Active Learning to Enhance Students' Learning Experiences in a Large Enrolled Computer Science Technical Module

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Abstract
Teaching technical modules such as those that involve programming to first-year, passive-learner students can be challenging. This challenge becomes more prominent when it is involving a large enrolment course. This research experiment aims to explain how a combination of active learning strategies such as a flipped classroom, problem-based learning, individual activities, and group activities can be employed to cultivate an interactive environment in which students can express their ideas freely and be involved in their learning. The experiment was conducted on undergraduate students who were enrolled in a compulsory programming module for a computer science degree programme. Strategies to keep students engaged are also discussed in this paper, which are vital for students' retention and progression. The findings from students' grades, their self-reported outcomes, and their feedback from a survey, indicated that exploiting various active-learning strategies improved their understanding of the technical computer science module in question, led to a greater interest of the module, and enhanced their social interactions with peers.

Keywords: Student-centred Approach, Active Learning

Introduction

For decades, academicians and educational researchers have been studying the effectiveness of teacher-centred approaches and student-centred approaches to teaching. A teacher-centred approach consists of most learning activities being carried out by a teacher, which produces a passive learning experience for students. In contrast, a student-centred approach puts students at the forefront, with a teacher acting as a facilitator rather than a director. Students influence the content, activities, materials, and pace of learning. Simply put: the teacher steps back and lets students take control.

Ritchhart et al. (2011) expressed that for students to understand a topic, they need to be involved in activities that include problem-solving, decision-making, and practices that are likely in future workplaces. So, to prompt students towards a deeper understanding of any subject, the teaching approach should shift from the widely utilised teacher-centred approach to a student-centred one. Various studies have shown that a proper implementation of such an approach can lead to students displaying an increased motivation to learn (Chung et al., 2004; Burrowes, 2003), an improvement in test marks (Anderson et al., 2005; Burrowes, 2003), a deeper understanding of the subject being taught (Anderson et al., 2005; Burrowes, 2003), and increased positivity towards the subject being taught (Anderson et al., 2005). For this teaching approach to have an optimum effect, activities and student engagement would be necessary prerequisites. Research into pedagogies that fulfil these two requirements has commonly defined this type of learning as active learning (Freeman et al., 2014; Prince, 2004). Active learning can be generalised to when students solve problems, answer, and formulate questions of their own, and discuss, debate and brainstorm ideas during class. Research into the benefits of active learning techniques have revealed positive impacts on students' learning experiences (Anderson et al., 2005; Thaman et al., 2013; Kember & Leung, 2005; Deltor et al., 2012; Roehl et al., 2013; Mathrani et al., 2016).

One thing that differentiates active learning from teacher-centred approaches is the variety of methods and activities that can be implemented. The work of Thaman et al. (2013) utilised multiple active learning techniques on first-year undergraduate medical students studying respiratory physiology: Pause Procedure, Minute Paper, Think-Pair-Share, Models, Multiple Choice Questions, Seminars, Short Assignments and Role Plays.

The applications of active learning have proven to elicit many benefits for students. One such benefit is the improvement of their performance in assessments. A met analysis of 158 studies across STEM fields in Freeman et al. (2014) presented that on average, students' examination results improved by approximately 6% with active learning, as opposed to teacher-centred lectures. Further analyses of the results concluded the increase in performance was irrespective of the STEM subject, course type and level, providing a much more reliable perspective on the positive outcomes of active learning.

Another benefit demonstrated from active learning has been offering students more opportunities to achieve a better understanding of course material. In the work of Thaman et al. (2013) which utilised a range of active learning techniques, over 90%

of students agreed that the active learning techniques used, helped to better understand the subject being taught. Regarding the individual activities implemented by the authors, students held significantly positive views towards many of them, believing they helped understand concepts better. In Kember & Leung (2005), responses from students yielded that those who identified their classes as having more active learning also identified the presence of greater teaching for understanding. Interestingly, further analysis of students' feedback by authors concluded that the presence of teaching for developing understanding in students, affected the growth of useful skills and knowledge for students.

Students of active learning have also been seen to experience a development in their academic skills. Over 75% of students that experienced a multitude of active learning exercises (Thaman et al., 2013) believed that the activities elicited an improvement in their ability to think critically. This skill, amongst others such as creative thinking, problem-solving and interpersonal skills were understood to have improved through active learning, based on student perceptions in Kember & Leung (2005). Further analysis of students' feedback by authors supported the positive effects that active learning provided on students' skills.

The interactions between students and teachers in active learning has also shown to help develop better relationships between both parties. Comments from students who experienced various active learning exercises in Thaman et al. (2013) mentioned seeing teachers as friends. A survey by Kember & Leung (2005) found that students which perceived their classes had more active learning also perceived better student-teacher interactions. Further analysis underlined the link between active learning and student-teacher interactions, whilst also showing that the amount of interactions between teachers and students was associated with the growth of skills such as critical thinking and problem-solving.

This paper presents a typical active learning session aimed at first-year undergraduate computer science students who are enrolled in a programming module. This module is a compulsory component of a computer science degree programme at the institute and aims to equip students with problem-solving skills to tackle computational problems using logical and numerical approaches. The paper also presents a list of varying assessments to encourage class participation and assess students' learning. An active-learning approach to this module would be particularly useful because of the difficult concepts that cannot always be easily understood from pure lecturing and given how programming is something which is understood better when students get hands-on experience and practice with it.

Methodology – Active Learning Session

Figure 1 shows the typical flow of events/activities that took place in the proposed active learning sessions of this paper, along with the respective timings of the activities. This teaching model was used for the first semester of a programming module with 140 first-year undergraduate students and was adapted for use in lecture theatres. In these sessions, different active learning strategies were employed one at a time; though subsequently, multiple strategies were used depending on the topic of the lecture. The typical active learning strategies used were Minute Papers, Think-Pair-Share, group-based activities, and pop-up quizzes. All activities were frequently

followed by an instructor-led discussion, intended to assist students with grasping a deep understanding of the topic. Every two to three weeks, unofficial written feedback from students was gathered to understand their abilities and improve upon the teaching style.

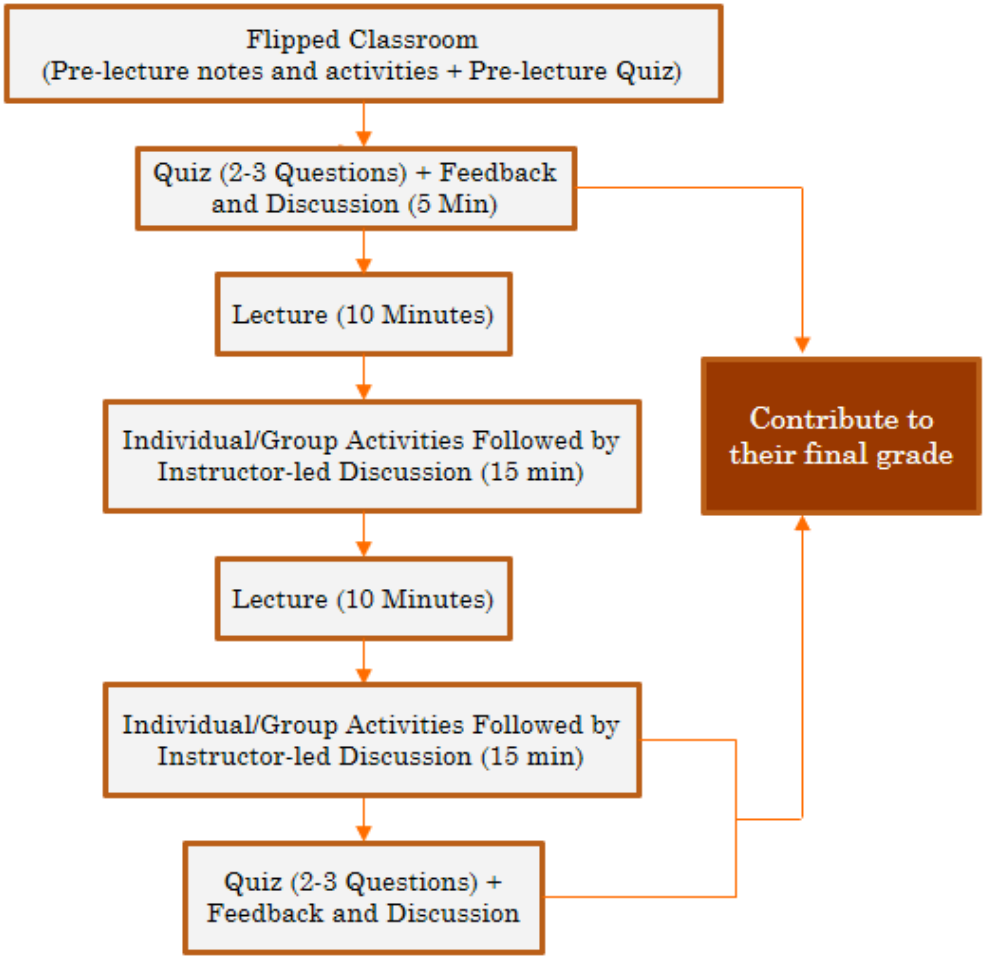

Figure 1: The block diagram of the proposed active learning session

Breakdown of Proposed Teaching Model

First and foremost, it can be vital for instructors to build rapport with students to encourage engagement in classes; this was a perception also mentioned by Chickering & Gamson (1987). Moreover, it can incline students to feel more comfortable asking for assistance from instructors, given the acknowledgement of a predetermined relationship. There exist numerous strategies for instructors to achieve rapport with their students: expressing enthusiasm in classes, increasing their availability, and trying to memorise their students' names. One that was used in the sessions of this paper was to share hobbies, research interests and experience. By doing this, students could relate and get comfortable with the instructor.

The use of a Flipped Classroom is a common active learning strategy, that revolves around assigning lecture materials as homework, so students can learn general concepts of a given topic before attending the lecture. By using this in the active

learning sessions of this paper, lecture time was able to be utilised for problem-solving, group activities and teaching advanced topics. Another advantage of Flipped Classrooms lies in their flexibility, in that the pre-lecture material for students can be provided as a lecture recording or a short recorded/written version of lecture materials (Roehl et al., 2013). By decomposing the lecture recording into several shorter clips to explain specific concepts, a more in-depth and "bitesize" version of pre-lecture material can be produced.

The appropriate practice to commence the sessions was to have a quick recap of the previous session and a condensed summary of the pre-lecture materials provided before the lecture. Think-Pair-Share was an active learning strategy that was regularly adopted during this time. Students were asked to recollect and/or answer questions about what they had understood in the previous lecture and pre-lecture material. They were then asked to pair-up with a student beside them to share answers and reach an agreement. This aimed to help students communicate and engage better with their peers, as well as reflect on their own understanding. Apart from Think-Pair-Share, a formative assessment such as an online in-class quiz was also used on occasion to assess students' understanding. By following this with an instructor-led discussion, misconceptions between students were able to be addressed efficiently.

The next 10 minutes of the sessions were used to explain an advanced topic that was not covered in the pre-lecture materials, or a complex problem-solving exercise(s) through instruction. Given the nature of the programming module, it was very common to demonstrate how to engage and tackle exercises which required problem-solving so students could visualise and understand the approach necessary, before attempting it themselves.

Students were subsequently introduced to a problem-solving exercise. This aimed to bridge the gap between the theoretical knowledge they had just acquired, and the practical understanding needed to apply their knowledge to real problems. It was also hoped that the transition from lecturing (the previous portion of the session) to something more active, would prompt students' engagement. Students attempted these exercises either individually or in a group. Grouping students favoured the supplement of more complex problems, as students would be able to work together on questions that required extra thought and could have proved more challenging if attempted individually. Chickering & Gamson (1987) also commented on the advantages of group work; one such advantage being that students' understanding of a topic could be improved by communicating with peers and learning from each other.

A similar of pattern of 10 minutes of lectures followed by an individual/group exercise was practiced until the end of the sessions. Sessions then concluded with a quick summative online quiz to assess students' overall understanding. These quizzes carried 1-2% of students' overall grade for the module, which in turn encouraged attendance and engagement in the sessions.

Results and Discussion

The end of the module's semester saw the administering of the University's official teaching evaluation, and a straightforward survey of five questions for student feedback. The responses of the latter are represented in Figure 2.

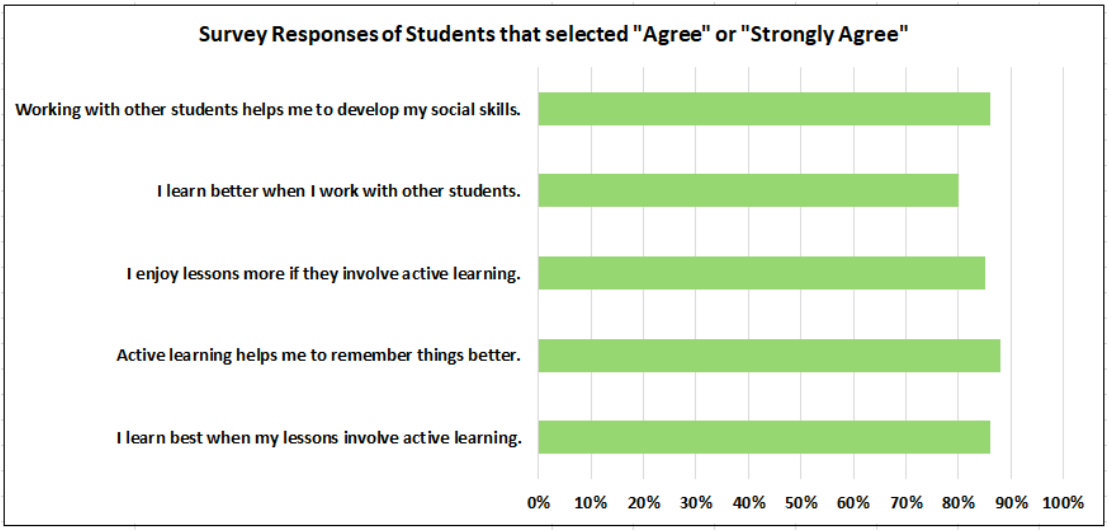

Figure 2: Illustration of students' responses to survey questions on active learning.

Analysis of the responses show that a significant number of students were of the consensus that they learnt better (86%) and enjoyed lessons more (85%) when they involved some form of active learning. This coincides with previous research by Anderson et al. (2005) and Thaman et al. (2013), where active learning provided better learning and enjoyment in classes than teacher-centred approaches. Students' reasoning behind their positivity clarified that they experienced opportunities to apply newly learnt concepts to distinctive problem-solving exercises either individually or within a group, and that they received immediate feedback from their peers and instructor (both of which were hoped for when designing the structure of the active learning sessions).

A large 88% of students believed active learning helped to remember things better. Given the teacher-centred approaches that students are accustomed to, which result in short-term memorisation, the responses of this question indicated that taught concepts connected better with students, inferring something stronger than just memorising. This provides implications that students were more than likely learning through understanding, as opposed to just memorising, which has been a common outcome of previous research of active learning (Anderson et al., 2005; Kember & Leung, 2005; Thaman et al., 2013).

A further 86% also felt active learning aided with the development of social skills, which proved useful in creating relationships with new friends and having healthier communications with existing ones. This meets feedback from active learning techniques used in Thaman et al. (2013), which also concluded that a significant number of students experienced better relations with peers. The instructors for the programming module shared their experience with witnessing the effects of active learning, as their initial observations at the beginning of the semester revealed that most students found it challenging to engage with peers. However, as the weeks progressed and different active learning strategies were exploited, students were perceived to gain more confidence to interact with fellow students and were more willing to contribute their opinions during classes.

When asked about learning better through teamwork, agreement between students was at 80%; a benefit which was also mentioned in the work of Chickering and

Gamson (1987). Interestingly, the instructors of the module noticed that the number of students that were willing to transfer their skills with/to their peers gradually increased over the course of the module, providing further support for teamwork as a viable teaching method, since students were observed to be learning from each other.

Conclusion

The active learning sessions in this paper proved useful in improving students' learning experiences. Student feedback demonstrated that a substantial number of students experienced benefits like better learning and remembering things better, when compared to without active learning. Given students are known to find concepts in computer science programming module difficult, this was a significant milestone in helping students overcome difficulties; something which was not done as efficiently when active learning was not at the forefront of session design. Other student benefits included greater enjoyment in classes with active learning, rather than those without, and improved social skills. This paper also shows the flexibility of active learning strategies, in their ability to produce results in large course settings. It therein provides support for the use of active learning, by showing a model that works in displaying greater student achievement and positivity than a teacher-centred approach to learning. It is important to note that the structure for the active learning sessions used in this paper was purposefully designed to align with course content, aims for the module (one of which was to equip students with advanced problem-solving experience), and necessary skills for future careers in the subject. Application for different subjects will most likely therefore need tailored structures. However, this paper is confirmation that a well-structured combination of active learning strategies can provide positive student learning outcomes.

References

Anderson, W. L., Mitchell, S. M., Osgood, M. P. (2005). Comparison of student performance in cooperative learning and traditional lecture-based biochemistry classes. Biochemistry and Molecular Biology Education, 33(6), 387-393.

Burrowes, P. A. (2003). A Student-Centered Approach to Teaching General Biology That Really Works: Lord's Constructivist Model Put to a Test. *The American Biology Teacher*, 65 (7), 491–502.

Chickering, A. W. & Gamson, Z. F. (1987). Seven Principles for Good Practice in Undergraduate Education. American Association of Higher Education Bulletin, 39(7), 3-7.

Chung, J. C. C. & Chow, S. M. K. (2004). Promoting student learning through a student-centred problem-based learning subject curriculum. Innovations in Education and Teaching International, 41(2), 157-168.

Detlor, B., Booker, L. D., Serenko, A., Julien, H. E. (2012). Student Perceptions of Information Literacy Instruction: The Importance of Active Learning. Education for Information, 29(2), 147-161.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences of the United States of America, 111(23), 8410–8415.

Kember, D. & Leung, D. Y. P. (2005). The influence of active learning experiences on the development of graduate capabilities. Studies in Higher Education, 30(2), 155-170.

Mathrani, A., Christian, S., & Ponder-Sutton, A. (2016). PlayIT: Game Based Learning Approach for Teaching Programming Concepts. Educational Technology & Society, 19(2), 5-17.

Prince, M., (2004). Does active learning work? A review of the research. Journal of engineering education, 93(3), 223-231.

Ritchhart, R., Church, M., Morrison, K. (2011). Making Thinking Visible: How to Promote Engagement, Understanding, Independence for All Learners. San Francisco, CA. Published by Jossey Bass, a Wiley imprint.

Roehl, A., Reddy, S. L., Shannon, G. J. (2013). The Flipped Classroom: An opportunity to Engage Millennial Students through Active Learning Strategies. Journal of Family and Consumer Sciences, 105(2), 44-49.

Thaman, R., Dhillon, S., Saggar, S., Gupta, M., Kaur, H. (2013). Promoting Active Learning in Respiratory Physiology – Positive Student Perception and Improved Outcomes. National Journal of Physiology, Pharmacy & Pharmacology, 3(1), 27 – 34.