Journal of University Teaching & Learning Practice

Volume 18
Issue 8 *Standard Issue 4*

Article 11

2021

Embedding online activities during lecture time: Roll call or enhancement of student participation?

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Recommended Citation

Nadeem, M., & Blumenstein, M. (2021). Embedding online activities during lecture time: Roll call or enhancement of student participation?. *Journal of University Teaching & Learning Practice, 18*(8). https://doi.org/10.53761/1.18.8.11

Embedding online activities during lecture time: Roll call or enhancement of student participation?

Abstract

Student attendance has long polarized the higher education sector with reports of no to little effect on student success to positive relationships between attendance frequency at face to face and synchronous online lectures and better student engagement and achievement. This study investigates the impact of embedded online activities during lecture time on student learning by utilizing students' portable devices to divert undesirable study behaviors such as gaming and social media activity during class. The aim of the learning intervention is to improve attendance at undergraduate engineering lectures as well as providing better connection to the subject content. Study participants were third year Bachelor of Engineering students enrolled in a mandatory "Digital System Design" course as part of their degree at a major research university in New Zealand. To explore the student experience of embedded active learning tasks on engagement and academic achievement, both qualitative and quantitative data were collected from N = 75 students over a three-year period when the course underwent a re-design utilizing a participatory action research approach. Student focus group discussions and learning analytics data revealed that the completion of online activities during lectures can lead to cognitive overload negatively affecting engagement. However, real-time feedback on learning via synchronization of learning tasks with the lecture content improved student–student and student–teacher connections and thereby contributed to a more positive overall learning experience. The role of stimulating learner motivation and attendance is discussed against Keller's ARCS model and recommendations for teaching practice are given.

Practitioner Notes

1. The embedding of active learning tasks in large undergraduate engineering lectures can improve the overall learning experience by connecting students with the lecture content, the teachers, and each other and therefore attendance for those who participated in the in-class activities.
2. Allowing students to complete activities synchronized with the lecture at a later stage asynchronously increased motivation to learn as online activity regularly exceeded attendance, but awarding marks for completion (either in-class or asynchronous) improved participation greatly.
3. The design of learning tasks to be completed by students during class time need to allow cognitive learning processes to take place to avoid multitasking resulting in distraction and cognitive overload.
4. The use of students' personal devices during class time for the completion of academic tasks can be an effective way of countering boredom and disengagement, breaking down content-dense subjects commonly taught in engineering.

Keywords

improving classroom teaching, student learning, active learning, student engagement, lecture attendance, technology enhanced learning, Keller's ARCS model, student feedback

Introduction

The present study explores the use of students' personal devices for the completion of learning activities during a face to face (f2f) third year engineering lecture. The aim of embedding active learning tasks into a lecture is to re-focus students' inherent affinity of personal device use for non-academic tasks such as social media and gaming during class time. The learning intervention was part of a course re-design utilizing the real-time audience response system XorroQ (www.xorro.com) for synchronous in-class learning tasks alongside asynchronous learning through connection with the subject content. A participatory action research approach was utilized to scope the student perception on whether the intervention supported their learning and enhanced engagement. The impact on student performance and lecture attendance is examined.

The current Covid-19 pandemic has shone a light on higher education (HE) practices globally, having to pivot virtually overnight from often in person, campus based and blended university learning and teaching to fully online environments. Initially, the abrupt shift to remote online teaching has left many instructors stranded on how to engage students and facilitate effective learning (Venton & Pompano, 2021). However, many universities, including the University of Auckland, have already embarked on a path to rethinking education towards more flexible study options in response to economic, societal, and cultural changes and internationalization of the HE sector (Bates, 2019; Beetham & Oliver, 2010; Smith & Duckworth, 2021). Increasingly, students' lived experiences are considered in curriculum design focusing on the whole student with emphasis, for example, on the first-year experience, widening participation, equity and social justice fostering students' well-being and sense of belonging towards active participation and retention in HE (EDUCAUSE, 2020). There is greater requirement to provide rich learning environments so students can develop skills that are in the context of their discipline as well as graduate attributes in readiness for employment (Bates, 2019). Consequently, traditional modes of knowledge transmission are replaced or supplemented with active learning environments that are engaging and make use of educational technology (Buskist et al., 2018; Crook et al., 2010; Ellis, 2018). Overall, the education paradigm has shifted from "emphasizing teaching to emphasizing learning" (Wilson, 2004, p.119). The benefits of active learning approaches through the use of higher order interactive tasks are now widely acknowledged (Drinkwater et al., 2017) and are effective across many subject areas including science, engineering, technology, and mathematics (STEM) (e.g., Theobald et al., 2020). A meta-analysis of 225 studies that reported on student performance in undergraduate STEM courses found that exam performance improved with active learning compared to traditional lecturing (Freeman et al., 2014; Lombardi et al., 2021).

Active learning is rooted in constructivist learning theories focusing on instructional designs where knowledge and authority is shared between teachers and students, the teacher's role is that of facilitator underpinned by negotiation, and learning is interactive rather than passive (reviewed by Bada & Olusegun, 2015). Constructivism emphasizes pedagogical goals that embed multiple modes of learning opportunities and encourage reflective and metacognitive knowledge construction processes (Bada & Olusegun, 2015, p, 68). Importantly, active learning opportunities give students agency to becoming independent learners, encouraging contribution to the learning process and the different perspectives. It is advocated for enhancing student's engagement and motivation (Chickering & Gamson, 1999) and meets universal psychological needs of the learner for autonomy, relatedness, and competence (Deci & Ryan, 2012). Moreover, Deci and Ryan's theory of self-determination (2012) has relevance in our increasingly cross-cultural HE settings and is in clear contrast to the use of high stakes incentives of traditional assessment practices as a mean of motivating the learner. While assessment undoubtedly drives student learning (Cowan in Race, 2009) and greatly influences how and what students learn, practices have dramatically changed in recent years (Bearman et al., 2020). Nowadays, assessment ‘as’ and ‘for’ learning, away from assessment ‘of’ learning through predominantly diagnostic and summative assessment tasks, are widely used (Dann, 2014). Therefore, learning activities connected with students’ self-assessment provide an effective way of formative feedback and checking understanding for self-regulated learning. Strategies range widely depending on discipline, context (e.g., professional degrees) and subject area including text-based (e.g., Ghilay & Ghilay, 2015) and quantitative fields (Freeman et al., 2014; Theobald et al., 2020). Flipped learning, which is particularly suited to large classes, is another effective approach to ensure students’ self-regulation, social and cognitive presence, and enhanced engagement through interactive and participatory learning tasks in the classroom while students engage with materials and video lectures online (e.g., Doo & Bonk, 2021). Irrespective of the method, the overall intent of active learning is to promote student-centric away from content-centric learning for authentic and socio-collaborative construction of meaning (Salmon, 2013).

Implementation of active learning needs to be underpinned by the principles of learning and feedback. It is therefore crucial to align tasks with learning outcomes and pedagogical intent. In the engineering context, the use of student response systems (SRS) which include activities such as brainstorming, quizzes, and polls during lecture time (synchronous), are an effective way of breaking down complex concepts for students and scaffolding high course loads (e.g., Nadeem et al., 2018; Padhye & Blumenstein, 2017;). Moreover, the output from the SRS during class can provide the teacher with valuable feedback on students’ understanding and gaps in knowledge. This enables teaching adjustments just in time, for example, explaining a concept in more detail or providing additional resources to support students’ learning. To sum up, active learning not only creates participatory, interactive classrooms for enhancing student engagement but provides meaningful feedback to both the teacher and learner. The immediacy of feedback can facilitate learner-led, on-demand formative assessment and correct misconceptions and guide further study (Breen, 2018; JISC, 2014, p. 17; Rosenberg, 2021).

Despite the compelling evidence outlined above, the traditional lecture is still commonplace in most campus-based engineering education. The main argument for such transmission teaching style is the vast amount of subject knowledge that needs to be covered. There is still a widely held perspective that attendance at f2f lectures can impacts academic achievement. Recent evidence from a meta-analysis of over one hundred achievement variables in HE confirmed the positive relationship between students’ attendance frequency and better academic results (Schneider & Preckel, 2017). Importantly, Schneider and Preckle (2017) claim that the general increase of online classes and blended learning does not diminish the importance and effectiveness of class attendance for achievement. One factor that impacts attendance at most universities is lecture capture technology. The recording of lectures is now common HE practice, and certainly contributes to some extent to lower attendance rates at live lectures. However, the effects on student attainment are polarised; some universities report no to little effect on student results, while others found frequent access to recordings can improve academic performance (Frith & Lloyd, 2020; Karnad, 2013; Nordmann et al., 2019). To counter non-attendance and improve student engagement and motivation at f2f lectures as previously described (Bacca-Acosta & Avila-Garzon, 2021; Bowen & Pistilli, 2012; López et al., 2015) the present study embarked on a course re-design that encouraged students’ personal device use for academic tasks in class. Non-academic mobile device use has been found to negatively impact student participation (Colb, 2006; Molleno & Herring-Morrow, 2020; Murray, 2011) as well as academic performance (Amez & Baert, 2020; Junco & Cotten, 2011; Kornhauser et al., 2016; Rosen et al., 2013).

The current study

This study is grounded in Keller’s (1987) ARCS (attention, relevance, confidence, and satisfiability) model to enhance student engagement and motivation through the synchronisation of learning tasks with the lecture content. The ARCS model was originally developed for computer classes but has since found application in other contexts such as mobile inquiry-based language learning (Chang et al., 2016) and enhancement of motivation and retention of distance students using ARCS-based email messages (Huett et al., 2008). When Keller first developed the model in 1984, there was no overarching theory or model on how to create instruction that would stimulate a student’s motivation to learn (Keller, 1987). Given the evidence from educational research, it is certain that the learning environment significantly determines student behavior, and more importantly, fostering participation and engagement through appropriate instructional design is crucial for student success (Coates, 2009; Kahu & Nelson 2018). With the growth of web-based technologies in higher education, the importance of enhancing learner motivation as a pathway to academic success has led to more recent models towards a better understanding of the antecedents of student engagement (e.g., Kahu, 2013; Reschly & Christenson, 2012). Nevertheless, Keller’s ARCS model provides a design dimension that directly addresses the question of how to create instruction that would stimulate the motivation to learn, adhering to a systematic process of define, design, develop, and evaluate (1987). The main aim of the current study is to improve student engagement through active participation in lectures. Inspired by Keller’s motivational design process, the lecture component of an f2f taught course (pre-Covid) was re-designed to include synchronous online learning activities. These activities could be completed by students in-class at any time using their personal device when students were not interacting directly with the teacher. The aim is to immerse learners in the context beyond the lecture slides to enhance active learning in the classroom. Overall, it is hoped that the provision of in-class online learning counters non-attendance of live lectures to improve student engagement and performance. In-class synchronous activities were available asynchronously before and after the lecture so not to disadvantage non-attending students. Specifically, this study seeks to explore the student perception of embedded online activities during live lectures via focus group discussions in the context of learning analytics. The aims are:

- To explore the student experience of embedding synchronous and asynchronous active learning tasks into a traditional engineering lecture and the impact on study behavior, in particular enhancement of engagement and connection to the content.
- **To examine the effect of synchronous and asynchronous online learning tasks on academic performance and attendance.**

Methods

Study design

The present study was conducted in the first semester (fifth overall) of the academic year of a third year "Digital System Design" course towards a Bachelor of Computer Systems Engineering. It was borne out of the lecturer's (first author) desire to enhance the f2f lecture experience for engineering students with the overall goal to improve attendance and student engagement by providing active learning opportunities in the classroom (synchronous) as well as asynchronously. Traditional engineering lectures are often content dense and passive learning environments. This and the recent mandate from our university to make all lecture recordings available to students may contribute to a generally observed decline in student attendance. What followed was a course re-design and implementation of active learning tasks during lecture time (synchronous) which were made available online after the lecture (asynchronous). The methodological approach taken involved a participatory, collaborative, and iterative process aligned with participatory action research (McTaggart, 1991). The action research cycle of plan, act, observe and reflect was enacted over three years. This approach ensured the success of a learning intervention that required the contextual knowledge of the teacher combined with the expertise of an academic developer (second author) and technical knowhow of learning designers out of a centralized learning and teaching service unit at the University of Auckland. The study received approval from the local Human Ethics Committee (Reference 018848) for the collection of qualitative and quantitative data to scope the student perception of the learning intervention via focus groups as well as the impact on attendance and grades (system generated learning analytics data).

The class comprised 75 five undergraduate students (80% male); the average age was 21 years (see Table 1 for demographics). Students were under no obligation to participate in the research as part of the course work; it was completely voluntary. A non-probability sampling method, i.e., convenience sampling, was used due to the exploratory nature of the present study to gather information on the student experience as well as the impact on engagement and learning. The objective was to enhance student attendance in a traditional undergraduate engineering lecture through the implementation of active learning tasks in class over a period of three semesters (semester one of the years 2017 to 2019) to inform further iterations of the course design.

Table 1.

Class demography

Year	# of Students	Male	Female
2017	75	60	15
2018	60	51	9
2019	82	74	8

The participants were students in a course taught by the first author which may pose a risk to the reliability of the study. To limit this risk as well as response bias due to power structures that might exist between the teacher and students (e.g., students may provide only positive and socially acceptable answers when posed by the teacher) a research assistant conducted the data collection where face to face interaction with students was necessary, such as focus groups.

Learning activities aligned with Keller's ARCS model

XorroQ learning activities

The embedded in-class activities were developed using Xorro-Q integrated into Canvas (Instructure.com), the university's learning management system (LMS). XorroQ is a real-time audience response system designed to make lectures more interactive and engaging. The principal investigator developed a quiz for each lecture comprising a maximum of 10 questions related to the content of the lecture being delivered. The activities were conducted during week 5 to 10 of semester one. Quizzes were designed to give students feedback on their comprehension (multiple choice) and retention of facts from the lecture as well as having to apply learnt knowledge to solve a problem, for example, requiring students to research the internet to answer a question. A total of nine online quizzes plus two writing exercises were administered over the semester, essentially one activity per lecture. The aim of these activities was to use students' addiction to the digital device for educational purpose by making them complete the online learning activities during the lectures with a view to enhance student engagement and interaction with learning material. This will not only foster the positive use of the digital devices as well as improve student attendance.

Pedagogical considerations – Keller's ARCS Model

Keller's ARCS (attention, relevance, confidence, and satisfiability) model (1987) was used to synchronize learning tasks with the lecture slides to optimize student engagement. ARCS theory claims that in order to motivate students, it is important to grab their attention through the use of attractive and stimulating medium or learning materials. The online activities were a relatively novel way to test students' knowledge in an otherwise traditionally delivered face to face course. This was underpinned by features that could easily capture students' attention and kept them interested by providing control over the learning material. Furthermore, many of the questions related to real-world examples and critical thinking were included with a view to capture and sustain attention. The in-class activities were complemented with other learning tasks that required a follow-up after class, for example:

> *"Think of a real-world digital system that could be used to solve an existing problem in the community. You are required to identify the problem, suggest a title for the project, and describe how it may benefit the community. Your description should be between 100 – 200 words, strictly. This activity will be peer-reviewed and marked by at least two other students."*

Another component of the ARCS model important for motivating students to learn is the relevance of the learning material and experience by allowing them to perceive present worth or future usefulness. The quiz question were closely related to lecture contents and designed to help students identify gaps in their knowledge. Quizzes were also related to upcoming assessment tasks for students to check their understanding in class.

Confidence is the third component of the ARCS model which is achieved by providing opportunities that give personal control over the learning. In order to boost students' confidence, a significant number of questions from each quiz were designed in a way so that students find it easy enough to complete the quiz quickly and score highly. Students solved the quiz in their own time without any constraints. The self-pacing aspect of task completion resulted in learning autonomy and a feeling that their success is not dependent on external factors, instead, self-driven. Also, students could solve the quiz multiple times and only the solution with the highest marks were considered. This took away the fear of failure bolstering confidence levels. Lastly, each question of the quiz incorporated an explanation of the answer which students were able to see immediately after solving the question. In this way students not only received feedback in the form of affirmation, but explanations provided helped identify shortcomings in their approach thus boosting their chances of success in a next attempt.

The final component of the ARCS model is satisfaction which is directly related to motivation. Students were rewarded in the form of positive feedback and marks earned as each activity contributed to the final grade, though at low weighting. Furthermore, activities could be completed multiple times with a view to create a challenge that rewarded students by getting on the leader board rather than attaching marks to it. This achievement of solving the quiz fully can be a major source of motivation for students.

The activities were conducted in an unstructured and uncontrolled environment for students to perform the tasks. Activities were available a few hours prior to the lecture until midnight that day so as not to disadvantage any student who did not attend. For learning activities that took place during class time, students were instructed to launch the activity, read the question, listen to the teacher, wait for the part of the lecture where the related topic was discussed and then answer the question. Feedback to students on their responses was provided during the lecture without allocating a specific time for discussion. It was not compulsory for students to complete the activities; however, participation carried a low percentage of marks (3% of total mark) as a reward for in semester one of 2017 and 2019. The reason behind the allocation of low weight bearing marks was to discourage the use of these activities as an extrinsic motivation tool that may lead to surface learning (Gibbs & Simpson, 2004). No marks were allocated (except writing activities) during the year 2018. The reason for not allocating any marks was to see if students are intrinsically motivated to complete these activities or they make a strategic decision to forego those marks and instead focus their time on other pieces of assessment which carry some marks. It should be noted, that adding an assessment weighting to participation in online activities brings with it an external motivator which may cloud the evaluation of the intervention and is one of the limitations of this study.

Data collection

Both qualitative and quantitative data were collected to explore the student learning experiences after introducing active tasks alongside the lecture to enhance in-class attendance as well as overall engagement. Specifically, three focus group discussions involving 25 students were conducted to evaluate the new learning tasks for future iterations of the overall course design. A qualitative approach was most appropriate for this exploratory study of scoping the student perception of whether in class activities were considered useful learning resources with the potential to positively impact their learning and lecture attendance. Focus group data were complemented by quantitative data such as lecture attendance, online engagement data, as well as marks earned from Canvas. The proxy for online engagement in this study involved counting the number of online activities completed and submitted (nine quizzes and two writing exercises) i.e., the time invested in learning and subsequent academic performance (marks) in course assessments and final exam. In addition to system log capture out of Canvas, student attendance was manually recorded in Excel spreadsheets over the duration of the 6-week lecture module.

Both, Canvas activity engagement data and attendance were collected for three consecutive years from 2017 to 2019, the period where the activities were embedded into the course design. For consistency, activities did not change over that period nor did the lecturers, learning content, and platform functionality thus keeping the distortion of quantitative data minimal, if any. However, during the 2018 semester, marking was allocated to six activities out of eleven whereby five received no marks to explore the students' view (in focus groups) on activities if no marks were allocated.

Student focus groups

Three focus group discussions lasting approximately 45 minutes and comprising 7 to 10 students were conducted, paying attention to a balanced representation of gender and ethnicity per group by first, inviting all students enrolled in the course for that semester to participate in the research via Canvas announcement (voluntary participation); second, by forming three focus groups from a pool of willing participants to achieve demographic representation within each group. Each discussion group included students who regularly attended the lecture as well as those who did not. To ensure students were able to express their experiences with the course delivery freely, the discussions were conducted by a graduate teaching assistant who was not involved in the teaching of lectures and had no knowledge of how the groups were formed. The teacher (first author) did not have any direct role in the collection of the qualitative data. The discussions were conducted in English, the language of instruction for the course, and took place during week 10 at which point students gained an understanding of the impact that embedded in-class activities may have in supporting their studies. A semi-structured format was followed exploring students' reasons for attendance and non-attendance, the main benefits of lecture attendance from the student perspective, and the kind of tasks and modes of engagement during lectures that were considered helpful for their learning. During the student discussions care was taken to let students express their honest opinions without being dominated by students who would impose their ideas on others. Participants of the focus groups were culturally diverse, many did not come from English speaking backgrounds, which may pose a risk to enable free discussion to scope a wide range of student perspectives. However, the majority had spent a considerable time at our university and were part of a cohort of students moving through the degree together. This familiarity countered the reluctance to speak freely during the discussion.

The facilitator's role was confined to asking standardised introductory questions and keeping the discussions on topic according to predetermined prompts. Audio recordings were transcribed verbatim into written text. Analysis of the transcripts was conducted in two stages towards the development of a coding frame according to methods described by Saldaña (2015) using NVIVO software (QSR International). First, a deductive approach was taken to categorise the content of group discussions aligned with the prompts of the interview schedule: 1) What motivates students to attend lectures? and 2) Do in class activities affect students' decision to attend lectures? and 3) Do in class activities support learning and engagement? Second, after re-reading the transcripts the three main categories were thematically analysed using an inductive approach. Similar conceptual categories were merged to create larger, overarching themes relevant to the student perception of in class activities following an approach described by Gale et al. (2013).

Results

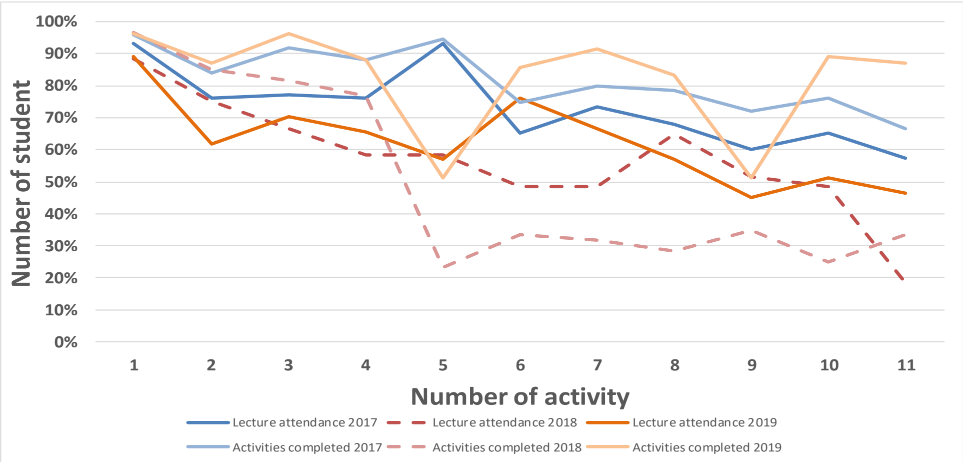
Data were gathered using qualitative and quantitative methods to provide an in-depth picture of the impact of embedded in-class online activities on students' participation and engagement, and perceptions about the usefulness. Student interaction with embedded online activities were automatically recorded by the learning management system Canvas and students did not have to do anything else besides completing the tasks online, either in class or at some other stage asynchronously. The findings from the quantitative data on students' online behavior in relation to attendance are detailed below, followed by a summary of the main issues pertaining to in-class embedded activities that emerged from the focus group discussions after coding the written transcripts into overarching themes.

Online engagement and lecture attendance

Figure 1 details the eleven activities and the number of students who completed those in comparison to lecture attendance data over the six-week period of the course conducted between 2017 and 2019. It indicates that students were engaged online; on average 82 percent completed the activities. Canvas log data showed that each student logged in about 28 times in order to complete the eleven activities. Interestingly, online engagement with the learning tasks was higher by about 10% than the actual recorded (head count) lecture attendance. A slight decline in participation, both online and lecture attendance, can be observed over time which can be attributed to students meeting deadlines for assignments towards the end of semester (average lecture attendance was at 72% dropping to as low as 57%). This is a general trend which is observed in many other courses as well. However, online activity regularly exceeded lecture attendance indicative of students who did not attend engaging in tasks asynchronously. As these activities did not carry any significant weighting towards the final mark, some students may view them as unnecessary (about 18% did not complete any tasks).

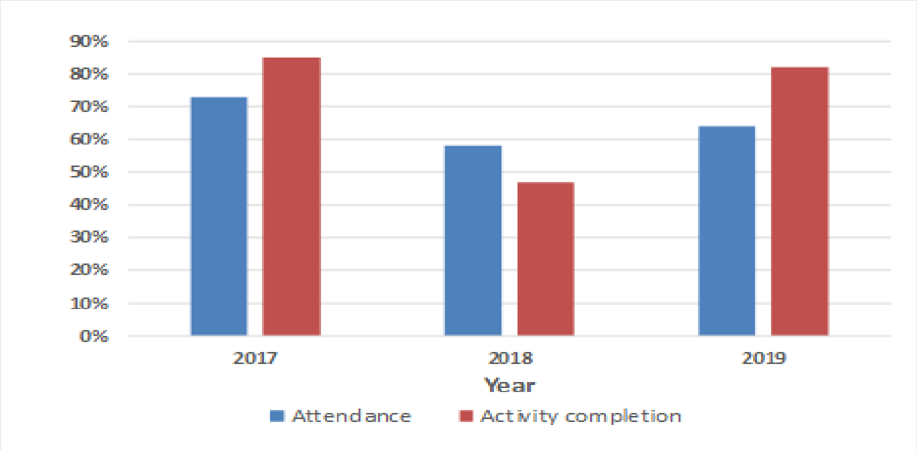
Figure 1

Student engagement and attendance



The same experiment was repeated in semester one of 2018 and 2019 with one difference that half of the activities during 2018 did not carry any marks which seem to decrease both attendance and activity completion for that semester in comparison to the years 2017 and 2019 (see Figure 1). Further, attendance for 2018 dropped to 58% compared to 85% and 82% for 2017 and 2019, accompanied by a decrease in activity completion rates to 58% compared to 73% and 64%, respectively (see Figure 2), most likely due to the fact that half the activities did not carry any marks in 2018. It should be noted the year 2017 had more writing activities compared to 2019 which students were required to complete in class. Attendance on the days of writing tasks was high (more than 90%) indicative of a relationship between attendance and the number of in-class writing exercises (Fig 2). Completion of online activity exceeds the rates for attendance in 2017 and 2019 but the reverse can be observed for 2018 where no marks were attached to the learning activities but attendance was proportionately greater. This is an indication that grades are not the only reason for completing online activities as nearly 50% of students (in 2018) completed those without the reward of a mark, likely because the feedback received supported their learning.

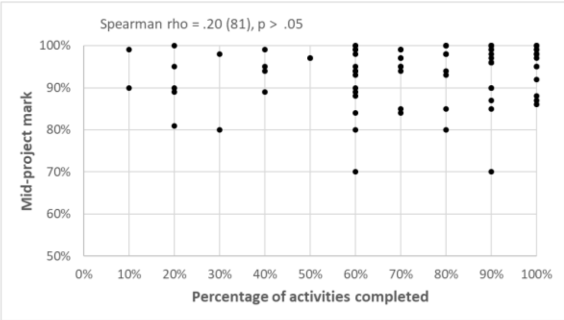
Figure 2.
Student engagement and attendance comparison



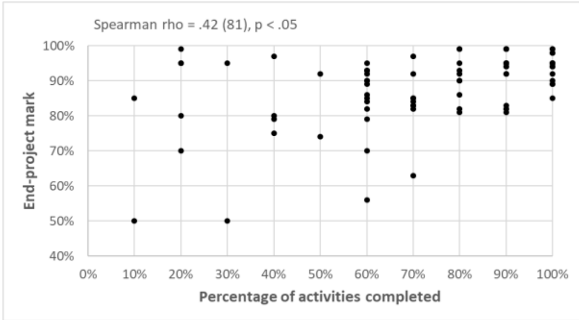
During 2019, we explored the effect of these activities on student learning. The content of the activities was incorporated in different assessments which included two interview assessments conducted for evaluating students' performance in the mini-project and the final exam. A series of Spearman rank-order correlations were carried out to determine if there were any relationships between activity completion and student performance as well as attendance (Figure 3). This non-parametric measure is often used to determine the strength and direction of association that exists between two variables measured on at least an ordinal scale. Results indicated that there was no significant association between the percentage of the activities completed and students' marks in mid-project assessment, an oral assessment conducted to assess students' progress in the project as well as their understanding (r_s (81) = .20, p =.059) as shown in Figure 3(a). A moderate correlation exists between the percentage of the activities completed and students' performance in the end-project assessment (r_s (81) = .42, $p < .05$) as well as between the percentage of the activities completed and students' performance in the final exams (r_s (81) = .34, $p < .05$) as shown in Figure 3(b) and 3(c), respectively. In summary, students' performance in the assessment is proportional to the completion of the activities, but attendance showed no association with final exam performance.

Figure 3.

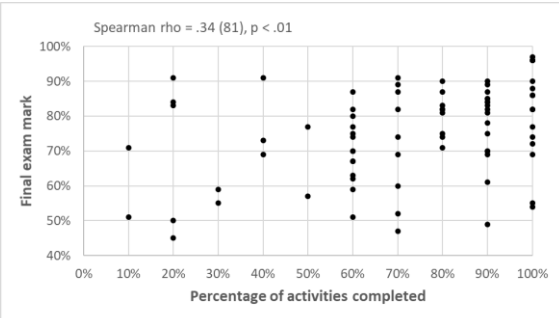
Effect of activities on student learning



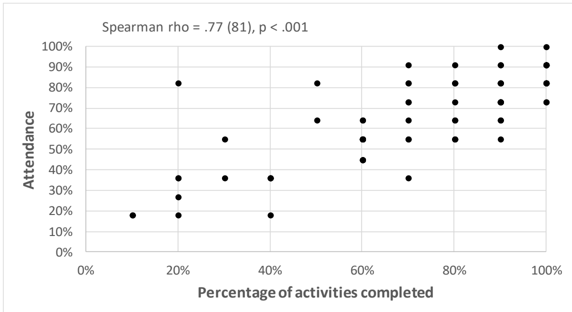
(a)



(b)



(c)



(d)

The score for the final exams and attendance for three years are: 2017 (Final Exam: mean=71.35, std. dev.=13.01; Attendance: mean=73%, std. dev.=18%), 2018 (Final Exam: mean=70.27, std. dev.=13.71; Attendance: mean=57%, std. dev.=8.93%), 2019 (Final Exam: mean=74.43, std. dev.=13.81; Attendance: mean=64%, std. dev.=13%). We did not find a relationship between final exam and attendance (Fig 3c). Upon student request the activities were reopened for ongoing self-assessment of understanding and exam preparation, however, data pertaining to this are not incorporated here. Overall, online activities have a positive effect on student engagement evidenced by the significant positive correlation between the percentage of the activities completed and students' attendance ($r_s(81) = .77$, $p < .001$; Figure 3d), confirming that students attending the f2f lecture were more likely to engage in these activities.

Usefulness of online activities: The student perception

The main themes that emerged from the focus group data analysis surround learning gains in the metacognitive and cognitive dimension. Figure 4 illustrates the coding frequencies of the main concepts that were mentioned at least five times by the participants. This led to the emergence of overarching themes that include evaluation of students' own learning processes, self-regulation through reflection on one-self and others' writing (metacognitive processes), gaining a deeper understanding of real-life problems and how to solve those conceptually (cognitive processes).

Evidence for metacognition can be drawn from responses to the question "Indicate the aspect of the peer reviewing which contributed most to your learning" as follows:

> *"If we came across the question in the quiz, we would have race to answer the question as quickly as possible."*

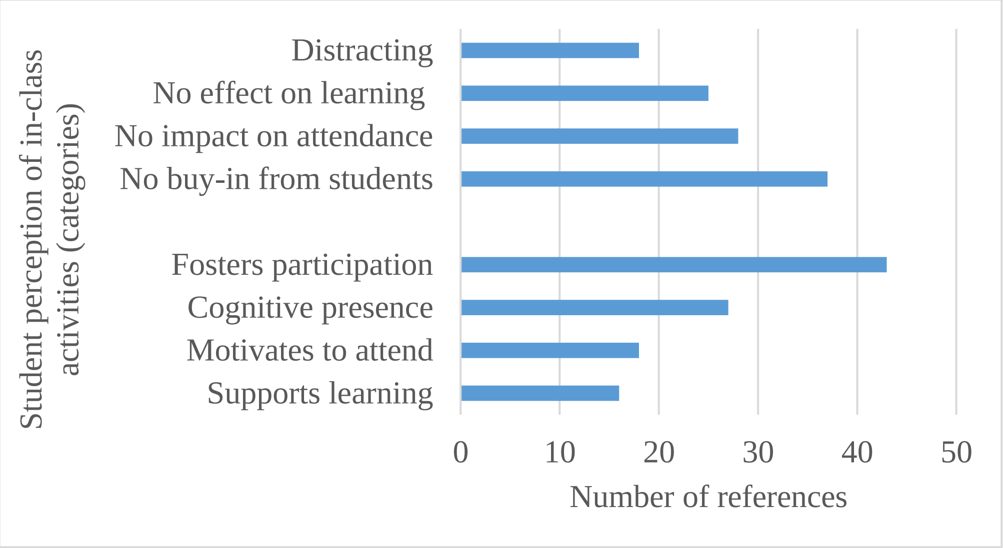
> *"Reading others' work provided me insight of their thinking and understanding."*

> *"I remember there were writing assignment which were pretty cool. It is not only to come up with a way to design it but it is cool to see what other people came up with and put idea into the system and that in a sense was really cool."*

The analysis of focus group data revealed several benefits but also concerns relating to the usefulness of embedded in-class activities on students' learning and engagement as shown in Figure 4. Students also gave other reasons why they do not attend a lecture, irrespective of active learning opportunities during the lecture or not, including work commitment, study load, and learning style (e.g., learning from lecture recordings) which are not included in the figure below (N = 43 comments).

Figure 4.

Coding frequencies derived from the content analysis of three focus group discussions.



Overall, in-class activities were perceived as beneficial (N = 108 comments) for student engagement and learning, while a similar number of student comments (N = 104) reported no impact or going as far as finding the in-class activities distracting. To answer research question 1 whether online activities offered simultaneously as part of an engineering lecture to enhance engagement, the main categories shown in Figure 4 were analysed inductively resulting in three overarching themes: Theme 1, in-class activities as positive reinforcement of good study behavior; theme 2, multi-tasking in class leads to cognitive overload for students; and theme 3, the need for meaningful feedback on activities during the lecture. Although the different focus groups discussed different ideas and experiences, all three themes were represented, suggesting a strong convergence of data.

Positive reinforcement of good study behaviour

Overall, students felt more engaged through the activities and some mentioned that they eagerly awaited the release to get started with them before going to the lecture and/or afterwards, evidenced by the following comments:

> *"Most of the students will look at the quiz before the lecture."*

> *"It is pretty good because it gives you the opportunity to do second time as well."*

Furthermore, students remarked on the positive use of their personal device contributing to their learning instead of being tempted to use it for social networking, surfing the internet, watching videos, playing games etc. The most frequent positive comments were related to the task "find answers", which helped students to familiarize them with the lecture content and provided instant feedback about their own knowledge and potential gaps as illustrated by the following quote:

> *"The questions were good and if you answer the questions, you know that you understand the contents of the lecture and in that way it was good."*

In terms of attendance, students' responses signalled that if there were no incentives (e.g., a low percentage weighted towards the final mark) to complete the online activities attendance would drop. Some students thought that online activities were a good incentive to improve motivation but did not necessarily influence overall lecture attendance.

> *"It made me to do slightly more but not attend the lectures that is all."*

> *"If I go to the lecture by the end of it I will be exactly at the same place as if I just read through the notes myself but if you feel that lecture is going above and beyond the notes and explaining things you feel more like it is worth going to actually attending …"*

In contrast, others reported that they attended all the lectures because they did not want to miss the content, irrespective of whether interactive tasks are provided in class or not. However, students understood the purpose of the online activities as a way of checking on their classroom presence, as one student poignantly said:

> *"It seems that online activity are aimed at getting a roll call. The question he (teacher) can ask is: are you present in the class? Yes or no. It is an indirect way."*

Students also commented on the quality of engagement which mattered to them, rather than the quantity. For example, students did not appreciate the mere engagement through online activities instead they liked tasks that provided timely feedback and with clear learning outcomes as illustrated below:

> *"I think he should allocate some time for the quiz and then carry on."*

> *"Some of them we submit the opinion based answers like the long answers and some of them are correctly defined answers and lot of times we don't get the answers when we do, it seems that (lecturer) is expecting different answers obviously."*

Multitasking and cognitive overload

Asynchronous online activities allowed students to complete the tasks at their own pace either during or after lecture time. However, some students did not like to complete those asynchronously because being part of the in-class experience was something they valued as shown by the following comment:

> *"Online activities are distractive giving time inside the class to do it will not be helpful."*

Students commonly commented on the problem of having to multitask in class, i.e., having to engage with the interactive tasks while listening to the teacher and possibly other students' discussion comments leading to cognitive overload as is evident from the following student quotes:

> *"Would you focus on the quiz or listen to the lecturer. Is it ok to switch between quiz and listen to lecturer? I think he (lecturer) needs to give you a specific time to do the quiz."*

> *"I always get distracted by the discussion that what he (lecturer) is saying and my eyes are always on the part and I should read this question."*

Another student compares his problem of having to listen and doing things in class at the same time to that of an FPGA (*Field Programmable Gate Arrays*), a device used for digital system design and well known for its ability to perform parallel computations:

> *"I am afraid I am not a FPGA."*

Multitasking means that the task is being interrupted and picked up a number of times before it can be completed resulting in a delayed and degraded product. Although students were fully engaged in the activities, they felt overwhelmed at times and lost track of the lecture as stated by one student:

> *"Everyone is trying to get the answer right, finish the MCQ and paying attention to Xorro-Q and do something…It is supposed to help you with the lecture not taking you away from the lecture."*

It also became clear during the focus group discussions that students would prefer time to finish a task in one go instead of having to break it up into chunks throughout the lecture:

> *"You are doing it in one go in 15 minutes and googling stuff and your focus is on the question and not on what lecturer is saying because you wanted to get it done and then it will distract you."*

Need for immediate feedback

The basic motivation behind the introduction of the online activities was to increase student engagement during class time and raise lecture attendance due to its linkages with improved academic performance as well as fostering the academic use of personal devices in class. However, another dimension, timely feedback on learning, emerged out of the focus group discussion with students.

> *"...sometimes when it is new contents, the teacher is just explaining the concept, you want to know that your thoughts are on the concept leading towards the right direction but if it is short questions then you know you are right."*

Although at the end of each activity students were provided with feedback in terms of scores earned it seems that it was not sufficient as one student expressed:

> *"Some form of feedback is better than nothing because we do not discuss it."*

In fact, students expected more meaningful and explanatory feedback, for example, in the form of a discussion instead of the correctness or incorrectness of a question as illustrated by the following quote:

> *"Question should be so that class needs to do it in two minutes and then they submit the answer on the Xorro-Q so that he can discuss it and keeps them engaged... He can then give the answers and it can become more interactive."*

Students not only value the feedback from the lecturer but also from their peers. The following student comment highlights also the social element of learning which may be an influencing element to attend lectures on a regular basis:

> *"The quizzes or some questions should be in groups so that you could discuss it with people so that there is more interaction, and you are more inclined to go because people are with you in a way. I think group collaboration is something which people like."*

It became apparent that feedback in any form is very much appreciated. Interestingly, students prefer feedback on more complex questions only after they had a chance of applying their knowledge first. In that instance, feedback is sought as an affirmation of their learning, for example:

> *"Give us few minutes to try and then give the solution. If I have the solution available for the reference that will be really helpful."*

Discussion

Student engagement is an important quality indicator in HE and drives technology-enhanced learning opportunities to enable choice and self-determination towards student success and retention. A critical issue is the frequent use of digital devices by students for non-academic purposes resulting in distractions, whether in f2f or blended or fully online education environments, impacting negatively on academic performance (Limniou, 2021; Feng, et al., 2019). In the absence of a physical campus during the COVID-19 pandemic and the pivot to remote online learning in a very short time, this issue has been exacerbated, with students being physically distant, busy, or distracted. A recent study by Chen, Nath, and Tang (2020) found that it can take up to half an hour to refocus on a task at hand after being distracted through the non-academic use of technology, for example. Therefore, it is crucial to implement online active learning tasks that are engaging and at the same time do not provide distraction from the content which may cause cognitive overload.

This paper demonstrates that the use of embedded online activities can enhance student engagement in a blended course setting. It was found that active learning reinforces good study behavior and time on task. Learning is most effective when the activities bear some reward (low weight bearing marks for completion). Despite the positive influence on enhancing student presence and motivation, the relationship between embedded activities and better attendance and achievement could not be established. More importantly, this study re-emphasizes the need for timely feedback on students' learning through active tasks connected to the lecture content, either in class or online. The risk of cognitive overload when implementing learning activities for students to complete during lecturing need to be considered in the instructional design for cognitive processes to take place as multitasking can negatively impact student engagement.

Active learning towards presence

In the present study, the provision of in-class online activities that did not carry any substantial marks (3% of total) may have contributed to the fact that attendance at physical lectures did not increase notably, especially when those could be submitted asynchronously. Also, some students may have placed a low priority on completing the tasks as previously reported (Friedman, Rodriguez, & McComb, 2001). Our data showed that there was a divide on whether activities were incentive enough to attend a physical lecture. Focus group data revealed that about half of the students thought it did not influence their behavior in this regard whereas the other half felt more motivated and more engaged. While a clear link between attendance and in-class activities cannot be made in this study, attendance was increased compared to previous years. Other factors may have played a role, for example, the impact of increased numbers of students enrolling for the course compared to other years, lecture room location, timing, and differences in incoming GPA. Furthermore, one could argue that the availability of lecture recordings and asynchronous activities were sufficient for students to feel supported in their learning without having to attend f2f lectures. Nordman et al (2019) also noted that the relationship between the use of lecture recordings and attendance remains unclear; while first year students benefitted from attendance and lecture recording use, a predictor of academic performance, this relationship waned as students moved through their degree. We argue that attendance as indicator of student engagement requires a re-think as it does not equate with presence in terms of being connected to the content, to peers, and the teaching as it happens. The significance of fostering cognitive, social, and teaching presences on students' learning engagement as part of a community of inquiry is widely recognised (Garrison, Cleveland-Innes, & Vaughan, 2000). In the absence of a single proxy for measuring presence (Joksimović et al., 2018), we postulate that participation and completion of active learning tasks are more appropriate indicators of knowing whether students are engaged or disengaged shifting away from attendance alone.

The findings from the current study suggest that active learning opportunities, synchronous and asynchronous, contributed to improved engagement with the lecture content, most students (82%) participated in and completed the activities. This approach also prompted the use of digital devices for academic purposes in class countering disengagement through non-academic device use (e.g., Colb, 2006; Murray, 2011). Many students were eager to complete the activities before the start of the lecture which indicated that they valued preparedness and goal orientation. Moreover, students involved in active learning tasks online (asynchronous) performed equally well compared to those who attended the f2f classes. In summary, there is a clear benefit for time-bound unsupervised activities, i.e., student-led activities outside the teacher's direct reach, to promote self-regulated learning (Clark & Post, 2021) and feedback.

Students' desire to not only receive immediate feedback about the right or wrong of answers but more detailed explanations surrounding complex concepts and ambiguities of electrical engineering was frequently emphasized in focus group discussion. This finding agrees with Nicol (2010) that effective feedback relies on a two-way communicative process. Instructional designs, therefore, need to include collaborative opportunities for students to engage in as opposed to feedback provision as a single event lacking depth and detail. In concordance with Liu and Carless (2006), students valued feedback from both the lecturer and peers. Interactive knowledge checks through online quiz-based activities in f2f, and fully online settings, can enhance attainment of learning outcomes especially when combined with formative feedback (van Alten et al., 2019).

Active learning can lead to cognitive overload

In this study, the subject content was covered in the f2f lecture while learning activities to deepen understanding were available both in-class as well as online in accordance with a blended learning approach (Yu, Ally, & Tsinakos, 2020). This type of learning instruction brought up issues with multitasking as revealed by the focus group data. When students completed online activities in synchrony with the f2f lecture many expressed cognitive overload. One could argue that both tasks, listening to the lecturer and completing tasks while listening are related as they share the same content. However, if tasks are temporally misaligned between lecture content and the time it takes students to complete them, it can result in cognitive bottlenecks. Problems with multitasking and cognitive overload were evident in situations where resources were allocated to several events, such as listening and reading, and motoric skills engaging with a device to locate the right option to click on. This has previously been described and explained through cognitive load theory (Sweller, Van Merrienboer, & Paas, 1998). Sweller et al (1998) propose that cognitive overload is typically high when learning something new due to a lack of prior knowledge and the absence of a schema to process this new information. Our findings concur that uncontrolled and unsynchronized activities presented in class may have became irrelevant to students' schema acquisition and acted as an extraneous load impairing learning. Therefore, future iterations of embedded learning tasks during f2f engineering lectures will require instructional design considerations so that students do not become overwhelmed. Creating pauses can help divert distractions and at the same time provide students with opportunities to clarify and consolidate their knowledge to affirm effective learning strategies (Fayombo, 2012). The success of synchronous learning methods largely depends on what the teacher does in terms of planning and implementation of tasks, feedback supports and resources. It requires careful consideration of how to facilitate the demonstration-practice-feedback cycle for students to be supported in their learning (Moorhouse and Wong, 2021). One thing became clear in this study, in line with other studies (e.g., Clark & Post, 2021), active participation in the learning process connects all students with the content, the teacher and their peers thereby enhancing engagement, irrespective of the learning and teaching mode (f2f, blended, fully online).

Active learning empowers learners

Drawing on students' comments from focus group discussions, embedded online tasks were an effective way of improving engagement through connection to the lecture content. The activities provided an instant check on students' understanding, especially to those students who were not confident enough to ask questions in front of their peers for affirmation of their own understanding. Online activities can be empowering for students towards becoming self-regulated learners and assist in meaning making as previously noted (e.g., Pintrich & Zusho, 2002; Hattie, 2015). Moreover, providing students with opportunities to apply knowledge and self-assessment enables student agency, a prerequisite to self-regulated learning by (Stenalt & Lassesen, 2021). One issue remains, namely students' perception of the activities not being interactive at all. To increase student-student and teacher-student interactions utilizing online tasks, more time would need to be allocated for this in class by, for example, discussing the results and providing feedback. One caveat is that engineering lectures are often content heavy. Therefore, time for interactions during lectures needs to be finely balanced against the need of covering disciplinary content as Bonwell (1991) found. For online learning to be successful and avoiding cognitive overload, the role of the teacher, or e-moderator is crucial in guiding students through a structured and developmental process of learning as exemplified by Salmon's (2013) five-stage model suitable for blended and fully online classrooms; students are scaffolded through the learning stages to promote (1) access and motivation, (2) online socialization, (3) information exchange, (4) knowledge construction, and (5) development.

Students highlighted the need for more examples during the lecture as well as practice questions as homework. This is indicative of undergraduate students still transitioning from a mode of learning within smaller group settings and detailed expectation settings at high school to university study. Some researchers (e.g., Walbeek, 2004) claim that the need for validation of learning throughout students' undergraduate years may be the result of spoon-feeding in the first year at university. We argue that well-designed and scaffolded online activities that supplement large lecture settings are well suited to connect students to the content, teachers, and each other toward independent and life-long learners at any stage of their study. This is particularly important in the light of increasingly diverse student cohorts from various educational backgrounds and their expectations. Learning tasks need to be varied and inclusive to provide all students with opportunity to participate. Online tasks that are student-centred can counter an often-observed reluctance of students expressing own perspectives in front of their peers and the teacher. While the current research involved a small sample size, one blended course with around 75 students over three years, the findings in relation to cognitive overload and enhancement of student engagement are well transferable to other learning settings beyond the f2f classroom.

Conclusions

Embedding active learning tasks into a large undergraduate engineering lecture can improve the overall learning experience by connecting students with the lecture content, the teachers, and each other. Moreover, participation in the tasks was higher in students who attended the f2 lecture compared to those students who did not attend and completed the task at a later stage asynchronously. Overall, student motivation improved among attending and non-attending students evidenced by the fact that online activity regularly exceeded attendance. Awarding marks for completion (either in-class or asynchronous) improved participation greatly. To allow for cognitive processes to take place, and to avoid multitasking that may lead to cognitive overload, care must be taken when designing learning tasks to be completed by students synchronously in class. Pauses may need to be introduced for students to catch up and accomplish the task on hand to avoid multitasking and cognitive overload. In the present study, students' personal device use during class time for the completion of academic tasks was an effective way of countering disengagement, as well as chunking content-dense subjects commonly taught in engineering. For educators to navigate the fast-paced development of new educational technologies, several frameworks aligned with learning theories exist and can guide practice. Examples include the TEC Variety framework (Bonk & Khoo, 2014) and Salmon's (2013) five stage model of active online (and blended) learning fostering motivation, socialization, information exchange, knowledge construction and development of metacognitive skills.

While the HE sector has previously placed great emphasis on student attendance for retention and academic success, there appears to be a paradigm shift towards presence (social, cognitive, emotional, behavioral) and how to foster the various presences in the different learning settings. While this study did not find a significant relationship between online activities, attendance, and achievement, it did yield insights into the importance of classroom presence and feedback for students to succeed in their learning. Students' decision to attend class is likely to be affected by a myriad of other factors which require further investigation. We argue that the emphasis needs to shift to participatory engagement away from attendance as a measure of student presence. This paradigm shift has become more prominent during the Covid-19 pandemic where many students study remotely and attend synchronous lectures but choose not to participate despite being logged-in. Embedded online activities can improve students' motivation to learn and provide a connection to the lecture content, irrespective of mode, either f2f, blended or fully online. In summary, for embedded learning activities to be effective so that students do not become cognitively overloaded, the pedagogical intent as well as temporal alignment with the lecture content needs to be considered.

Conflict of interest

The Author(s) declare(s) that there is no conflict of interest and no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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