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Enhancement of student learning and interaction in engineering programmes using an audience response system

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ABSTRACT: Focusing on engineering students' needs and their learning progress requires an interactive teaching approach that plays an essential role in active learning, especially in the context of classrooms with heterogeneous academic levels. In this study, an audience response system (ARS) was implemented in three different electrical and mechanical engineering courses of different programmes and levels at the Australian College of Kuwait (ACK), Kuwait City, Kuwait, to investigate its effectiveness in terms of boosting the students' engagement and learning through continuous formative feedback. The iVote-App system was used as an add-in to PowerPoint at the instructor side and on a personal mobile phone or tablet at the student side. The study started on campus and continued as e-learning due to the Covid-19 pandemic. Significantly, a high number of students agreed that the ARS has increased their attention, participation and enjoyment in classroom activities. The anonymity of the students' responses and the continuous feedback that was provided throughout the class were also highly appreciated by the students.

INTRODUCTION

Many higher education institutions have shifted to a student-centred approach, where students are at the centre of the teaching-learning process. This regularly requires several modern learner-support technologies, which can operate in a range of time and place settings. With the conventional student-centred approaches, to ensure a higher level of student success, educators should focus on the students' requirements and tailor the instructions and activities to be able to support and teach them within the classroom.

Focusing on the students' needs and their level of understanding requires an interactive teaching environment that plays an important role for students with different abilities, skills and attitudes. Students who are shy and unconfident, mostly take great effort not to be noticed and rarely engage in group discussions. Therefore, a safe and non-judgmental environment need to be established in classroom to encourage low profile students to participate actively in classroom activities. In this perspective, active learning approaches maximise student participation in classroom activities and student interaction with their instructor and peers.

Student engagement impacts student success, accomplishment and supervision. While students usually engage in their education via assessment, that assessment is vital to enhance student engagement and thus, learning assessments must become thoroughly linked to the teaching process. Using instant, formative feedback is an ideal form of assessment, however it is not easy to be translated into practice, as it is time consuming, especially in large classes.

Participation in classroom activities is another important element of student-centred learning. Students must be the main actor of the learning process. If only a few students actively participated by asking or answering questions, the class session might lose the opportunity to assess and promote learning for all students. Hence, it is the instructor's responsibility to ensure the participation of every student by creating a safe and non-judgmental environment and by setting discussion rules and principles, where all participants can express and exchange their thoughts freely. In that way, the whole class can explore issues and ideas in depth and learn to tolerate different points of views.

Moreover, students have different personalities and learning preferences that might affect their participation in classroom activities; for instance, some students who do not speak often in class are reflective learners who typically develop ideas and questions in their minds before speaking; others are shy students who feel uncomfortable speaking in front of groups. The instructor's goal is to create conditions that enable students of various learning preferences and personalities to contribute. To reach this goal, an audience response system (ARS) was proven to be a good tool in some studies: students participate more when an ARS is used in the classroom [1][2].

The aim of this research is to examine the effectiveness of an audience response system (ARS) as a part of active learning to:

- Enable higher education students to overcome their shyness and oral participation insecurities, by providing a safe, non-judgmental environment and some basic rules for discussions, conducive for students’ active participation in productive classrooms discussions.
- Provide formative assessment and feedback for educators, to tailor their classroom instructions and activities to students’ needs, to maximise and enhance learning opportunities, and make students overcome their learning difficulties and misconceptions.
- Reduce students’ attention lapses due to demanding and challenging teaching materials in engineering courses by lecture segmentation.

The ARS technology has also been used as: an electronic voting system [3], personal response system [4], student response system [5] and clickers [6]. These systems permit users to answer a different type of questions in different ways and using different tools, which in a classroom setting, allows the instructor to promptly gather and examine student responses to questions posed during class. Usually, students are tested with multiple-choice, short answer or calculation questions, and respond using a smart device, such as a computer, mobile phone or tablet.

Students’ responses are anonymous, and for evaluation purposes, the instructor may require only a specific set of students to respond. Once students respond to a question, the results are immediately collected and presented for the entire student group to review and discuss their answers. Based on the result, the instructor may revisit some of the teaching material in a different way or trigger peer or classroom discussion so that students can work out misconceptions and overcome difficulties. ARSs were first used in 1966 [7], but they were relatively new in higher education as they began to be used in 2003. Several studies have examined the use of ARSs in different educational programmes [1]. But only few papers could be found investigating the use of ARSs in engineering programmes [8][9].

In this study, iVote-App (an on-line interactive application with an add-in to PowerPoint) was used to allow the instructor to include questions directly into teaching materials. Students respond in real-time to these questions using their portable devices, such as laptops, phones or tablets through the Internet service. This tool also provides the students with private, immediate feedback about their performance. iVote-App provides immediate information about the level of question understanding by the class based on the students’ responses, and it allows effective use of time within each class. Should any discrepancy in understanding arise during the learning process, there will be a rapid recovery by reconsidering the concept. iVote-App is easily accessible from the student side through an installed application on their smart devices. Also, the instructor decides whether the students are required to answer anonymously or enter their names prior to answering the questions. The anonymous feature is very valuable in letting shy students contribute to class activities without feeling under pressure, as they tend to feel when making mistakes when answering orally.

Many studies have affirmed that the ARS offers significant educational benefits in higher education, such as engagement in classroom activities, motivation, satisfaction, improved student attendance, interaction, discussion, learning performance, quality of learning and assessment benefits [10][11]. Students are more likely to be engaged in the learning process if they enjoy it, they are more likely to participate in classroom activities when they are encouraged, which increases peer-peer and student-teacher interactions, and reveals the students’ understanding of concepts [12][13].

THEORETICAL FRAMEWORK

It can be a challenge to ensure students’ engagement in their learning process, and active learning allows this kind of engagement. Students actively involved must make a mental effort to discover knowledge and discuss it with their peers and teachers. Students often have to go through a conceptual change in active learning, to let go their misconceptions and build knowledge on a solid correct basis. Active learning stands in contrast to passive learning, where the teacher traditionally gives a lecture to students to transmit knowledge: students are considered passive recipients of knowledge, void of any prior knowledge or conceptions. Moreover, active learning increases students’ motivation, enhances their understanding and mastery of concepts to achieve the course learning outcomes, and forms lifelong learners.

Many different active teaching methods could be included in classrooms, such as case studies, problem solving, role playing, projects, research studies and presentations, laboratory hands-on activities, group work, debates, questioning, group discussions. In project-based learning when students undertake roles that simulate professional engineering practice, active learning is considered experiential; for example, working in teams to design, simulate and implement projects and case studies.

In this study, a mixed teaching methods was implemented in classrooms: some passive transmission of knowledge followed by individual work, then discussions. All classes were following the operational flowchart depicted in Figure 1. The lecture material was shared with students ahead of the session. A diagnostic assessment and pre-class preparation were conducted before the teaching session to tailor the teaching activities to students’ requirements and use the instructional time in an optimal way. This has shown to be very helpful and motivating the students for more pre-class preparation. The session started traditionally, as the teacher explained some concepts for around 15 minutes, then moved on to ARS questions.

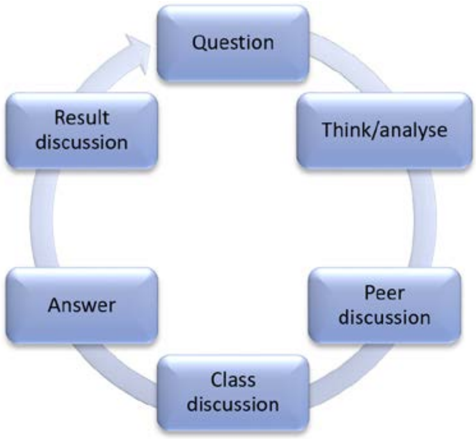


Figure 1: The response sequence for most ARS questions.

As indicated in Figure 2 below, students had to think individually, then discuss in peers their findings and opinions, communicate, justify their point of view, co-operate with each other, learn, and help each other to clarify any concerns arising from the presented question. When in doubt, peer discussions moved to classroom discussions to seek the instructor's help and advice. The shift from traditional teaching after 15 minutes of lecture to active teaching strategies is underlined by the evidence that student attention wanes after about 15 to 20 minutes in a traditional classroom environment [14].

Accordingly, presenting ARS questions at 15-minute intervals is an effective technique of segmenting a long lecture, and allowing students to shift their attention and actively participate in the learning process. Many studies have reported that higher education students are more attentive when an ARS is used [1][4]. Utilising an ARS in teaching is underlined by the research findings stating that it increased discussion, particularly when used with a peer instruction strategy: *With this strategy, students felt good at ease, safe and more confident to discuss and calibrate their understanding of specific concepts* [4]. In addition, students noted they were more engaged, motivated and entertained when peer discussions were occurring as a result of ARS feedback [1].

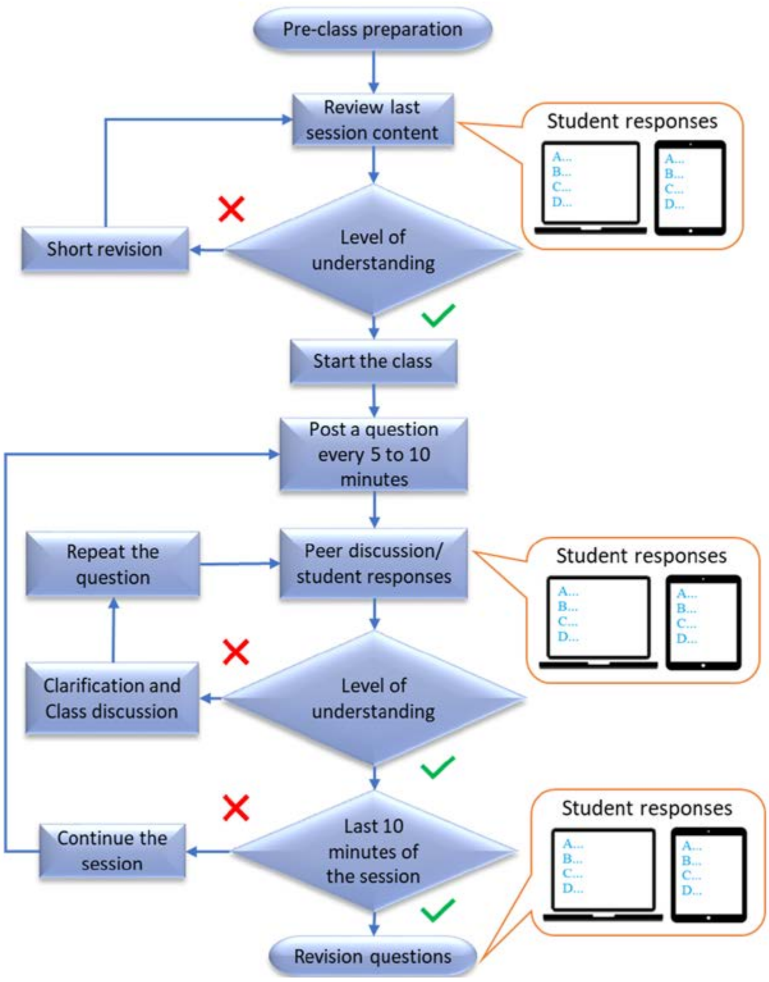
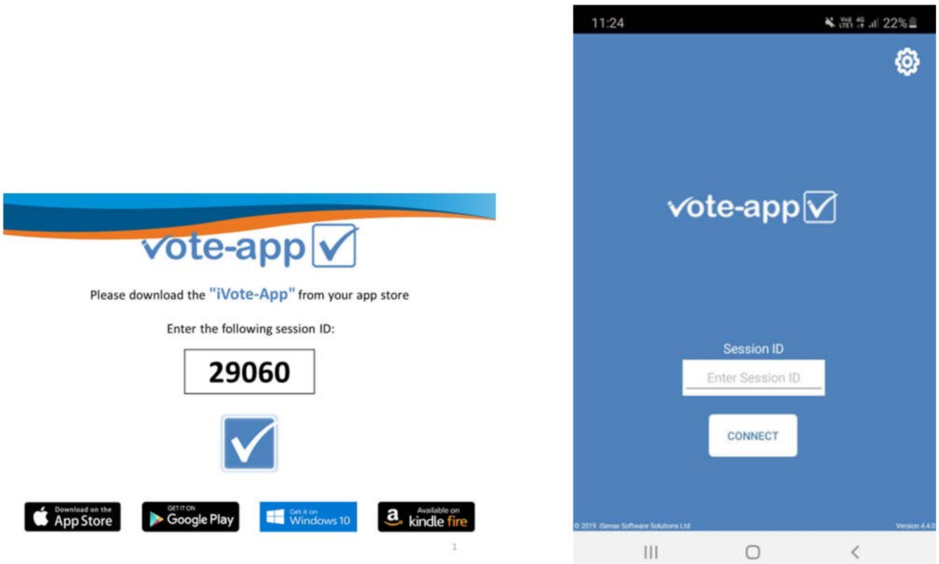


Figure 2: Operational flowchart of ARS in an active learning environment.

IMPLEMENTATION

The impact of ARS on student satisfaction, learning outcomes, engagement and levels of confidence has been assessed in three engineering courses at the Australian College of Kuwait, Kuwait City, Kuwait. The three courses chosen for this study were from electrical and mechanical engineering: Electromagnetism Fundamentals from the first year, Process Measurements from the third, and Engineering Plant Design from the fourth year. The on-line ARS (iVote-App) was used in all classes on tablets or other mobile devices. At the beginning of the class, the instructor shared the session ID through the instruction page with students that allowed them to respond to the posted question (see Figure 3).



a) b)

Figure 3: a) ARS instruction page including the session ID; and b) student's view.

The students responded to the question by entering the session ID in the pre-installed application on their devices. Once a question was posted by the instructor, the students were notified to answer the question. After a predefined time, the students' responses were posted on the board and they got feedback on their devices.

iVote-App has many features for instructors and students. The instructor may decide whether students participate anonymously or with their ID in the case of graded activities. Also, it provides the instructor with a session statistics report that includes the percentage of students' participation in every activity and a questions summary. From the student side, iVote-App permits the students to save all their activities for future study.

RESULTS

To evaluate the usefulness of the ARS in enhancing active learning, data were collected via several meetings conducted with the involved instructors to share their experiences and comments on the most effective method of using the ARS.

Students were also invited to contribute by completing an anonymous survey to examine their satisfaction level with the new teaching style, and to assess different elements that were involved to enhance active learning. The survey was created on Microsoft Forms that simplify data collection. The survey consisted of several multiple-choice questions addressing all aspect of the ARS use. The students responded within a scale ranging from strongly disagree, disagree, neutral, agree to strongly agree.

Figure 4 shows the students' responses to the survey.

Fifty-eight students participated in this survey from the three courses where the ARS application was implemented. Based on the students' responses, it was evident that they were very satisfied with the use of ARS in the engineering courses. Most of the students recommended it for other courses. Notably, there was a significant correlation between the students' participation in classroom activities and the ARS anonymity, and also between formative assessment and preparation for summative assessment.

The summarised aims of the survey were sent to the students via their e-mail and Microsoft Teams pages prior to the survey conducted via Microsoft Forms. The students were notified that all collected data were non-identifiable, not including any personal or sensitive data, and that privacy and confidentiality were protected, and participation was anonymous and voluntary. The students were also notified that the survey was not part of any student assessment and they could not withdraw from the survey once submitted.

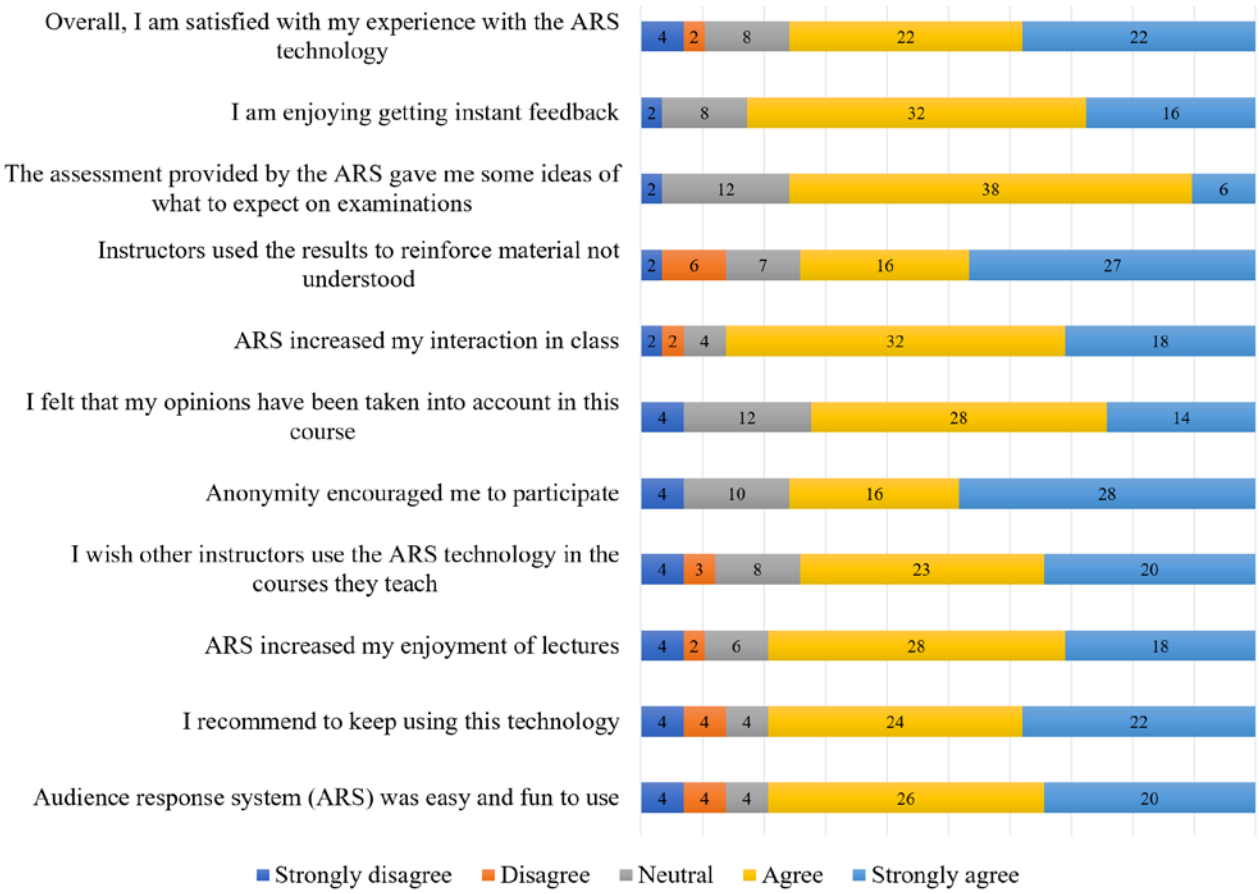


Figure 4: Students' responses.

CONCLUSIONS

An audience response system was applied in three engineering courses at the Australian College of Kuwait, Kuwait City, Kuwait. The student survey and the instructor's feedback have shown a good improvement in terms of motivation, participation and providing instantaneous feedback to the students and instructors, and hence enhancing active learning in classrooms. Moreover, students had a very positive view of the ARS technology implementation, and most of them stated that the technology was exciting, energising, and enjoyable to learn and use.

The anonymity associated with the use of ARS was viewed as encouraging by students. In addition, the widespread presence of mobile technology with almost all students equipped with a mobile device enables the implementation of powerful software tools, such as the ARS technology that support active learning at all levels of education. Audience response systems can be utilised to increase engagement and participation of learners with different backgrounds, personalities and aptitudes, especially in large group settings.

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