



Comparing the Impact of Asynchronous Online Quizzes on Student Learning Outcomes in a Computer Communication and Networking Course

Azlina Ahmadi Julaihi

Faculty of Computer Science and Information Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia.

ABSTRACT

This study investigates the effectiveness of asynchronous online quizzes in improving student learning outcomes in higher education. Specifically, we compare the impact of two teaching methods - Synchronous Lecture and Asynchronous Tutorial pair (SLAT) versus Asynchronous Lecture and Synchronous Tutorial pair (ALST) - in delivering weekly quizzes to 70 undergraduate computer science students. Our results show that the SLAT outperformed the ALST method in enhancing students' academic performance after each learning unit. The findings highlight the potential of asynchronous quizzes as a valuable learning tool, particularly when combined with live lecture classes and asynchronous tutorials. These results have implications for educators looking to implement blended learning models that prioritize student engagement and academic achievement.

Keywords: undergraduate studies, synchronous learning, asynchronous learning, quiz, self-directed learning

ARTICLE INFO

Email address: ajazlina@unimas.my (Azlina Ahmadi Julaihi)

*Corresponding author

<https://doi.org/10.33736/jcshd.4877.2023>

e-ISSN: 2550-1623

Manuscript received: 3 August 2022; Accepted: 23 March 2023; Date of publication: 31 March 2023

Copyright: This is an open-access article distributed under the terms of the CC-BY-NC-SA (Creative Commons Attribution-Non-Commercial-ShareAlike 4.0 International License), which permits unrestricted use, distribution, and reproduction in any medium, for non-commercial purposes, provided the original work of the author(s) is properly cited.

1 INTRODUCTION

Encouraging meaningful interaction among learners in fully online courses is a complex and multifaceted issue that has been extensively investigated in tertiary education. One of the fundamental dimensions of online learning environments is the timing and location of learning activities, which can be broadly classified into two categories: synchronous and asynchronous. Asynchronous settings are characterized by higher learner autonomy and reduced dependence on instructor guidance. Consequently, such settings require more self-directed learning, motivation, and digital literacy skills to navigate the course content and achieve learning goals effectively. On the other hand, Synchronous online learning provides a more "live" learning experience, enabling real-time social interaction and feedback among learners and instructors. The benefits of synchronous online learning, including increased engagement and motivation, have been documented by several scholars. Nonetheless, this modality also presents significant challenges, such as the need for robust technical infrastructure to ensure a seamless learning experience. These issues have been explored in prior research (Bullock et al., 2008; Bernard et al., 2004; Xie et al., 2018; Harnett, 2015; Kim et al., 2019; Blau et al., 2017; Hrastinski, 2008) and must be carefully considered in designing effective online learning environments that foster optimal learning outcomes.

Research outcomes regarding the influence of synchronous and asynchronous methods on student performance are not without a doubt. Based on the study conducted by Nieuwoudt (2020), the results showed that there is not much difference in the students' accomplishments whether they attended synchronous online classes or watched the previously recorded video of the lecture classes. However, the amount of time the students contributed to online learning activities greatly affected their academic growth. Both synchronous and asynchronous online learning settings whereby the students participate actively have led to better engagement and higher academic success. According to King (2004), in a study of student perception of online learning, videos and screencasts can increase the instructors' visibility and ability to communicate the course content effectively.

Similarly, engagement with the students required relevance between the materials, tasks, and activities, including the available technological tools such as video (Bailey et al., 2014). Thus, to facilitate communication in these two educational settings, synchronous and asynchronous, researchers felt that there is a need to distinguish between several types of activities and interactions on how students can be engaged in their learning (Nieuwoudt, 2020; Rapanta et al., 2020; Zhu, 2006). Most studies propose that using students' online discussion forums is a valuable learning exposure in various disciplines (Jin, 2005). Other techniques, such as quizzes, can improve understanding of the assigned course materials (Narloch et al., 2006). It is known that quizzes have become one of the popular online learning tools on the online platform eLeap. Using quizzes can help the students be more focused than before, and it could identify gaps in their knowledge, build self-confidence and help them retain knowledge.

However, there is an argument about how quizzes influence student academic performance. Grimstad and Grabe (2004) observed that students who completed learning unit quizzes significantly improved their academic performances. Brothen and Wambach (2001) mentioned

that quizzes could enhance academic performance if the students use the quiz to test their knowledge of the material.

Online quizzes are popular in blended learning models in higher education and with students in fields such as psychology and medicine. For instance, in human development, a previous study suggested that participation in this online quiz may assist students in learning a psychology subject. However, it was unclear whether participation in every learning unit may lead to an improved subject-learning outcome. Furthermore, there are no studies on using asynchronous quizzes as a self-directed learning tool in engineering and science. Thus, this study investigates the link between using such quizzes using two different teaching styles, as evidenced by their quiz marks, in the Computer Communication and Networking course. The study will see whether using asynchronous or synchronous online teaching methods with every learning unit quiz improves course performance.

2 METHODOLOGY

The Synchronous Lecture and Asynchronous Tutorial (SLAT) teaching and learning method carried out lectures in real-time. The tutorial was done asynchronously every week using quizzes in the eLeap platform. A brief description of the method is explained in the following subsection.

Students were notified in their first class that online discussion activities such as forums and quizzes are part of the instructional methods. They must complete all given tasks after every learning unit. The quiz is structured based on the tutorial questions: multiple-choice answer questions, short answer questions, fill-in-the-blank, or other question types available in eLeap. eLeap is a Moodle-based learning management platform the university uses as the primary online education platform. Students can attempt the quizzes multiple times, and time is allotted to complete the quizzes. Previously, the tutorial questions were uploaded in eLeap and given to the student in pdf or word document and have never been done before using eLeap quiz format. It is because, from previous semesters, it was known that students tend to neglect to do their tutorial questions and compile the answers from the instructor without understanding them. To encourage every student to participate in answering the tutorial questions, thus, for this study, all tutorial questions were converted using the eLeap quiz format and were graded accordingly. The eLeap quiz feature has a self-checking grading tool; therefore, it is easier to measure the students' performance immediately after each learning unit. For example, tutorials repeatedly commenced after the lecture class with 10-15 combinations of multiple-choice or matching questions to encourage students to reflect on the lecture materials.

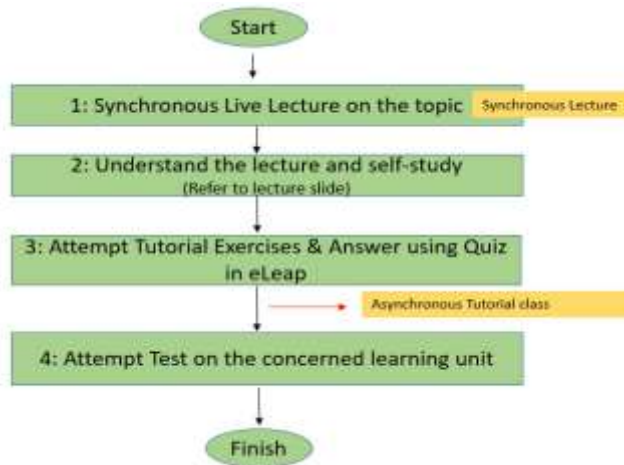


Figure 1. Steps 1 to 4 of *SLAT* pair teaching and learning method.

The figure above shows the four steps in Synchronous Lecture and Asynchronous Tutorial (*SLAT*) teaching and learning approach. The students were taught using the *SLAT* pair method for the first half of the semester. The main point is that the Synchronous Lecture classes run in real-time. These live lecture classes with students and instructors attending together but from various locations used the web and videoconferencing technology such as Webex. The class sessions ran every week for two to three hours, depending on the topic, and after the class, the students would do their self-study as in Step 2, depicted in Figure 1. The synchronous session usually incorporates interactive components to engage with the students, such as polls, breakout rooms, and surveys. That allowed the students to show themselves and actively participate in asking questions regarding the topic.

The tutorial session was done asynchronously, as in Figure 1, which allows the students to learn in a self-paced manner. For this study, the tutorial was designed asynchronously to ensure that the students tried and attempted the tutorial questions independently, and each tutorial would be graded accordingly. It can be done by converting all the tutorial questions to quizzes in eLeap. Instructors could track students' progress by attempting tutorials, which can be easily obtained in the eLeap report section. The instructor monitored any students who did not attempt the tutorial questions.

There were two noncumulative tests in the course, scheduled at the end of the week, within the allocated time consisting of 10 questions, covering about two to three topics of the course materials, respectively. Since tutorials were being done asynchronously, instructors could not evaluate a student's readiness or performance in person. Thus, online tests significantly determine the student's understanding of the topic taught (Narloch et al., 2006). Finally, for the final *SLAT* step, they would attempt a small test on the learning unit that was graded accordingly using eLeap.

For the second approach, the Asynchronous Lecture and Synchronous Tutorial (ALST) teaching and learning method was designed to observe the impact on students' performance; in a different teaching method from the previous SLAT. ALST ran asynchronously via recorded video lectures, and the tutorial was done synchronously every week, face-to-face with the students. A brief description of the method is explained in the following subsection.

For the second half of the semester, a different approach was used to evaluate the impact of the ALST teaching and learning method. The learning flow is depicted in Figure 2.

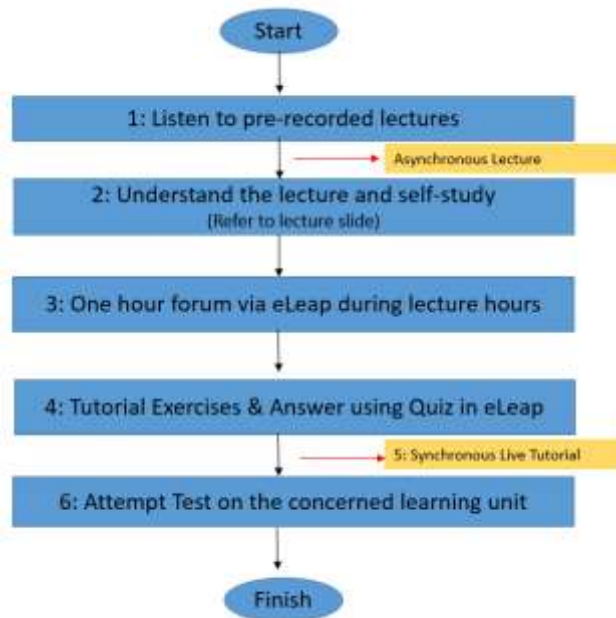


Figure 2. Steps 1 to 6 of ALST teaching and learning method.

First, in Step 1, the students listened to the instructor's pre-recorded lecture videos. In step 2, the students attempted self-study by watching the videos and learning at their own pace. They would understand the lecture videos by referring to the lecture slides given earlier in eLeap. In Step 3, there was a forum during the lecture hour conducted in eLeap to address any questions asked by the students regarding the topic. This asynchronous lecture delivery mode requires a great deal of self-motivation and proactiveness. Thus, the students must post at least one question on any critical topic. They could also post any questions that needed clarification, which were addressed immediately during the lecture hours. Then, after watching the videos, students opened and completed the tutorial using a quiz housed in the course platforms assessment feature eLeap (Step 4).

Afterwards, a synchronous live tutorial session was conducted to discuss the tutorial questions (Step 5). This synchronous learning is to check on their understanding and assist some students who might be unable to answer the questions. Finally, in Step 6, the students attempted a test on

the concerned learning unit, the same as in the previous method. The required, short, graded test assessments associated with the second half of learning units were a check to ensure students are engaged with the course contents.

The research design for this study first proposes an approach for the asynchronous and synchronous online learning method, or the SLAT and ALST approach (as described in the previous section). Based on the objectives of this study, the student's learning performance using quizzes for each learning unit and tests were compared and analysed for one semester on the mentioned subject.

This study involves a cohort of 70 undergraduate students (61% female) pursuing a course on communication and computer networks within the Faculty of Computer Science and Information Technology at UNIMAS. All participants are first-year students registered for the second semester of the 2021/2022 academic year. The course entails four hours of weekly instruction, evenly split between didactic lectures and interactive tutorial sessions.

For this study, the sample was assigned to one group to observe the effectiveness of SLAT and ALST methods and to measure the influence of online chapter quizzes and tests on the students to improve academically in the selected computer communication and networking course.

- Students who were exposed to SLAT attempted every learning unit quiz and two tests in the first half of the semester
- Students who were exposed to ALST and attempted every learning unit quiz and two tests in the second half of the semester

The marks from each quiz and test were graded accordingly by all 70 students.

The instructor developed a 6-item survey using the Google Forms tool to assess students' perceptions about the two methods and asynchronous tutorials using quizzes. Items 1 and 6 were open-ended questions that asked respondents to use their own words about what they understood by asynchronous learning and what they liked about the previously recorded videos and provided suggestions on which areas could be improved for the learning experience for this course. The other four were multiple-choice questions to ask what they liked best or preferred. On top of observing students' academic performance, to gather students' perceptions of the two approaches, participating students were given a survey. They were asked:

1. In your own opinion, what is asynchronous learning?
2. Which method do you prefer?
-Live Lecture class, then Asynchronous Tutorial using Quiz
-Recorded video lecture, then Live Tutorial class
3. Do you think using Quizzes in eLeap to do your Tutorial Exercises with Answers benefits your learning?
4. Do you feel that having Quizzes at the end of each topic benefits your learning?
5. Which approach do you think is better for the coming batch for this subject?

- Live Lecture class, then Asynchronous Tutorial using Quiz
 - Recorded video lecture, then Live Tutorial class
 - Both Live Lecture and Tutorial sessions
6. What is your further suggestion to improve teaching and learning for this course?

3 RESULTS AND DISCUSSION

This section shows the learning performance of a group of students as described in the earlier section. This section explains the results and is followed by a summary of the feedback obtained from the students. This section also provides justification for the results obtained from this paper.

Table 1. The average marks for each tutorial for Computer Communication and Networking course.

Teaching and Learning Method	Learning Unit	Tutorial	No of Questions	Sum of Marks	Average Marks	%
SLAT	1	T1	8	525.1	7.5	93.8
	2	T2	12	802.6	11.5	95.5
	3	T3	17	1079	15.4	90.7
	4	T4	10	658	9.4	94.0
	5	T5	25	1581.3	22.6	90.4
ALST	6	T6	9	509.5	7.3	80.9
	7	T7	19	1094	15.6	82.3
	8	T8	13	762.3	10.9	83.8
	9	T9	10	544	7.8	77.7
	10	T10	11	611	8.7	79.4

Table 1 shows the average marks for each tutorial for Computer Communication and Networking course. The course consisted of ten tutorials for every learning unit during the semester. These tutorial grades contributed 5% of the final course grade. Note that the average marks were taken from the number of students who completed the tutorial quiz, and incomplete attempted quizzes were not recorded. On average marks, the SLAT approach was much higher (range = 90.4% - 95.5%) than ALST, slightly lower with a range of 77.7% to 83.8%. For example, during the SLAT teaching and learning approach, for Tutorial 1, every student attempted all eight tutorial questions converted to quizzes in eLeap and the sum of all marks were taken. The average marks were calculated by the number of students attempting the tutorials. Finally, the marks were converted to a percentage against the number of questions. The results for all tutorials conducted using the two approaches are stipulated in Table 1.

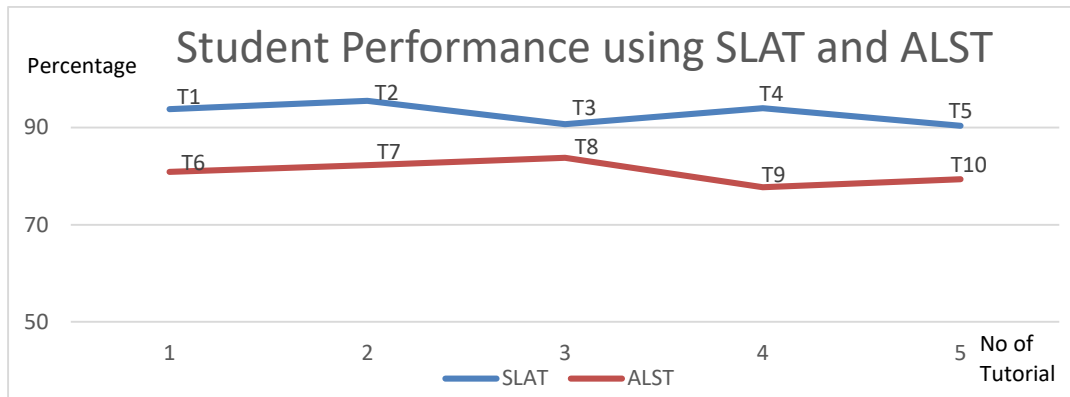


Figure 3. Students' learning performance after each tutorial attempt using quizzes.

Next, the data from Table 1 uses a line graph to show trends across the tutorials in one academic semester. The analysis answers the research questions in which teaching methods were reported by students who experienced two settings: Synchronous Lecture and Asynchronous Tutorial (SLAT) and Asynchronous Lecture and Synchronous Tutorial (ALST). The comparison of the entire students' performance shows that students in synchronous lecture settings report a more positive learning performance than in asynchronous recorded video settings. Looking at the average marks graded in each tutorial quiz, the SLAT percentage is higher than ALST average marks, as depicted in Figure 3. The phenomenon may be due to a lack of discipline in viewing and understanding the video lectures independently; not going through the lecture slides contributes to the low average marks in their tutorial quizzes. Other factors might include students' tendency to procrastinate and take less accountability for attempting the tutorial quizzes more 'seriously', leading to lower results.

Based on recent work by other researchers, other than gender, grade level and mindsets, factors such as not viewing instructional videos multiple times before and after class, mobile learning and non-mandatory quiz may contribute to lower scores (Yoo et al., 2022). Their findings found that students who failed to complete watching the videos had lower grades due to procrastination and lack of persistence, significantly influencing achievement. Thus, the recorded video lecture as a teaching and learning method in ALST might have the same contributing factors that led to lower student performance scores compared to the SLAT method, as depicted in Figure 3. SLAT highlighted that there was a positive association between attempting the quizzes weekly and synchronous lectures did show a significant impact on course performance. Other studies by Argyriou (2022) found that greater use of online quizzes could increase their final exam grade by completing all weekly quizzes. They also suggested that positive behavioural engagement in multiple learning activities in students has a comparative benefit on their final course performance.

3.1 Test Performance on SLAT and ALST

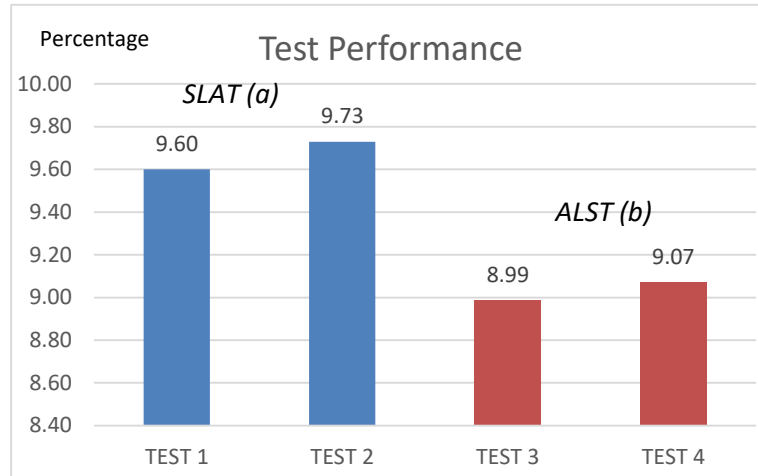


Figure 4. Students' performance after two tests in the first half and two tests in the second half of the semester.

Figure 4 shows the four noncumulative tests in the course. All tests consisting of 10 multiple-choice questions each, covered fundamental building blocks of computer networking, different applications and implementations in computer networking technologies, and concepts to specific examples. Test 1 and Test 2 covered half of the learning unit in the first semester, while Test 3 and 4 covered the second half of the learning unit in the second semester. The questions for these tests are like the ones in the tutorial quizzes, except that it is much more technical. The students need to understand the theories and concepts comprehensively. These test grades also contributed 5% of the final course grade for each student.

The most important question is whether the tutorial quiz aided students in learning the material covered by the quizzes. To answer this question, we categorized the test questions as combinations of 3 to 4 chapters in each test (in the first half of the course, there were six chapters and another six chapters for the second half). The SLAT approach and the ALST approaches were then compared. Overall, performance was better for the SLAT approach (average marks 9.6 for Test 1 and 9.73 for Test 2 over 10) versus the ALST approach, slightly lower (8.99 over 10 for Test 3 and 9.07 over 10 for Test 4). The reason may be that since it was the first half of the semester, the students were more eager to learn, and the will to learn remained intact. Since the lecture class was also done synchronously, perhaps the students could ask more questions in real-time compared to asynchronous lectures. Students were more connected to their peers when they all learned together. Since every class activity was done synchronously, this may boost participation from the students, deepening their understanding of the course materials (Nieuwoudt, 2020). Moreover, the earlier completion of the tutorial quizzes influences their performance for the subsequent tests.

In general, the test performance results in Figure 4 supported the notion that the SLAT approach would improve students' performance. Although the actual mean difference between these two approaches was slight, students' performance on those test scores was significantly better than their performance for ALST. Thus, this shows that the influence of using quizzes for tutorials with synchronous lectures impacts student performance.

Of the 70 students, 62 gave feedback for the survey. For the first question, the students were asked whether they understood the meaning of asynchronous learning. Most answered self-paced learning, flexibility, self-discipline, and using pre-recorded videos to learn the course materials. Most students understand asynchronous learning and how it will be delivered.

When asked which method was preferable, the students' feedback can be summarized as having chosen the SLAT method (41.9%), followed by either SLAT or ALST methods are fine by 32.3%, and only 25.8% preferred the ALST method depicted in Figure 5. It may be because SLAT may assist the students in understanding the lecture material better as real-time communication occurs. Having the asynchronous tutorial using quizzes can help them know exactly where their weaknesses are and help them point out which areas they need to improve. In addition, 32.3% of students gave feedback that they would prefer ALST with previously recorded video lectures that could help them learn at their own pace and focus on the live tutorial session to ask any questions that need further clarification.

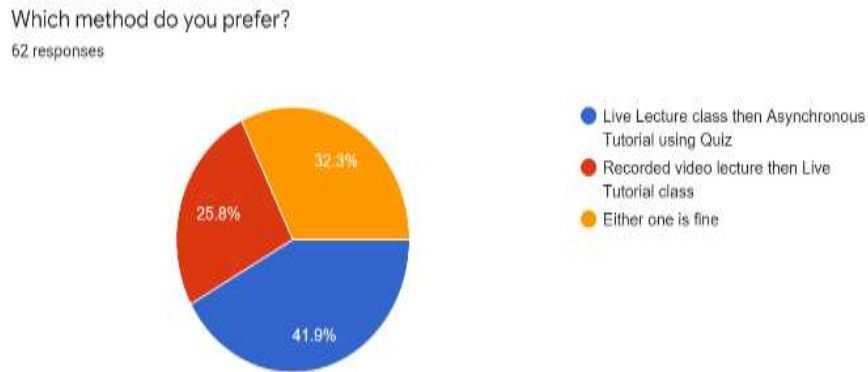


Figure 5. SLAT vs ALST student preference.

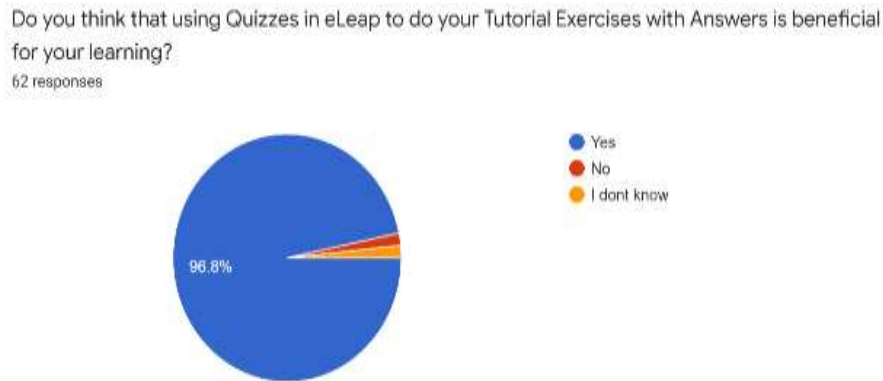


Figure 6. Asynchronous Tutorial using quizzes in eLeap preference.

Many students who indicated that they "strongly agreed" believed that asynchronous tutorial sessions using quizzes in eLeap strengthened their student content engagement, as depicted in Figure 6. 96.8% felt that using a quiz to do their tutorial exercises is beneficial for their learning. According to Bangert-Drowns et al. (1991), how the assignment and feedback are constructed in a course can affect how students approach the task. The students may attempt them several times in the quiz until they get the correct answers. Each tutorial is graded accordingly based on average marks over the tutorial questions.

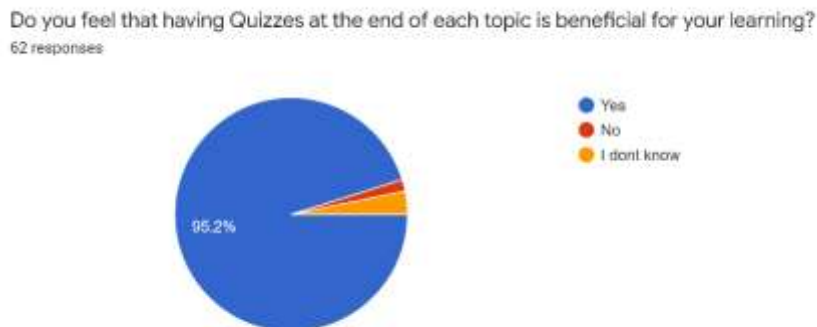


Figure 7. Students' feedback on attempting tests after every learning topic for both SLAT and ALST.

Figure 7 shows the student feedback on four tests they have conducted during the semester. Of 62 responses, 95.2% agreed that these tests enhanced their understanding of the topics and prepared them better for the course's final exam. Since they needed to prepare themselves before every test, and since each test was included in their final course grade, most felt that having those tests before their final exam was helpful. Only one student did not agree with this (1.6%), and two were neutral (3.2%).

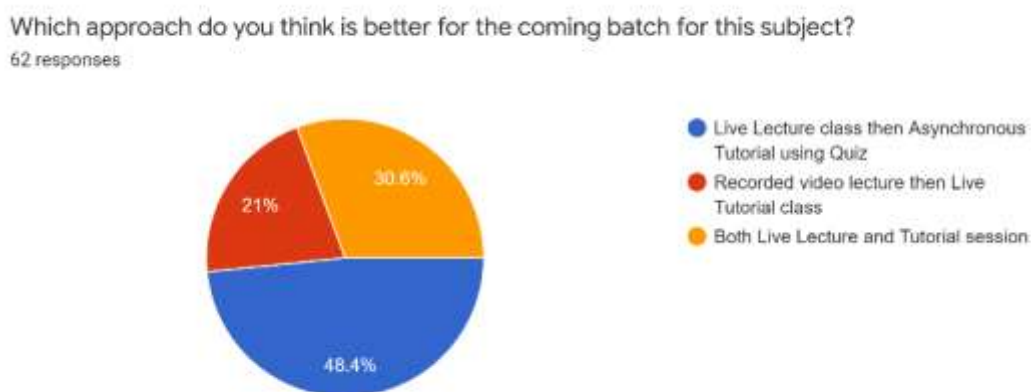


Figure 8. Students' preference for teaching and learning methods for future batches.

Figure 8 shows that almost half of the students (48.4%) preferred the SLAT teaching and learning method for the future batch taking the course. They agreed that the delivery method, a live synchronous lecture, and asynchronous tutorial using quizzes in eLeap, could influence student engagement and student learning in this course. 30.6% suggested synchronous sessions for lecture and tutorial classes, and only 21% agreed on the ALST teaching and learning method. It may be because the students prefer real-time communication or screen-to-screen interaction. Furthermore, it could be unfavourable to students' mental health and academic results if continuous asynchronous learning is not paired with some real-time follow-up. Thus, the ALST approach is designed in such a way that it is paired with a synchronous tutorial session to foster more sense of community and in-depth discussion on the topics covered.

For the final question, the students were asked for further suggestions to improve teaching and learning for this course. Almost all students agreed on the first synchronous lecture and asynchronous tutorial using the quiz as a platform to enhance their learning. A few commented on using more technological online tools such as Kahoot to create more student engagement. They love the idea of attempting the tutorial questions with answers given immediately that can guide them to point out which area they need to improve. Other comments, such as "having the asynchronous videos", benefited them, whereby they can access or replay the videos a few times to make them understand better.

From the psychological development of the learner's perspective, the effectiveness of the SLAT and ALST method could be attributed to self-directed learning. Knowles (1975) defined self-directed learning as the ability to learn independently. Similarly, Garrison (1997) described self-directed learning as one of the approaches where learners are responsible for their internal monitoring (cognitive responsibility) as part of constructing meaningful learning outcomes. He described a self-directed, comprehensive learning model that encompasses three dimensions: self-management (task control), self-monitoring (cognitive responsibility), and motivation (entering and task) (Garrison, 1997). SLAT and ALST can highlight that these three dimensions overlap and are intimately connected during learning. For self-management concerns task control issues and

the activities associated with the learning process. In both methods, SLAT and ALST, materials and resources are provided, approaches are suggested as depicted in Figure 1 and Figure 2 above, and flexible pacing in learning is accommodated for the students by focussing on using quizzes in eLeap. Questions and feedback are provided during the synchronous session when they are deemed needed by the instructor. This way, self-management of the students' learning process will facilitate continuous learning throughout the semester by looking at the quiz grade marks after each learning unit. The advantage of these two methods will let the students evaluate their strengths and weaknesses while monitoring their progress through the quizzes. More extensive study is required to fully understand the ALST and SLAT approach in greater detail between the cognitive and motivational dimensions. Specific cognitive strategies can be associated and linked with critical thinking in various phases of the thinking-learning process.

4 CONCLUSION

The reported study proposed and explored two student-participation teaching and learning methods using quiz assessments through the lens of computer science students. These two methods revealed how different approaches to teaching could influence students' learning performances differently. Moreover, these two models investigated the use of online quizzes after every learning unit and how these interact with the students' learning performances based on the quiz grade to influence student learning significantly. The findings reported are considerable for SLAT, a blend of Synchronous and Asynchronous Learning, and promise new debates on how students perform and participate in asynchronous online activities. Future studies can duplicate this research in other disciplines, such as engineering or business. Even though this study was conducted as part of online learning where face-to-face classes are still not the mode of study for FCSIT first-year students, perhaps in the future, if face-to-face sessions emerge, this study can still be tested with more test subjects to reach a more general conclusion in asynchronous online activities.

Moreover, the quiz and test actions only considered the quantitative aspects of student performance. Furthermore, the quality of those quizzes and tests was not adequately identified. Future research can look at how to incorporate quality measures in these two approaches and examine those changes and their influence on student learning.

REFERENCES

- Argyriou, P., Benamar, K., & Nikolajeva, M. (2022). What to Blend? Exploring the Relationship Between Student Engagement and Academic Achievement via a Blended Learning Approach. *Psychology Learning & Teaching, 21*(2), 126–137. <https://doi.org/10.1177/14757257221091512>
- Bailey, S., Hendricks, S., & Applewhite, S. (2014). Student perspectives of assessment strategies in online courses. *Journal of Interactive Online Learning, 13*(3), 112-125. Retrieved from <http://www.ncolr.org/jiol/issues/pdf/13.3.2.pdf>

Bangert-Drowns, R. L., Kulik, C.-L. C., Kulik, J. A., & Morgan, M. (1991). The Instructional Effect of Feedback in Test-Like Events. *Review of Educational Research*, 61(2), 213–238. <https://doi.org/10.3102/00346543061002213>

Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, A., Wozney, L., et al. (2004). How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research* 74, 379–439. <https://doi.org/10.3102/00346543074003379>

Blau, I., Weiser, O., & Eshet-Alkalai, Y. (2017). How do medium naturalness and personality traits shape academic achievement and perceived learning? An experimental study of face-to-face and synchronous e-learning. *Research in Learning Technology*, 25, 1-23.

Brothen, T., & Wambach, C. (2004). The Value of Time Limits on Internet Quizzes. *Teaching of Psychology*, 31(1), 62–64. https://doi.org/10.1207/s15328023top3101_12

Bullock, L. M., Gable, R. A., & Mohr, J. D. (2008). Technology-mediated instruction in distance education and teacher preparation in special education. *Teacher Education and Special Education*, 31(4), 229-242. <https://doi.org/10.1177/0888406408330644>

Garrison, D. R. (1997). Self-directed learning: Toward a comprehensive model. *Adult education quarterly*, 48(1), 18-33. <https://doi.org/10.1177/074171369704800103>

Grimstad, K., & Grabe, M. (2004). Are Online Study Questions Beneficial? *Teaching of Psychology*, 31(2), 143–146. https://doi.org/10.1207/s15328023top3102_8

Hartnett, M. K. (2015). Influences that undermine learners' perceptions of autonomy, competence, and relatedness in an online context. *Australasian Journal of Educational Technology*. 31, 86–99. <https://doi.org/10.14742/ajet.1526>

Hrastinski, S. (2008). Asynchronous and synchronous e-learning. *EDUCAUSE Quarterly*, 31, 51–55. <https://er.educause.edu/-/media/files/article-downloads/eqm0848.pdf>

Jin, S. H. (2005). Analyzing student-student and student-instructor interaction through multiple communication tools in web-based learning. *International Journal of Instructional Media*, 32(1), 59.

Kaczynski, D., Wood, L., & Harding, A. (2008). Using radar charts with qualitative evaluation: Techniques to assess change in blended learning. *Active Learning in Higher Education*, 9(1), 23–41. <https://doi.org/10.1177/1469787407086743>

Kim, H. J., Hong, A. J., and Song, H.-D. (2019). The roles of academic engagement and digital readiness in students' achievements in university e-learning environments. *International Journal*

of Educational Technology in Higher Education, 16, 1–18. <https://doi.org/10.1186/s41239-019-0152-3>

King, S. B. (2014). Graduate student perceptions of the use of online course tools to support engagement. *International Journal for the Scholarship of Teaching and Learning*, 8(1). <https://doi.org/10.20429/ijstl.2014.080105>

Knowles, M. S. (1975). *Self-directed learning: A guide for learners and teachers*. Chicago, IL: Follett. Retrieved from <https://archive.org/details/selfdirectedlear0000know>

Narloch, R., Garbin, C. P., & Turnage, K. D. (2006). Benefits of pre-lecture quizzes. *Teaching of Psychology*, 33, 109–112. https://doi.org/10.1207/s15328023top3302_6

Nieuwoudt, J. E. (2020). Investigating synchronous and asynchronous class attendance as predictors of academic success in online education. *Australasian Journal of Educational Technology*, 36, 15–25. <https://doi.org/10.14742/ajet.5137>

Rapanta, C., Botturi, L., Goodyear, P., Guàrdia, L., and Koole, M. (2020). Online university teaching during and after the Covid-19 crisis: refocusing teacher presence and learning activity. *Postdigital Science Education*, 2, 923–945. <https://doi.org/10.1007/s42438-020-00155-y>

Xie, H., Liu, W., & Bhairma, J. (2018). Analysis of synchronous and asynchronous E-learning environments. *2018 3rd Joint International Information Technology, Mechanical and Electronic Engineering Conference*, 270-274. Atlantis Press. <https://doi.org/10.2991/jimec-18.2018.58>

Yoo, J. E., Rho, M., & Lee, Y. (2022). Online Students' Learning Behaviors and Academic Success: An Analysis of LMS Log Data from Flipped Classrooms via Regularization. *IEEE Access*, 10, 10740-10753. <https://doi.org/10.1109/ACCESS.2022.3144625>

Zhu, E. (2006). Interaction and cognitive engagement: An analysis of four asynchronous online discussions. *Instructional Science*, 34, 451–480. <https://doi.org/10.1007/s11251-006-0004-0>