THE IMPACT OF BLENDED LEARNING ON STUDENT PERFORMANCE IN AN INTENSIVE BLOCK MODE TEACHING SETTING

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Abstract

In an attempt to transform the first-year student experience, Victoria University adopted a Block Teaching Model. Under this 3.5 weeks-long intensive setting for a physics unit, face-to-face sessions were complemented with various blended learning initiatives, including interactive HTML5 (H5P) rich video presentations, an open-access electronic textbook, and online simulations and quizzes. A strong correlation between student performance in assessment tasks and participation in corresponding blended learning activities was discovered. Similar findings were obtained by analysing gain in student conceptual understanding. These results clearly showcase how technology enabled learning can enhance student performance in an intensive block mode teaching setting.

Introduction

Recent shifts in tertiary education have resulted in a significant increase in the participation of students undertaking university studies. While this phenomenon has created studying opportunities for various normally disadvantaged social groups (i.e., high school leavers, mature age students, etc.), it has also led to an ever-increasing degree of diversity among the student cohort across the Western world and beyond (Biggs, 2011). Recent research has also shown that students entering Australian universities with low tertiary admission ranks (ATAR) “continue to be less prepared, less able to cope with study, less academically engaged than their peers, and are at greater risk of attrition” (Baik, Naylor, Arkoudis, & Dabrowski, 2019).

In an attempt to address this issue and in the process, to provide a better learning experience for students while also improving student retention and satisfaction, Victoria University (VU) has recently adopted an innovative mode of teaching (McCluskey, 2018). The Block Model is designed so that students are able to focus on one subject comprising eleven classes over a three and half week “Block”. Underlying this design is an expectation that studying just one subject, via an intensive, face-to-face block in a relatively small class of approximately 30, will allow students to achieve a better conceptual and practical understanding of the investigated topics. Within such a class, students establish a much more meaningful relationship with their peers and educators (Dodd, 2018). Intensive teaching formats create opportunities for a range of different active learning opportunities such as peer learning (PL) or interactive engagement (IE), the benefits of which are well documented in literature (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Hake, 2002; Wieman, 2017). This study explores how a blended learning approach can influence student performance in a first year physics unit under VU's recently adopted block mode of teaching.

Literature Review

Decades of research in science education has shown that traditional lecture-based instruction fails to promote deep holistic learning experiences. Surface learners tend to focus predominantly on memorizing basic physics concepts or following a set of defined procedures while using formulas. This approach obstructs development of their critical thinking and problem-solving skills (Redish, Hammer, & Elby, 2001). A student who readily accepts information provided through authoritative sources (teacher, textbooks) without question often comes to believe that physics knowledge consists largely of an unrelated collection of incontestable facts and formulae. Such students tend to memorise physics problems and formulas for assessment purposes and are even capable of solving problems they have previously seen; however, the main drawback of such a learning approach is that students cannot solve problems they have not encountered before, even if trivial changes are made to the problem. Research shows that although many students succeed in passing physics courses, few students retain a deep understanding of the core physics concepts after they complete their course (Redish et al., 2001). Given the drawbacks of surface learning approaches, it has been proposed that an active learning approach based on the principles of learner-centred teaching approaches and interactive engagement can facilitate the construction of deep and meaningful knowledge (Drinkwater et al., 2014). Numerous studies have shown that students develop deep understanding when they are actively engaged in the learning process and are provided opportunities to demonstrate their learning with immediate and meaningful feedback (Biggs, 2011; Wieman, 2017).

Blended learning is a relatively new approach to university instruction that combines face-to-face (F2F) instruction with the delivery of a variety of evidence based online learning activities without reducing F2F classroom contact hours (Dziuban, Hartman, Cavanagh, & Moskal, 2011). The key advantage of blended learning is that it maximises the class time dedicated to problem solving and students developing a deep conceptual understanding of the content being explored (Bergmann & Sams, 2012). Following the paradigm shift from teacher-centred to learner-centred pedagogies, which are collectively labelled as "constructivism", blended learning is currently a very popular approach to educational frameworks (Means, Toyama, Murphy, & Baki, 2013). Numerous researchers of online education have demonstrated that both the effectiveness and learning outcomes of blended learning are comparable or better when compared to those of traditional F2F classroom environments (Allen & Seaman, 2015;

Larson & Sung, 2009). A few studies have also shown that students in blended learning environments tend to outperform those in F2F classroom environments (Larson & Sung 2009; Means et al., 2013).

Blended learning environments have been shown to produce more effective and measurable learning gains in science-based courses (Bernard, Borokhovski, Schmid, Tamim, & Abrami, 2014; Larson & Sung, 2009; Means et al., 2013). However, there is mixed evidence and a lack of rigorous research studies into the effectiveness of different blended learning activities (Means et al., 2013; Zhao & Breslow, 2013) in intensive teaching settings. In our study, we hoped to identify if a correlation exists between student performance in certain assessment tasks and student participation in corresponding blended activities for a Physics unit. The Physics unit in focus (NEF1202 – Engineering Physics 2) is offered to undergraduate engineering and education students under the recently adopted block mode of teaching at VU. Focus was also placed in analysing student conceptual understanding in two thirds of the topics covered in this unit via application of the relevant Brief Electricity and Magnetism Assessment (BEMA) tool.

Unit Design

The primary informing factor when designing this unit was to provide the best possible teaching/learning approach suited to a diverse student cohort, within the time limitations imposed by the block model and the subject's unique specific discipline-based challenges. This was achieved by establishing a balanced variety of tasks that were also directly aligned with carefully crafted learning activities (LAs) based on Millner's types of media (Millner, 2008) suited to phases of Diana Laurillard's conversational framework (Laurillard, 2002).

Under the recently adopted VU Block Model (McCluskey, 2018) a three and half week period consisting of 11 three hour long sessions of F2F teaching is required for the completion of each four week long blocked unit. In the case of science and engineering units, lab activities that provide opportunities to further experiment with the covered topics are integrated in addition to the main 3 hour sessions. Table 1 presents the schedule of the investigated Engineering Physics 2 unit, which focuses on three main areas of undergraduate fundamental Physics; static electricity, magnetism and thermodynamics. A one-hour long session for problem solving is included in Sessions 1, 2, 4, 5, 7, 8, and 10, while three long laboratory experiments consisting of two hours are included in sessions 3, 6 and 9. Also shown in Table 1 are the blended learning types of activities that have been integrated within VUs customised Brightspace Learning Management System – VU Collaborate (VUC) – in this unit. Session 11 is used for final assessment and viewing of students' video presentations.

For every session, students are expected to complete learning activities embedded within a 10 min HTML5 (H5P) rich interactive video as part of a pre-class activity. Each video is designed to introduce the key session concepts, while reinforcing main ideas through the aid of embedded conceptual questions. Students are simply encouraged to watch these videos with no impact on their overall mark as part of a formative assessment strategy. Videos used in this unit were sourced from the Crash Course YouTube channel (CrashCourse, n.d.), while questions were integrated by converting these videos in HTML5 (H5P) rich format. On average 10 questions were generated for each video.

Table 1
*Unit schedule and corresponding in-class and blended activities (noted by *).*

Learning Activities	**Topics & Sessions**										
	Week 1: Static Electricity			**Week 2: Magnetism**			**Week 3: Thermody-namics**			**Week 4: Revision & Videos**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Html5 rich interactive videos *	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Open Access Electronic Textbook *	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Online Simulations, Applet & Demonstrations *	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Problem solving sessions	✓	✓		✓	✓		✓	✓		✓	
Practice Quizzes*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Weekly Long Inquiry Based Activities		✓			✓			✓			
Laboratory Sessions			✓			✓			✓		
3.5 -Week Long Activity – Video Presentation						✓					

These questions were also included in the question library that was built to support a series of online practice quizzes. The question library also included a large group of different versions of the various numerical Physics problems undertaken during the F2F workshops. A randomly generated practice quiz retrieving different combinations of conceptual and numerical problems from the central question bank is formed every time a student attempts a practice quiz. Students are encouraged to undertake these practice quizzes at the end of every session, so that they can reinforce their understanding of the investigated topics. As noted above, relevant numerical based Physics problems would be introduced in the form of supporting tutorial problem sheets in every workshop. Students were able to gain further assistance and practice time within the additional problem solving sessions designed to complement most of the main three long F2F workshops.

During the main workshops, time would normally be utilised discussing the ideas presented in the pre-class videos and clarifying answers to the conceptual questions and mathematical Physics problems. Focus was also placed in introducing each week's inquiry based group (3-4 students per group) activity as well as monitoring student progress while providing feedback and support within the relevant infrastructure. Time was also devoted towards the facilitation of the block-long inquiry based activity, where students had to provide a video script and then generate a 5-10 minute long video presentation in one of the explored concepts (i.e., a presentation on the application of Gauss's Law).
Investigated topics are further explored with the aid of relevant in-class demonstrations or online applets and simulations. The latter has been found instrumental in teaching physics, since it assists with the representation of many physical concepts that normally students have considerable difficulty visualising and understanding. Learning challenges can become even greater when students do not have real world experiences or mental images of the investigated concepts. Such concepts include flux, electric potentials, electric fields, imaginary Gaussian surfaces, etc. (Sadaghiani, 2011), which constitute the topic of interest for two thirds of the investigated unit. Further support was provided via direct references to the OpenStax University Physics Volume 2 open access electronic textbook (Ling et al., 2016), that students are encouraged to access throughout the whole course of the unit.

Special emphasis was likewise placed during the unit designing stage to develop relevant assessment tasks with direct links to the unit's learning objectives and developed blended activities. Online based in-class quizzes randomly generated from the same question banks were undertaken for each investigated topic in the first hour of every first session in weeks 2, 3, and 4. Students are also instructed to record their problem solving process in writing, so that cross-referencing against their online responses can be used for the provision of feedback and partial marks. The term hybrid is thus used to describe the dual submission protocol (online & paper based) of these tests. The remaining marks were allocated for students' efforts in the corresponding inquiry based and laboratory based activities, including their video presentation.

Methodology and Empirical Study

This investigation focuses on identifying if a correlation exists between student participation in any of the four utilised blended activities (i.e., videos, electronic textbook, online simulations/applets, and practice quizzes) and their test performance in three linked in-class hybrid tests. It was hypothesised that students who spend considerable amount of time using the developed blended activities would exhibit more effective learning gains despite the apparent time constraints of this unit running within a Block Teaching Model. Learning gain was assessed by comparing student performance on the BEMA multiple-choice instrument that tests understanding of subjects covered in a typical introductory electricity and magnetism course (Ding, Chabay, Sherwood, & Beichner, 2006).

Our data set consisted of a total of 90 1st-year (predominantly engineering and also a few education) students. Students that may have enrolled and never attended any classes or dropped the unit before the end of the block have not been included in this study. Student participation data were manually extracted from the automatically generated learning analytics (LA) that are available on the VUC platform throughout the duration of each taught block. In all, this unit was offered over a period of four different blocks and collection and analysis of data was performed after the end of each of the four blocks.

Table 2
Summary of blended activity LA and corresponding empirical study

Blended Activity	LMS Analytics	Empirical Study Variables
Pre-class HTML5 rich interactive videos	Video Watching time & number of video visits	Students that spent 60 minutes or more during a topic vs those that spent less than 60 minutes.
References to Open Access Electronic Textbook	Number of visits	Students having accessed 50-100% of the notes vs students having accessed less than 50%.
Links to Online Simulations & Applets	Number of visits	Students having accessed 50-100% of the applets vs students having accessed less than 50%.
Post-class Practice Quizzes (PQ)	Number of PQ attempts & time spent on PQ	Students having practiced on average one time or more per PQ quiz versus students that practiced less than one.

Table 2 presents a summary of the extracted LA as a function of blended activity and corresponding empirical study. As noted earlier, each video lasts on average around 10 minutes, which can be considerably extended when students reflect before providing answers to questions embedded within the video. As such, a large diversity in total watching time was observed for different students, which was further intensified when comparing data between different sessions. It was therefore decided to analyse the effect of the total video watching time over every three sessions, which corresponds to the number of sessions used for each of the three explored physics topics. The effect of videos as a function of student performance in the corresponding end-of-topic hybrid in-class test was then analysed by comparing students that on average have spent more than 60 minutes of watched time versus students that spent less than 60 minutes.

When studying the effect of the open access electronic textbook or that of relevant online simulations and applets, data was only available in the form of if these resources were accessed by the students or not. The average number of visits over the total number of sessions was then compared as a function to the average total mark for the three end-of-topic tests. A comparison between students having accessed more than 50% of either blended resource versus students that did not was then undertaken.

The impact of practice quizzes (PQ) on student performance was investigated by comparing the average number of PQ attempts per session as a function of the average total mark for the three end-of-topic tests. Likewise, assessment of student learning gain with the aid of the BEMA instrument was achieved by looking into the average number of PQ attempts per session over the first six sessions only. The BEMA was used as both a pre-test (first session of the block) and as a post-test (eleventh session of the block). The normalised learning gain was then computed, which is the ratio of the actual to the maximum possible gain (Sadaghiani, 2011).

Data Analysis and Results

As noted earlier, four sets of LA data were collected and analysed in conjunction with students' scores on corresponding end-of-topic hybrid quizzes and student performances on the BEMA test. Figure 1 represents the student score distribution on the three end-of-topic hybrid in-class tests as a function of watched video time. It can be observed in all three cases that a significantly better grade was achieved when students spent more time interacting with the corresponding pre-class videos. On average, close to 75% of students achieve a mark of around 60% and over when they have spent twice as long time as the duration of each video per session. Only about 50% of the students achieve a similar result from the other group. Likewise higher medians are showcased in all tests for the first group of students (Electricity test: 0.71 vs 0.63, Magnetism Test: 0.84 vs 0.61, and Thermo Test: 0.71 vs 0.62) with all differences appearing statistically significant when undertaking a two-sample (assuming unequal variances) significance test (p-values of 0.0014, 0.0001, and 0.0003 respectively for the three sets of data).

Similar data analysis was performed when investigating the link between accessing the recommended open access electronic textbook or relevant online simulations/applets and distribution of the average student score in the three tests (Figure 2). Comparing the computed median values, it becomes clear that students that have accessed more than 50% of either type of blended resource performed better in the corresponding quizzes (Electronic Textbook: 0.73 vs 0.61 and Online Simulations: 0.73 vs 0.59). A two-sample (assuming unequal variances) inferential statistics test shows that the observed differences are significant (*p*-values of 0.003 and 0.038 for the two sets of data).

Analysis of data regarding the effect of practice quizzes was performed by identifying the impact on students' test scores as well as improvements in student conceptual understanding using the BEMA instrument. It was found that students undertaking a PQ at a rate of over one per session greatly outperformed those that did not (Figure 3 – Solid Filled Box Plots). Over 75% of students from the first group achieved an average test score of 60% and over, while only about 30% of students from the second group achieved similar marks, with these differences once again appearing statistically significant (*p*-value of 3.24×10^{-5}).

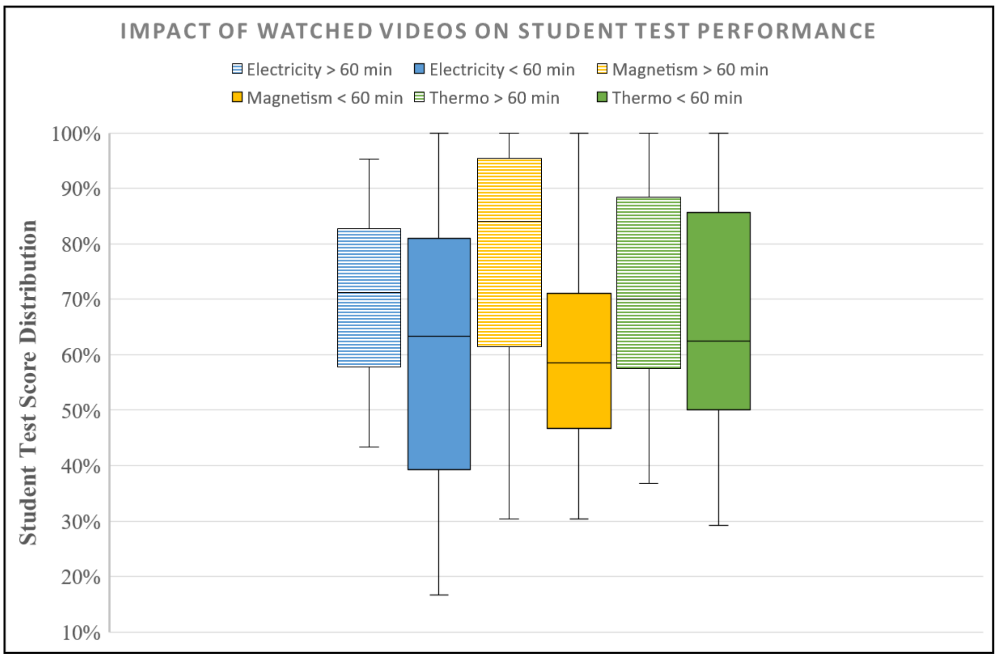

Figure 1. Impact of time watching pre-class videos on test score.

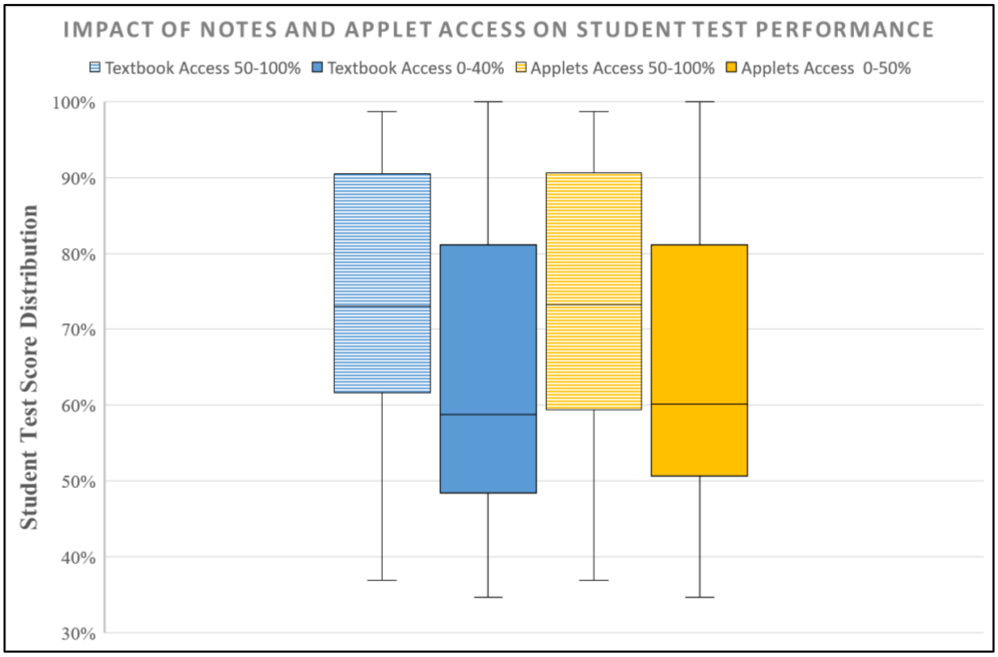

Figure 2. Impact of accessing the electronic textbook (leftmost blue spans) and applets (rightmost yellow spans) on test scores.

Although no significant difference in pre-course BEMA results had been observed between the two groups, students undertaking more practice quizzes outperformed those that did not in the post-course, resulting in a roughly 5% higher normalised learning gain (29.91% vs 25.03%).

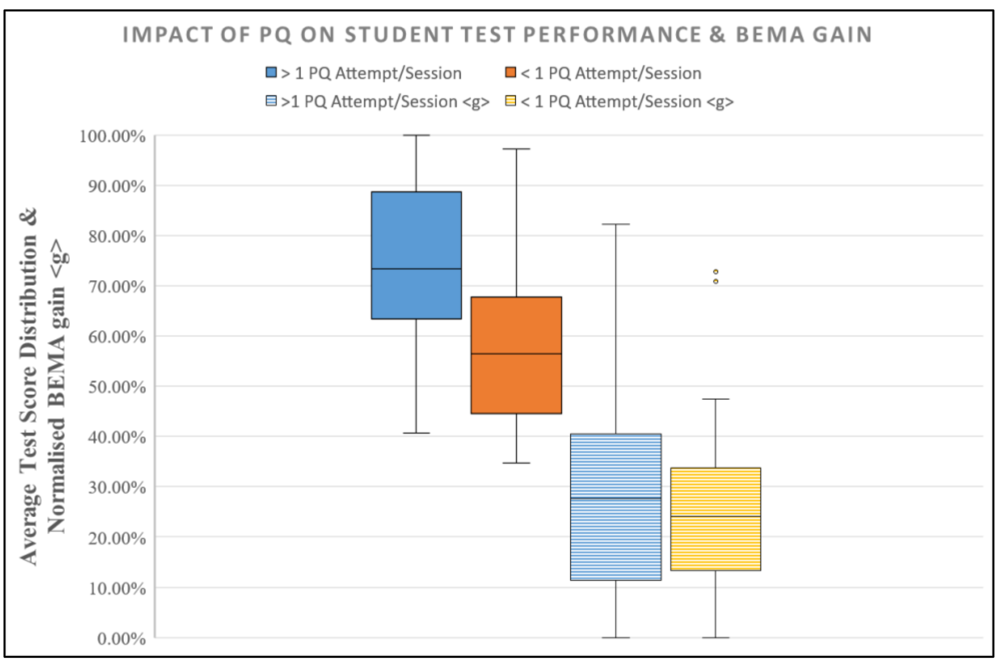

Figure 3. Impact of practice quizzes on test scores (leftmost solid box-charts) and on normalised gain (rightmost pattern filled box-charts).

Conclusion

This study investigated the effects of using a range of blended learning activities on students' performance in an introductory university physics unit delivered under the recently adopted Block Teaching Model. The findings suggest that uptake of the available blended resources can significantly increase the possibility of students achieving a higher overall mark as well as demonstrating a higher conceptual understanding at the end of the unit, despite the apparent time constraints of this unit running within an intensive teaching format. Based on the outcomes of the BEMA instrument, it was found that students' overall conceptual understanding ($44\% \pm 17\%$) was comparable to what has been shown in previous studies assessing students under the traditional mode of teaching ($44\% \pm 13\%$) (Maloney, O'Kuma, Hieggelke, & Van Heuvelen, 2001).

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