The value of student attendance at face-to-face classes, as part of a blended learning experience

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eLearning can create more flexibility for students; more efficiently utilise infrastructure; and can provide high-quality learning at scale. We have investigated perceived value and learning gains associated with online (eLearning) and face-to-face (f2f) components of a blended learning experience. We hypothesised that individual student preference for eLearning and f2f learning would be variable but that participation in f2f learning opportunities would enhance student learning. Using a design-based research approach, we have evaluated blended learning with interactive eLearning materials, and a collaborative, active f2f class. We have combined qualitative evaluation survey data and quantitative f2f attendance data and student grades. Students overwhelmingly value active learning, both within eLearning materials and f2f classes. Final marks positively correlate with the number of f2f classes students attend. Analysis of a subset of intended learning outcomes (ILOs) shows that students who access the eLearning materials independently and students who attend the f2f class perform equally-well in ILO-related assessment tasks; however, students are more likely to choose an assessment task directly-related to a class they have attended. We suggest that attendance at f2f classes as part of a blended learning experience is beneficial however students can sufficiently obtain selected ILOs from engaging eLearning materials.

Keywords: Blended learning; eLearning; student attendance

Introduction

This study explores the value (perceived and actual) of attendance at face-to-face (f2f) classes as part of a blended learning experience. Students are increasingly requesting more flexible study options, including the ability to engage with learning online due to inability to attend f2f classes (Brown, Davis, Sotardi, & Vidal, 2018; Norton & Cakitaki, 2016). Many major universities, including The University of Melbourne, are adopting teaching and learning strategies that require their educators to provide fully online and blended learning opportunities (FlexAP project, https://about.unimelb.edu.au/teaching-and-learning/innovation-initiatives/pedagogy-and-curriculum-innovation/flexap-project). Here we have utilised a design-based research approach to evaluate changes made to a blended second year undergraduate cell biology course.

Early definitions of blended learning refer to a blend of asynchronous text-based online material and synchronous f2f learning (Garrison & Kanuka, 2004), but as technology has evolved, so too has the definition (Sharpe, Benfield, Roberts, & Francis, 2006). Further descriptions of blended learning introduce the concept of 'strong' and 'weak' blends, depending on the amount of eLearning and also discuss the variable media and activity blends available (Littlejohn & Pegler, 2007). The Joint Information Systems Committee (JISC) define blended learning as "a combination of face-to-face learning and dynamic digital activities and content that facilitate anytime/anyplace learning" (Hibberson & Barrett, 2017). We define blended learning as requiring two key components: a f2f component that must occur synchronously; and eLearning that can be accessed asynchronously. It is of course possible for students to form study groups and access online material synchronously and in groups, but here we assume that the majority of our students access online materials independently and asynchronously.

The JISC definition refers to "dynamic digital activities". Based on the Oxford definition of dynamic "characterised by constant change, activity, or progress" (Lexico Dictionary www.lexico.com/en/definition/dynamic), we believe that this could be interpreted in at least two different ways: i) that the digital activities are variable within and between learning sessions and between subsequent iterations of the same learning session with different cohorts; and ii) that the digital activities themselves are interactive and require elements of active student participation. We believe that both of these aspects of the definition of 'dynamic' are valid and in designing our digital activities we have included a range of different activities, chosen to best support attainment of ILOs, and to encourage student learning in different ways; and many of the activities themselves are also interactive rather than being static and predominantly didactic in nature. In the blended learning that we describe in this paper, attendance at the f2f classes is not compulsory and many students are unable to/choose not to attend the f2f classes. We also understand from personal communication with current and

previous students that many students prefer online learning while other students prefer f2f learning. This led us to question the value of these f2f classes. Specifically, we are interested in investigating the following: How do students value the f2f and online components of the subject and how does each component support student learning? If students do not see value in f2f classes and these do not further support their learning, we should consider whether these classes are necessary. Conversely, if these classes significantly enhance student learning, regardless of whether students see value in them, perhaps attendance at these classes should be further encouraged or mandate.

Active learning takes a constructivist approach to learning whereby students learn through active participation rather than passive transmission (Freeman et al., 2014; Waldrop, 2015). A key aim of active learning is to increase 'deep', transformative learning that can change learners perception of the world and develop new representations of knowledge (Biggs & Tang, 2007; Entwistle & Ramsden, 1983; Marton & Saljo, 1976; Prosser & Trigwell, 1999). We therefore define active learning as that in which students do not passively 'absorb' information, but actively develop their understanding and practice application of knowledge and skill through interactive learning activities, discussion with their peers and teaching staff and ultimately learn through a process of discovery. Examples of active learning include: group problem-solving; completing worksheet activities; participation in tutorials; answering 'clicker' questions or in-class polls; participating in peer instruction; and participating in workshops (Freeman et al., 2014; Matsushita, 2017). There is little debate that active learning is beneficial and should be included where appropriate (Chickering & Gamson, 1987; Freeman et al., 2014; Waldrop, 2015).

Active learning is often combined with 'flipped classroom' (EDUCAUSE, 2012) such that pre-class materials must be studied by students at their own pace before attending an active learning class in which students engage in discussions with teachers and peers. Although research on flipped classrooms is still in a nascent stage (DeLozier & Rhodes, 2017) it has been argued that the method is particularly beneficial to students whose performance in traditional educational environments is impaired (Du, Fu, & Wang, 2014). A key element of active learning that we took advantage of in both our online and f2f components was interactive knowledge checks within the online material, as flipped classrooms have been shown to increase attainment of learning outcomes when quizzes are included in their design (van Alten, Phielix, Janssen, & Kester, 2019) and several studies have shown that practice tests improve learning (Butler & Roediger, 2007; Cranney, Ahn, McKinnon, Morris, & Watts, 2009; Vojdanoska, Cranney, & Newell, 2009). As it has been reported that practice testing with feedback consistently outperforms practice testing alone and protects against perseverance errors, we ensured that all knowledge checks provided students with formative feedback (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013).

We therefore acknowledge the significant potential to maximise student learning through the use of both blended and active learning strategies. Based on our definition of blended learning, both the online and f2f components can be inherently 'active' and as such our blended learning could be described as active blended learning. Here we describe an intervention in which the use of active learning strategies was increased in both online and f2f components of a blended course and evaluate these changes in an attempt to differentiate between the value provided by the active online learning opportunities and the active f2f learning opportunities

A design-based research approach

Design-based research is a relatively new but well-established methodology which combines "empirical educational research with the theory-driven design of learning environments" (The Design-Based Research Collective, 2003). More recently, 'design thinking' (Elliott & Lodge, 2017) has emerged as a key theme in "Visions for Australian Tertiary Education" (James, French, & Kelly, 2017). A framework has been developed that places educational design research along a continuum of the design process: from analysis and exploration of a pedagogical issue and context; to design and construction of an intervention; and finally to evaluation of and reflection on this intervention and implications to the broader context (Kopcha, Schmidt, & McKenney, 2015; McKenney & Reeves, 2018). A comprehensive review of undergraduate student experience of blended eLearning has highlighted the requirement to "use blended learning as a driver for transformative course redesign" (Sharpe et al., 2006, p4). These recommendations encompass a design-based research approach, reminiscent of that which we have utilised here. Here, we focus predominantly on the design and delivery of an intervention required to address changes in infrastructure and analysis of preliminary empirical evidence collected to evaluate this intervention.

We have designed and implemented changes to a second-year cell biology course, with approximately 120 students, at a large Australian University. The course is taught through lectures and 'computer-aided learning' (CAL) classes, this study focuses solely on the CAL classes. Due to an upcoming change in learning management

system (LMS), existing CAL eLearning materials were required to be redeveloped in a new platform. In addition, infrastructure changes enabled the f2f CAL classes to be relocated from a 1:1 (student:computer) computer lab to a brand new, purpose-built collaborative learning space (Figure 1). The CAL eLearning materials were originally designed to be accessed by students individually in the 1:1 CAL lab. The building change and changing student demographics, specifically an increase in student 'BYOD' (bring-your-own-device) has decreased the necessity to provide timetabled teaching in CAL labs and a global shift toward collaborative active learning has identified the opportunity for these eLearning materials and the associated f2f classes to be redesigned. Attendance at CALs is not compulsory and attendance rates have progressively declined over the past years (personal observation). We wanted to make optimal use of the new collaborative learning space and create more engaging eLearning materials. We hoped to encourage student attendance by providing a valuable f2f learning experience but also to provide an active, solely online learning experience for students unable to attend the f2f classes.

There are eight CALs for this subject (CAL1-CAL8) and changes were progressively introduced across the semester. In an attempt to minimise the impact on teaching staff and to mitigate student expectations we implemented a 'soft' transition, whereby more minor changes were introduced this semester with an aim to iteratively make further developments over subsequent semesters. The developments we have introduced and evaluated so far are:

1. redesigning pre-class and f2f eLearning materials in a new software package;
2. moderately increasing the amount of pre-class ('flipped') eLearning; and
3. moderately increasing the amount of f2f active learning.

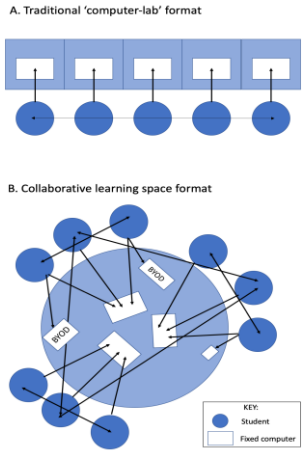

Figure 1. Schematic representation of two learning spaces.

A. Traditional 'computer-lab' format. The main interactions occur between individual students and eLearning resources on fixed computers; some inter-student interactions occur. B. Collaborative learning space format. Fully blended interaction occurs between students, tutors, fixed computers and various students' 'bring-your-own-devices' (BYOD).

We chose to redevelop the eLearning material in Articulate Rise (Articulate 360, Articulate Global, Inc. 2019) as this facilitated inclusion of various design elements that we believed would make the material more interactive, accessible, responsive and ultimately enhance student learning. For example, the software allowed us to implement different ways for students to engage with the material, from activities in which students had to categorise information (sorting activities) to exercises in which they could click on interactive images to receive more information (hotspot activities) and activities in which they had to connect concepts to their definition (connecting activities). The original CAL eLearning materials contained some interactivity, but we extensively increased the number of interactivities in the redeveloped eLearning materials. To illustrate this, the number of interactions increased from 53 to 112 in eLearning materials for CAL7.

In CAL7 we utilised a team-based learning (TBL) approach for the f2f class. TBL is a structured form of active, small group learning that has been shown to enhance mastery of course content (especially for students in the lowest academic quartile) (Koles, Stolfi, Borges, Nelson, & Parmelee, 2010), and can be scaled up for implementation in large classes (Michaelsen, 2002; Parmelee, Michaelsen, Cook, & Hudes, 2012; Rajalingam et al., 2018).

TBL consists of various phases (Michaelsen, 2002; Parmelee et al., 2012). Here we describe the key phases as performed in our classroom. In the preparation phase, students work through pre-class materials, in our case an eLearning module introducing the most important concepts and methods to study cell proliferation and the cell cycle. The f2f phase commenced with an individual Readiness Assurance Test (iRAT), consisting of ten multiple choice questions (MCQs) related to the pre-CAL eLearning. This was then immediately followed by the team Readiness Assurance Test (tRAT). Student groups answered the same ten MCQs, but this time utilised peer instruction and discussion to come to a consensus on their answer. We developed a bespoke tool in Qualtrics which enabled the provision of immediate feedback on incorrect submissions until the correct response was discovered and included a scoring system that added an element of gamification to the activity. In the third f2f phase, the team Application (tAPP) students applied their learning to a series of research-based case studies. Various online tasks were created to accompany student progression through these activities including posting images of a graph of expected results from an experiment through Padlet and responding to MCQs via PollEverywhere. As student groups submitted their responses to these activities, class wide discussions were conducted, and students were encouraged to defend or explain their responses. The best discussions occurred when there were conflicting opinions about the correct answer and indeed the questions and answers were designed to encourage debate rather than to represent 'correct' and 'incorrect' answers. In many cases all answers were valid, and we believe the most powerful learning took place when students realised that there were strengths and weaknesses to all options.

We have initially examined student opinions of all eight CAL classes and have examined the correlation between attendance at CAL classes and final scores. We have then conducted a more focused analysis on CAL7 to compare the value of the active eLearning material and participation in the team-based active learning tasks in terms of perceived learning and demonstration of intended learning outcomes (ILOs) in constructively aligned summative assessment tasks. Qualitative data analysed were anonymous student evaluations of the course. Data were obtained from online and paper-based questionnaires, transcribed and imported into NVivo for coding and memoing. Data were progressively coded to identify key themes and then calculate coverage of relevant comments by the key themes. Specific quantitative data analysed were student LMS access dates; f2f class attendance records; mid-semester test scores; end of semester exam question item analysis; and final subject scores. These data were collated in Excel and statistically analysed in GraphPad Prism 8.1.2 (2019). This research study was approved by the University of Melbourne School of Biomedical Sciences Human Ethics Advisory Group (Ethics ID: 1953765.1).

Results

To gain an overall impression of the benefit of attendance at CAL classes we conducted an analysis of student final marks and correlated these to the number of CAL classes they attended. We see a modest positive correlation with students who attend more CAL classes scoring higher final marks (Figure 2).

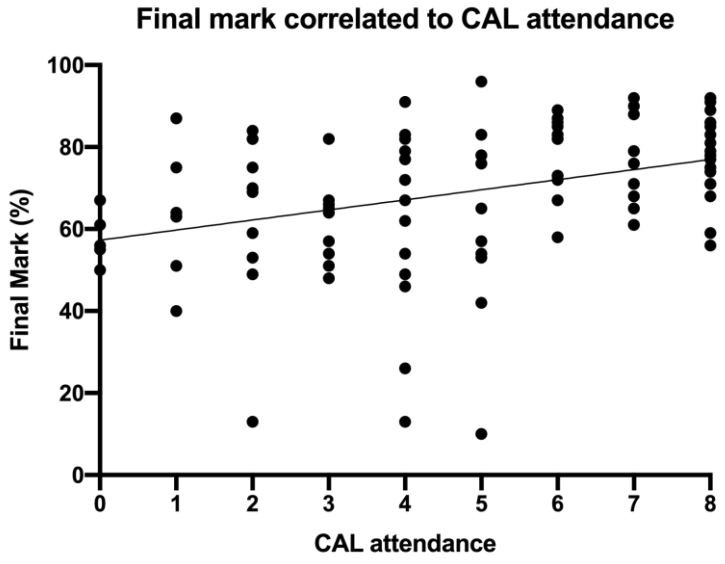

Figure 2. Attendance at CALs is correlated with significantly higher final marks.

Individual final marks (y axis, %) are plotted against the total number of CALs that students attended (x axis). Linear regression demonstrates that the slope of the line of best fit (slope=2.5, R2=0.1292) is significantly positive (p=0.0002) demonstrating a positive correlation between CAL attendance and final mark.

CAL7 followed a team-based learning (TBL) format and was formally evaluated to determine student opinion and impact on learning. In an end-of-semester subject evaluation students were asked: "Which CAL module assisted your learning the most and why?". Some students mentioned more than one CAL, but out of the eight CALs for this subject CAL7 was most frequently mentioned (n=26 students). The reasons students provided were subjected to a coded analysis and five major themes emerged: content; integration; interactivity; engagement; and team work (Table 1). When asked "Which CAL module assisted your learning the least and why?" only 5 students mentioned CAL7. Together these data suggest that overall, CAL7 was well designed and delivered and contributed positively to students' self-reported learning.

Table 1: Aspects of CAL7 that students self-reported helped their learning the most.

Theme	**Details and student quotes (in italics)**	**Number of mentions / % text coverage**
Content	Information; topics; concise; thorough and detailed; pre-CAL; related to lecture material; able to be self-taught; layout; clear explanations; diagrams; extensive and informative. *"The CALs tied specifics together."* *"The CALs were a good source for me to review and revise all the content which I learn in lectures."*	16 / 42.4%
Integration	Consolidation; relationship to prior knowledge, "bigger picture". "*The CALs were great, almost like forced revision, really consolidated learning."*	8 / 27.0%
Interactivity	Interactive; application; questions; workshop dynamic. *"The CALs resulted in my deepest learning in general. The interactive format and in-depth content explanations worked very well."*	8 / 16.8%
Engagement	Fun; interesting; engaging. *"I enjoyed the CALs and interactive style."* *'The CALs were the most beneficial as they were particularly engaging and fun to go through."*	4 / 8.0%
Team work	Team-based learning; incentive to participate; talking with peers; group-work. *"[...] learning it together with my friend clarified my understanding and stimulated my learning more."*	4 / 5.8%

Given that students reported that they felt that CAL7 helped their learning the most out of any of the CALs, we were interested to explore this in more detail and so conducted an intended learning outcome (ILO)-based evaluation of constructively aligned assessment tasks. We analysed student scores in a mid-semester test directly related to CAL7 and scores in a final exam question that assessed concepts and skills covered in CAL7. We were interested in evaluating the performance of students who attended the f2f class and participated synchronously ('Attend') and students who accessed the eLearning materials independently and asynchronously ('Async'). We also examined the performance of students who did not attend the f2f class or access the eLearning materials ('No access', as determined by LMS analytics). Students who attended CAL7 and students who accessed the CAL7 eLearning materials asynchronously achieved a significantly higher CAL7-related mid-semester test score compared to students who did not attend the class and who did not access the eLearning materials (Figure 3A). Interestingly, we saw no significant difference in CAL7-related mid-semester test scores between students who attended the f2f class and those who accessed the eLearning material asynchronously and independently. We also conducted a similar analysis of student scores in a final exam question directly related to CAL7 ILOs. Students

who attended or asynchronously accessed the CAL7 eLearning material performed slightly, but not significantly, better than students who did not access the CAL7 eLearning materials (Figure 3B). These data suggest that the summatively assessed ILOs can be obtained through interaction with the eLearning materials and that there is no added benefit to students in attending the f2f class, in terms of directly-related ILO attainment.

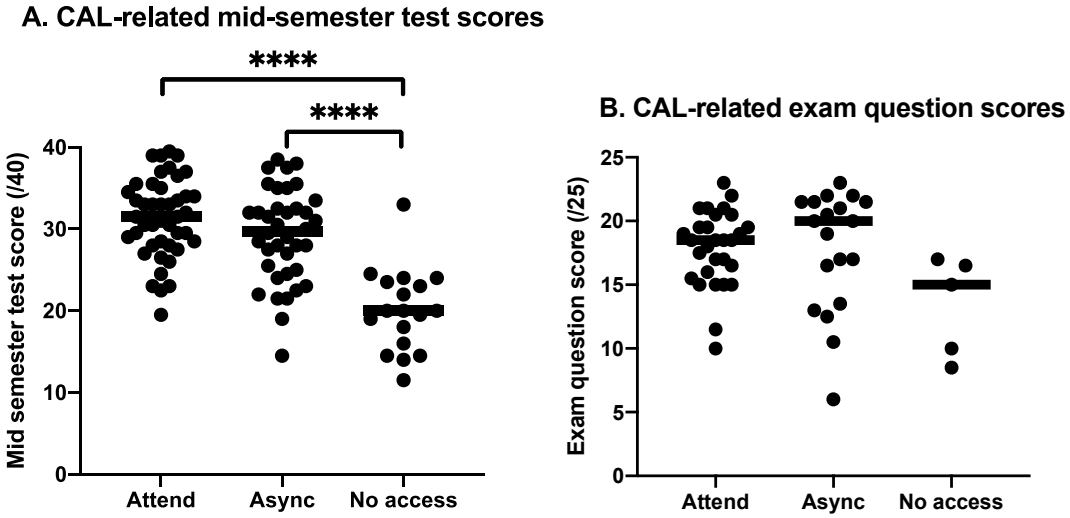

Figure 3. Students who attended CAL7 or accessed CAL7 asynchronously perform better in the CAL7-related mid-semester test compared to students who did not access the CAL7 eLearning materials.

A. Students who attended CAL7 ('Attend', median=32/40) and students who accessed CAL7 asynchronously ('Async', median=30/40) performed better than students who did not access the CAL7 eLearning materials ('No access', median=20/40), in a mid-semester test assessing ILOs specific to CAL7 content ($p<0.0001$). There is no statistically significant difference in performance between the 'Attend' and 'Async' groups. B. Students who attended CAL7 (median=19/25) and students who accessed CAL7 asynchronously (median=20/25) performed slightly, but not statistically significantly, better than students who did not access the CAL7 eLearning materials (median=15/25), in a final exam question directly related to CAL7 content ($p=0.0507$). Kruskal-Wallis test with Dunn's multiple comparison test.

While we didn't see a difference in median CAL7-related final exam question scores between CAL7-attendees, CAL7-asynchronous participants and students who did not access CAL7 we noticed that there were fewer students in the 'Async' and 'No access' groups who answered the CAL7-related exam question compared to the 'Attend' group. We therefore did a subsequent analysis of this observation.

The final exam was divided into three parts: a 20-mark MCQ section; a 40 mark (4 x 10 mark) short answer question section; and a 50 mark (2 x 25 mark) long answer question section. Students were required to answer all questions in Parts A and B, but Part C comprised four questions, of which students had to choose two to answer. Given that we saw no significant difference in scores for the CAL7-related Part C exam question we further asked whether attendance at CAL7 impacted the tendency of students to select the CAL7-related question. 48 students attended CAL7 and of these 30 (62.5%) chose to answer the CAL7-related exam question. 42 students accessed CAL7 asynchronously and of these 21 (50%) chose to answer the CAL7-related exam question. Finally, 22 students did not attend CAL7 or access CAL7 eLearning materials and of these, 6 students (27%) chose to answer the CAL7-related question. Given the available choices, there is a 50% expected chance that any student will answer any given question. Thus, there is a significantly higher percentage of students who attended CAL7 and chose to answer the CAL7-related exam question ($p=0.0104$, two-tailed binomial test). The number of students who chose the CAL7-related exam question and accessed CAL7 asynchronously fits with the expected distribution of 50% and unsurprisingly, students who did not access CAL7 materials were less likely to choose the related exam question ($p=0.0059$, two-tailed binomial test). These data suggest that students who attended CAL7 and were therefore able to discuss the material with their peers and tutors and who were able to participate in the team-based learning component of the active learning class may be more confident in selecting an exam question related to this material.

Discussion

Using a design-based research approach, we designed and delivered blended learning with interactive pre-, f2f and post-class eLearning materials. Our evaluations suggest that students valued the interactive learning activities both in the eLearning material and the active learning activities in f2f class. Moreover, student final marks positively correlated with the number of f2f classes students attended. The class that most students identified as best supporting their learning was CAL7. We have undertaken further analysis of this class, which utilised a significant proportion of 'flipped' pre-class eLearning content and a team-based learning (TBL) f2f active learning structure. Our data show that students who attended the f2f class and students who accessed the eLearning materials independently and asynchronously performed equally-well on assessment of CAL7-related ILOs in a mid-semester test. Students who did not access the eLearning material performed worse on average, than students who attended the f2f class and students who worked on the eLearning independently and asynchronously. We also found an effect of f2f class attendance on students' choice to answer a specific exam question, in that students who attended the CAL7 f2f class were more inclined to answer an exam question directly related to the CAL7 class they attended. These data suggest that while the content can be taught and learned via the eLearning materials, students gain more confidence in their knowledge and skill by participation in the f2f active learning components of the class.

There is a push to move more learning opportunities online to facilitate flexibility for students in terms of what and when they can study. We must make a decision as to whether it is appropriate to offer this subject solely online, if it should continue to be offered as a blended subject with non-compulsory attendance at f2f sessions or whether attendance should be mandated. Others have shown that attendance at classes positively correlates with scores (Devadoss & Foltz, 1996; Oldfield, Rodwell, Curry, & Marks, 2017). Our preliminary data support this observation. At an individual class-level (CAL7), despite students self-reporting that CAL7 helped their learning the most, we do not observe any significant learning gains in students who attended the f2f class versus students who accessed the eLearning materials asynchronously and independently. This demonstrates that we achieved our aim of creating engaging eLearning materials that benefit students equally, whether they are able to attend the f2f class or whether they access these materials independently and asynchronously. However, given that we show that the average final score is higher depending on how many f2f classes students attend, this could suggest that there is a collective benefit to students in attending a series of CAL classes. Reasons for this may include development of confidence in working as part of a team over the semester as well as increased subject-specific mastery due to more content engagement. We also question whether it is possible to replicate any advantages of attendance through engagement with an online classroom, for instance via a discussion board, synchronous video conferencing or other digital methods. These are ongoing areas of interest to us and we will further investigate this in future iterations of this subject.

While we show that student final marks tend to be higher with higher levels of CAL attendance, at an individual CAL class level analysis of ILO attainment we show that attendance at CALs is not beneficial in and of itself. This could of course be due to the fact that more able students may be more likely to attend classes. A positive relationship between prior grade average and class attendance and performance has been found previously (Devadoss & Foltz, 1996), and this is indeed an area that warrants further investigation. This could be further investigated by exploring the reasons that students don't attend classes. But there is no evidence from our qualitative surveys that suggests that students don't attend classes because they are intimidated or feel less able. The most common reasons are logistic: long commute times; clashes with other subjects; and clashes with non-study related commitments (e.g. part-time work, caring responsibilities) which is in line with previous findings that working more hours in paid employment, having more social life commitments, and facing coursework deadlines were, among other factors, predictors of poorer attendance (Oldfield et al., 2017).

One reason that students' performance was similar after the f2f class and after accessing the eLearning independently and asynchronously, may have been the fact that the mid-semester test and final exam questions asked students to remember, understand and apply knowledge, while TBL may also be effective to foster learning in higher levels of Bloom's Taxonomy (Allen et al., 2013; Anderson, Krathwohl, & Bloom, 2001). Moreover, students sat the exam and mid-semester test individually and the questions were more likely related to individual aspects of the students' learning, while the f2f classes, and the TBL-class in particular, were team-based. In future, we aim to shift the focus from individual assessment to the assessment of groupwork and we expect students who attend f2f classes to perform better on this type of assessment.

We saw a statistically significant difference between the mid-semester test marks of students who attended CAL7 or accessed the CAL7 eLearning materials independently and asynchronously. Data from a CAL7-related exam question showed a similar trend but the differences were not statistically significantly different. As mentioned

above, one reason for this could be the variable group sizes as a result of skewed student selection of this exam question based on whether students attended the CAL class or did not access the eLearning materials at all. Another area to consider is the short-term versus long-term benefits of the learning intervention as it has previously been shown that TBL may induce short-term learning gains which do not persist in the long-term (Emke, Butler, & Larsen, 2016). The CAL7-related mid-semester test occurred earlier than the final exam, so the learning gains we observed in mid-semester test scores may reflect a short-term increase in student learning that is not retained over a longer timeframe.

Our findings support the further development and evaluation of interactive and active blended learning. One specific aspect we will focus on in the future is assessment reform and shifting the focus from individual to group assessment and from lower to higher order skills on Bloom's Taxonomy. Although our results show promising support in favour of fully online courses, it is also clear that the f2f interactions can significantly enhance student experience, which is key at the undergraduate level as students develop their self-regulation skills.

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