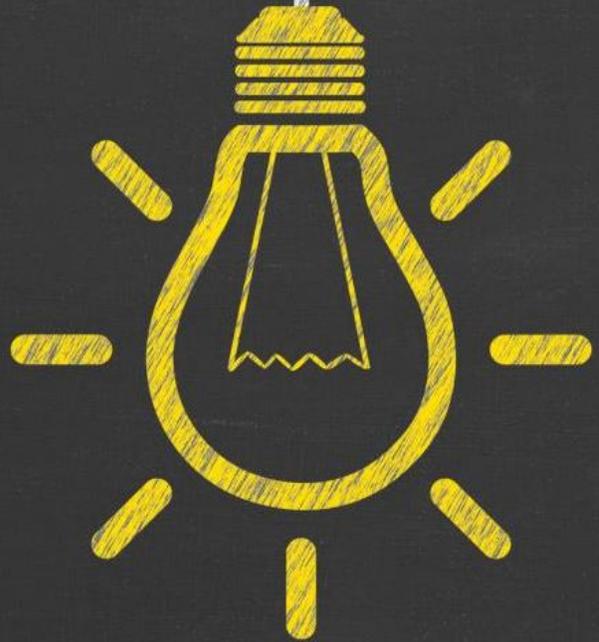
Key Emerging Themes	Literature Review
Professional Development	AR also worked well in higher education setting, in particular when it comes to courses which involve mechanisms of machinery and systems as well as complicated theories (Bower, Howe, McCredie, Robinson, & Grover, 2014).
Diverse Learners	The application of the technology covers extensive fields including art, tourism, archaeology, emergency management, entertainment, leisure, industrial manufacturing and education. (Chen et al., 2019).
Motivation	The developed AR apps using Unity 3D and Vuforia was able to translate a complex laboratory setup into an AR content where the interactivity focuses on assisting the practical training, showing details description of the training system elements. It is concluded that majority of the learners exhibit a positive attitude towards AR technology (Bazarov, Kholodilin, Nesterov, & Sokhina, 2017).
Safety	In addition to ability to address the issue of lack of resources due to financial and space constraints, safety of students can also be assured through minimal practice of dangerous experiments (Martín-Gutiérrez, Fabiani, Benesova, Meneses, & Mora, 2015).
Improvement/Learning Enhancement	The students' results have shown improvement in their learning experience and understanding, subsequently proving that AR works well in portraying complex concepts (Yip, Wong, Yick, Chan, & Wong, 2019).

# Literature Review

Most Common Methodologies	Literature Review
Classroom observations	The studies aim to affect performance and stimulate learners' motivation through application of AR in their curriculum subjects where in this case the test was done to 24 engineering students. (Bazarov, Kholodilin, Nesterov, & Sokhina, 2017).
Surveys	Review studies which concentrate on possible factors of AR in education was conducted in (Bacca, Baldiris, Fabregat, & Graf, 2014). Based on their studies, Science tops the usage of AR in education with 40.6%, followed by 21.9% of humanities and arts and 15.6% of engineering, manufacturing and construction.
Qualitative research	The studies from a series of focus groups shows that this method of learning process would improve the understanding of a subject due to the instantaneous example shown and interactivity of the system. (Mustafa Kamal, Mohd Adnan, Yusof, Ahmad, & Mohd Kamal, 2019).

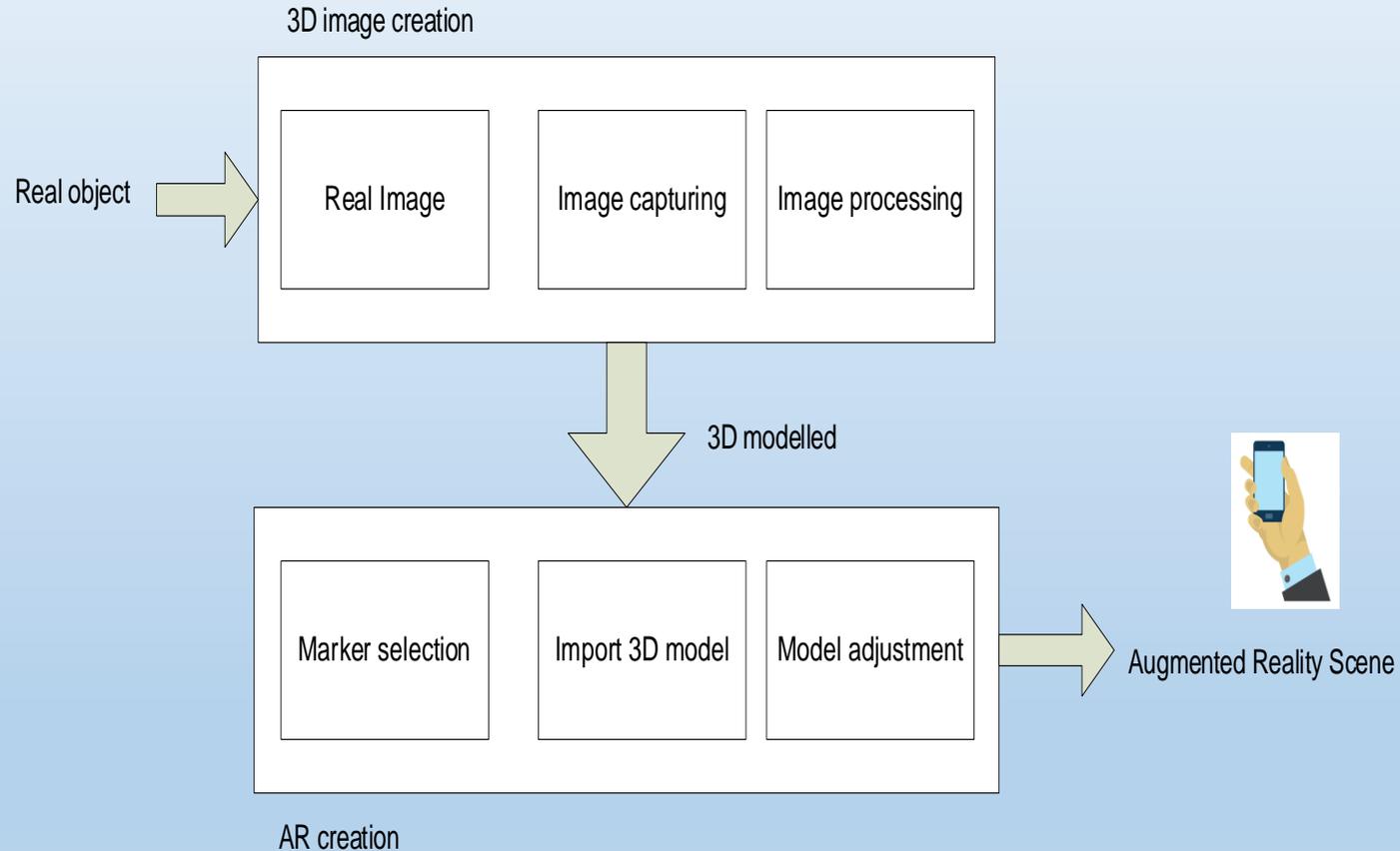
# Literature Review

Limitations	Literature Review
Limitation of technology	<p>However, poor internet connection that cause buffering is somewhat an annoyance and disruptive. The challenges that could hamper the progress of mixed reality education are apparent such as the scarcity of appropriate technical infrastructure and the costly content development process that affect both educators and students. (Mustafa Kamal, Mohd Adnan, Yusof, Ahmad, &amp; Mohd Kamal, 2019).</p> <p>The studies agree that AR technology can be applied in educational settings but not without its downside such as lack of student's activities tracking mechanism, virtual objects collision detection, the trackers and virtual objects relationship and so on. (Mota, Ruiz-Rube, Doderro, &amp; Figueiredo, 2016).</p>
Lack of Expertise/Training	<p>Without proper training to teachers, AR can be overwhelming as multiple tasks must be done simultaneously such as lecturing, operating the AR, reading, answering question and so on (Thomas, Linder, Harper, Blyth, &amp; Lee, 2019)</p>



Methodology

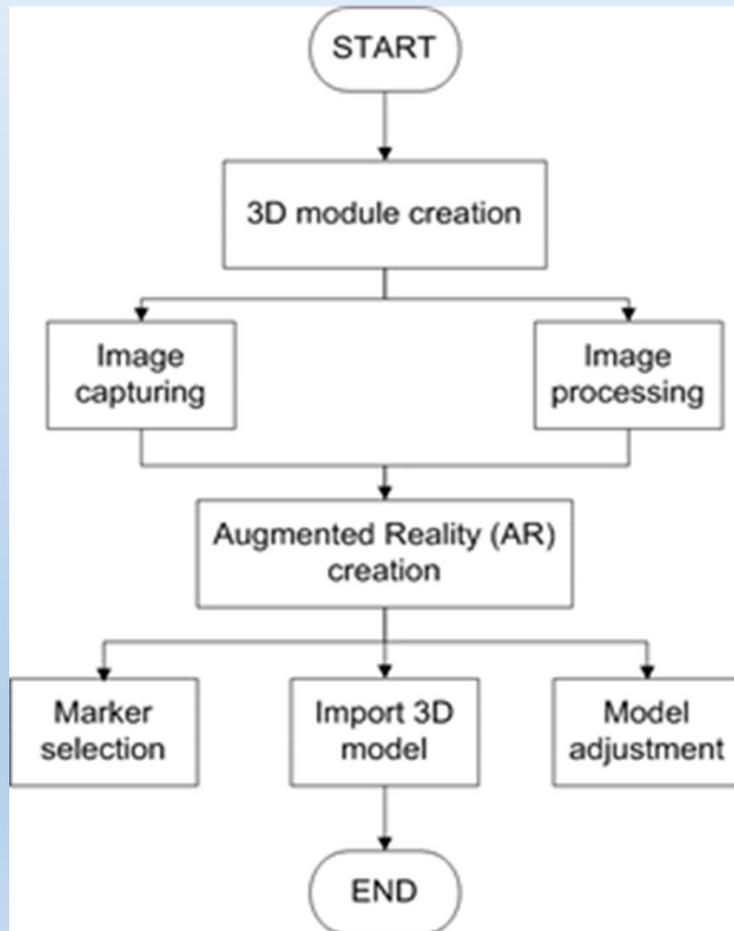
# Block diagram of the AR scene



The general architecture of Augmented Reality AR for this course is shown in block diagram of AR scene. The basic steps involved in developing AR are; creating 3D object, creating AR, and creating AR viewer.

Fig: Block diagram of the AR scene

# Flow chart of AR development



- 3D model creation;

The best pictures taken are used to reconstruct the 3D model. The steps of image processing include the acquisition of 3D information of the object that needs to be modelled.

- AR creation;

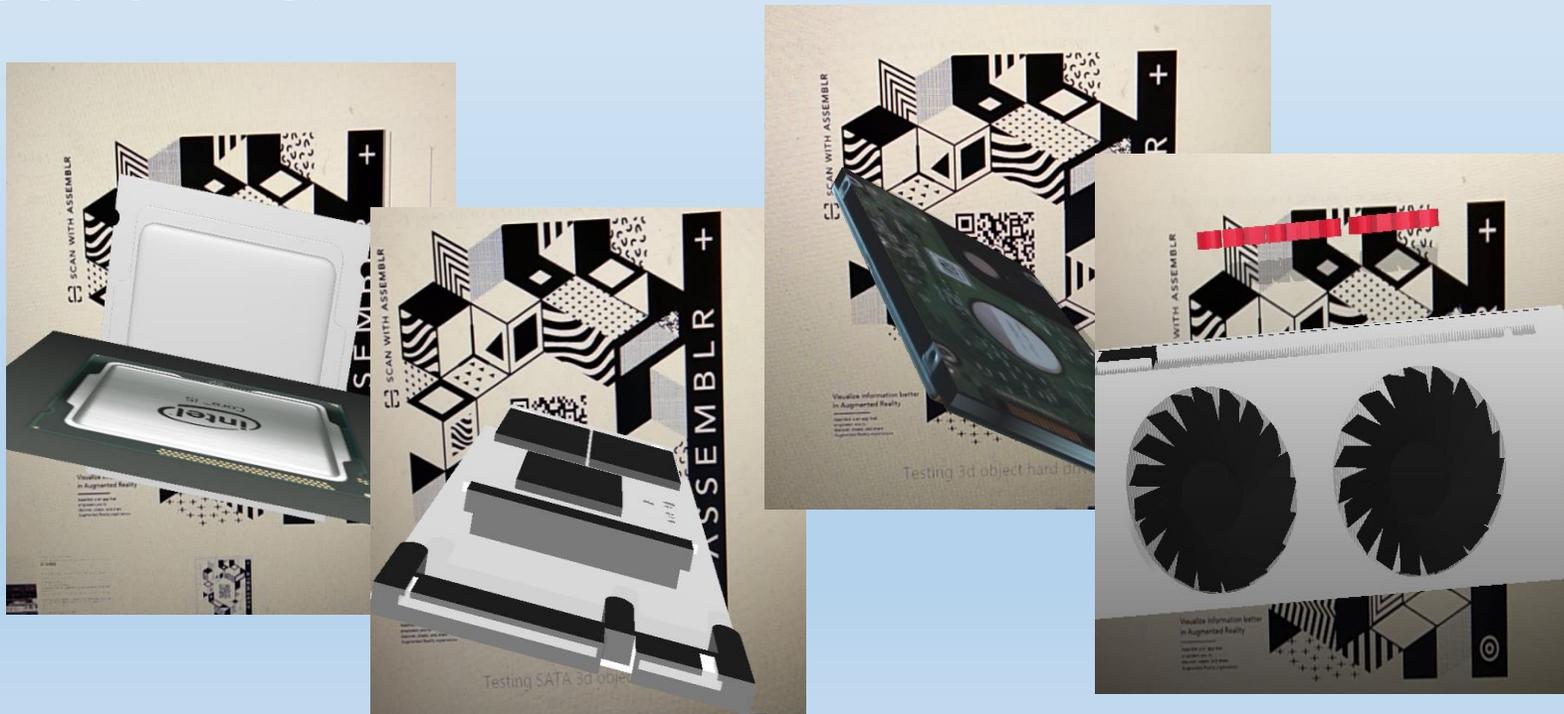
First, a marker is generated and printed, so the scene can be visualized interactively as it is being created. Then, the 3D model is imported, and it undergoes some adjustment to produce the best AR image. Next, the camera scanner needs to be activated and pointed to the printed marker.



# Results and Discussions

# Results and Discussions

- AR View - Each component has its corresponding marker which can be printed and given during face-to-face class session and can also be provided online.



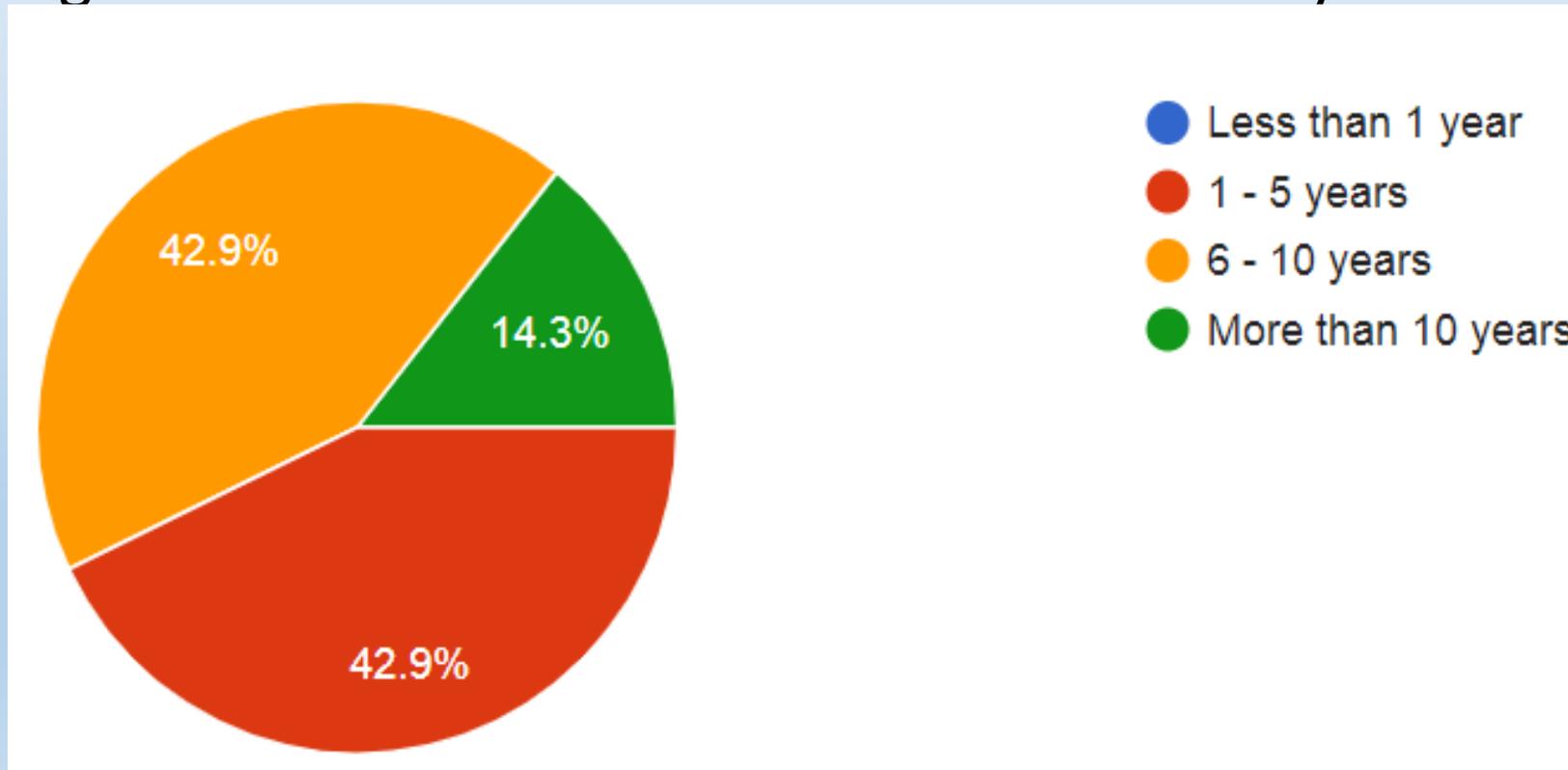
# Results and Discussions

- Survey- This survey aims to obtain user experience responses from selected educators of Electrical Engineering courses. For the initial testing, seven educators have tested the developed AR and then answered the survey to provide their perceptions.

Criteria	Questions	Options of Answers
Background	Years of experience as an educator	Less than 1 year, 1-5 years, 6-10 years, More than 10 years
	Area(s) of research interest	Subjective (open ended)
Awareness	I have heard about AR before. I know how AR functions.	Strongly agree, Agree, Neutral,
Usability	Students can be more interested in learning by using this AR.	Disagree, Strongly disagree,
	The interface of this AR is user friendly.	
Suggestion	Comments for enhancement.	Subjective (open ended)

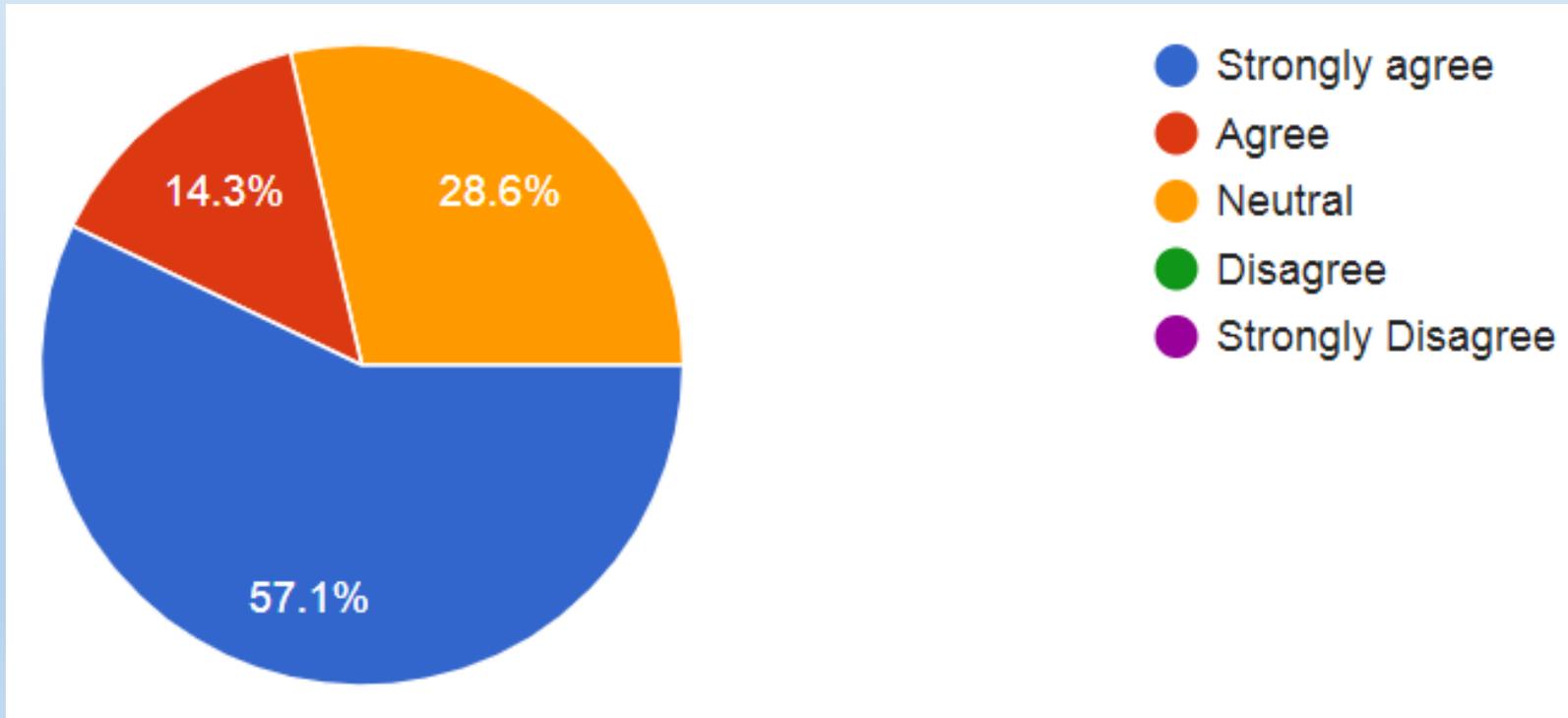
# Results and Discussions

- Almost 85% respondents have more than 5 years experience and the remaining have worked as educators for less than 5 years



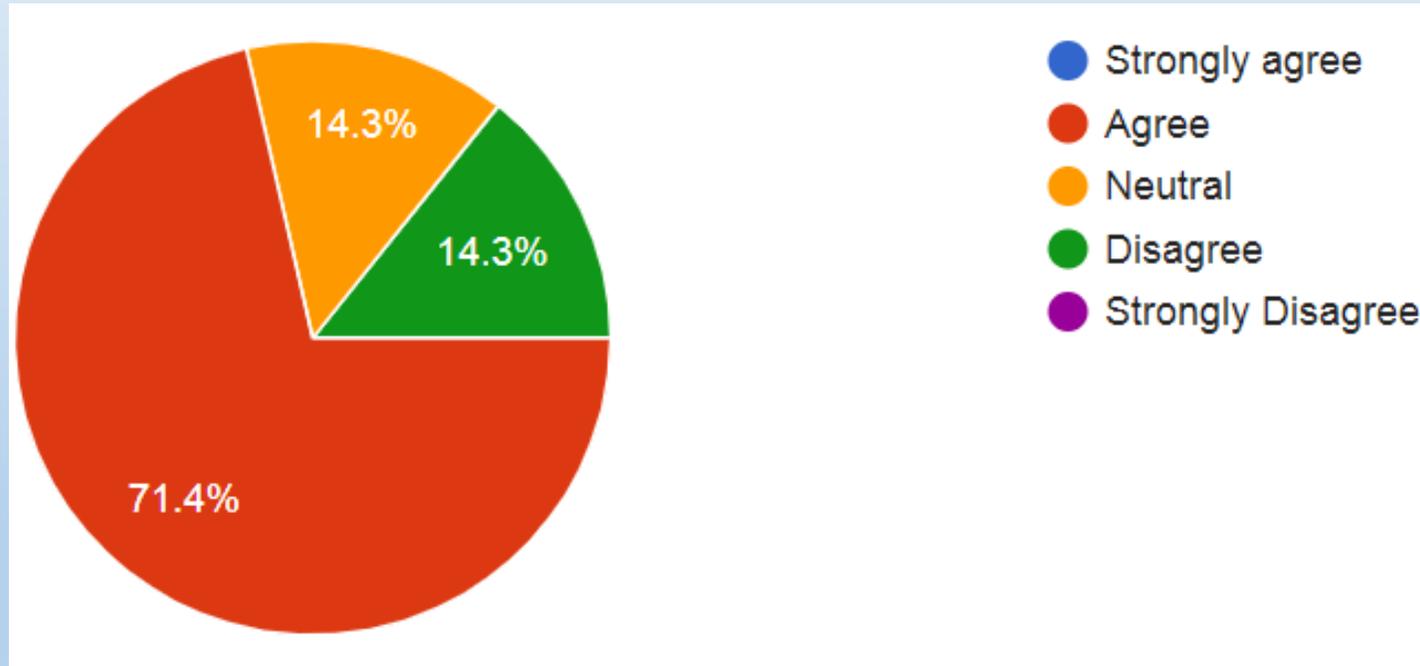
# Results and Discussions

- Responses to question: I have heard about AR before



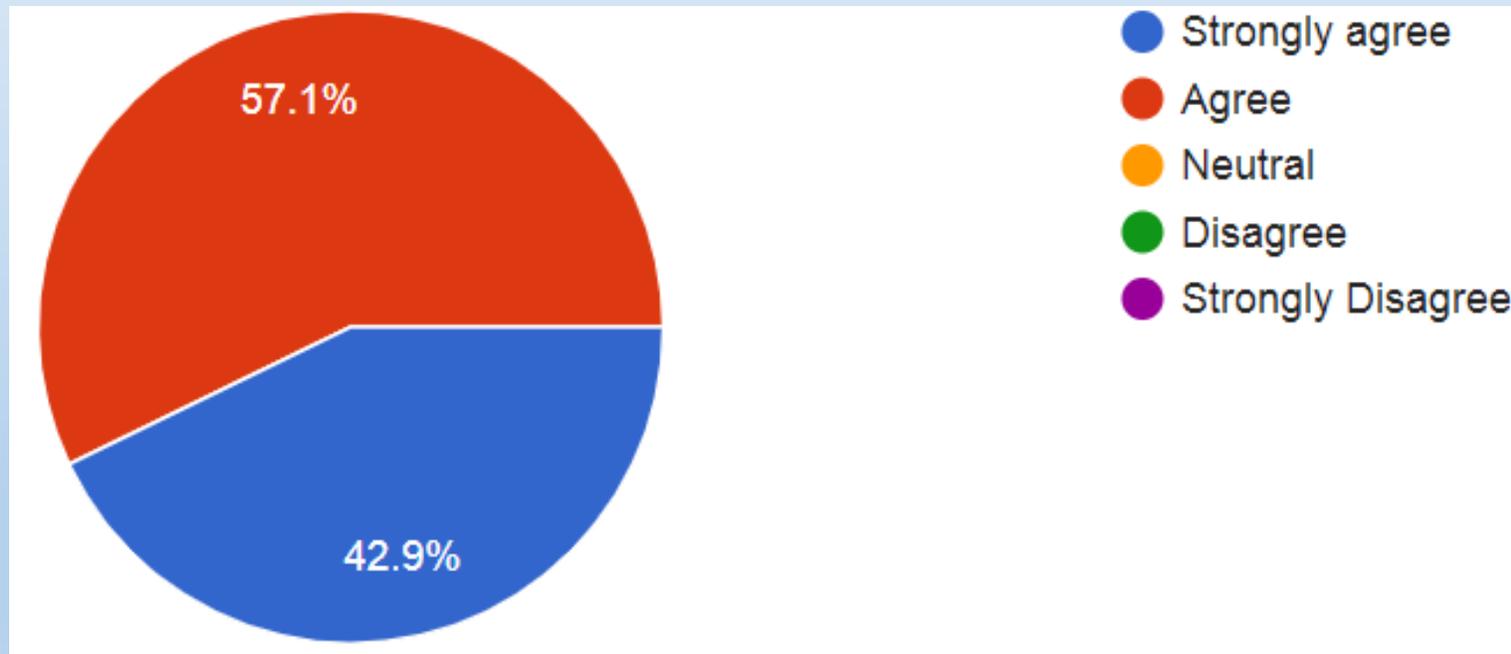
# Results and Discussions

- Responses to question: I know how AR functions



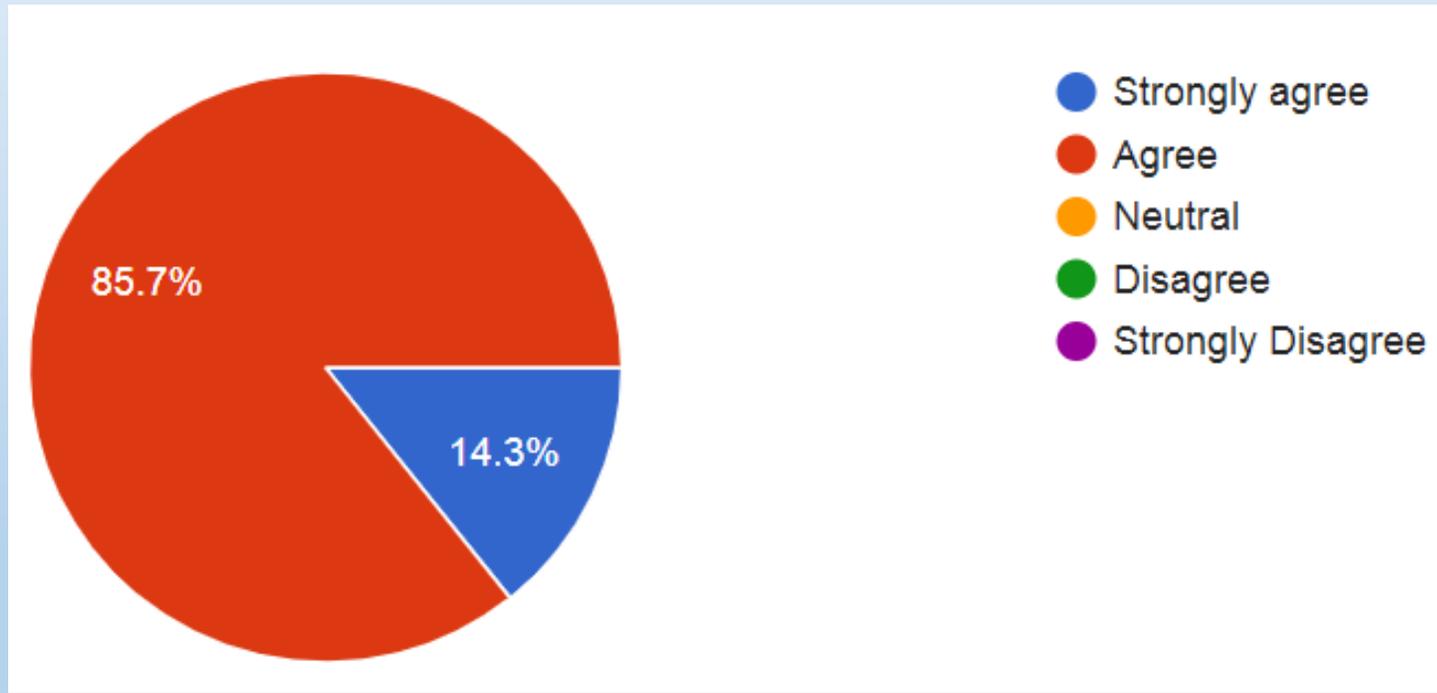
# Results and Discussions

- Responses to question: Students can be more interested in learning by using this AR



# Results and Discussions

- Responses to question: The interface of this AR is user friendly



# Conclusion and Future Work

- This work presents the development of AR to address the facilities constraints, safety issues and to increase interest of students in teaching and learning process.
- An AR has been developed by using computer hardware components as the contents.
- Several educators in engineering courses have been selected to experience AR demonstration for initial testing of the developed AR.
- The obtained responses indicate that the developed AR is well received and perceived as having potential to engage students more in teaching and learning process.
- In the future, the developed AR will be improved based on the respondents' feedbacks and will undergo more testings with larger number of respondents including educators and students before being implemented in real classes.



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