Blended Learning as an Effective Pedagogical Paradigm for Biomedical Science

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Abstract : Blended learning combines face-to-face class based and online teaching and learning delivery in order to increase flexibility in how, when, and where students study and learn. The development, integration, and promotion of blended learning in frameworks of curriculum design can optimize the opportunities afforded by information and communication technologies and, concomitantly, accommodate a broad range of student learning styles. This study critically reviews the potential benefits of blended learning as a progressive educative paradigm for the teaching of biomedical science and evaluates the opportunities that blended learning offers for the delivery of accessible, flexible and sustainable teaching and learning experiences. A central tenet of biomedical science education at the tertiary level is the development of comprehensive hands-on practical competencies and technical skills (many of which require laboratory-based learning environments), and it is advanced that a blended learning model, which combines face-to-face synchronous teaching and learning activities with asynchronous online teaching and learning activities, effectively creates an authentic, enriching, and student-centred learning environment for biomedical science. Lastly, a blending learning design for introductory biochemistry will be described as an effective example of integrating face-to-face and online teaching, learning and assessment activities within the teaching domain of biomedical science.

Keywords: blended learning, biomedical science, biochemistry, laboratory skills, asynchronous learning, synchronous learning, constructive alignment, authentic assessment, engagement, feedback.

Background

The internet and the use of information and communication technologies (ICT) are central facts of life for the current generation that has grown up using these tools. Students today – raised with online technology – demand the use of online technologies in their learning environments and they make use of search engines and online referencing to research topics that they are interested in on a daily basis. Indeed, it is important to recognize that the integration of online technologies into 21st century education, at all levels, should fundamentally reinforce current students' innate cognitive processes.

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The pace and spread of advances in ICT and online learning in tertiary education is challenging assumptions, preconceptions, and expectations of instructional and learning paradigms. Student engagement can be supported both inside and outside the classroom by constructivist electronic pedagogies (eLearning and ICT), which may afford educative opportunities that utilize student-directed computer-supported collaborative learning through podcasts, blogs, discussion forums, online collaborative activities, and wikis. The expectations of students as learners are being transformed because the learning tools and technologies available are changing. It is evident that contemporary tertiary students have learning and teaching preferences, and a range of learning styles, that have been developed through technology-supported instruction. Consequently, students have a degree of expectation that their tertiary studies will utilize and integrate ICT tools to support their learning. Educators, with institutional support, need to acknowledge, embrace, and incorporate these expectations and preferences into their effective teaching practices. It has been suggested (Hart, 2008) that current learners have the following learning preferences:

- web-based information coming from multiple sources;
- multitasking – working with multiple inputs simultaneously;
- visual learning – pictures, audio, video, rather than text;
- short attention spans – bite size chunks of learning;
- experiential learners who learn through discovery;
- social learners – enjoy working in collaborative teams, sharing learning opportunities, operating within learning communities;
- demand immediate feedback – they are used to instant gratification;
- independent learners who consider that they can teach themselves with guidance; and
- prefer to construct their own learning – assembling tools and resources from different sources to synthesize learning outcomes.

Online learning environments can be tailored to meet the needs of students and ICT frameworks can be utilized to develop high quality learning and teaching materials that engage, enthuse, and inspire learning. However, simplistic online pedagogical approaches potentially lack flexibility, richness, and downstream functionality. On the other hand, complex online pedagogical approaches that provide engaging and contextualized learning experiences for students will be more difficult and time-consuming to initiate and establish. A successful online learning environment would allow an educator to effectively create and distribute supportive educational materials and learning resources, while simultaneously providing an efficient and engaging experience for students. Together, these learning resources and experiences must align the teaching and assessment activities and realize the intended learning outcomes.

Tertiary level education in science, technology, engineering, and mathematics (the so-called STEM educational fields) depends on engaging students with face-to-face hands-on practical learning experiences, which are traditionally taught in practical laboratories or through tutorial-based learning activities. Consequently, the opportunity for courses in these practically-focused STEM fields to escape to a fully online mode of instruction and learning can be enormously challenging, and the middle ground of a blended learning approach can be conducive to the effective delivery of instruction and fulfillment of intended learning outcomes. Blended learning, in its simplest form, combines face-to-face teaching based in a bricks and mortar classroom with the use of asynchronous online technological modes of teaching and learning delivery to enrich the learning environment and increase the flexibility in how, when, and where students study and learn. Thus, the strengths of synchronous (face-to-face class based) learning activities can be integrated with asynchronous online learning activities that facilitate learning opportunities without the constraints of time and place – ‘anytime, anywhere’ or ‘on demand’ learning. Importantly though, a definition of blended learning needs to incorporate face-to-face instruction with online learning activities in a planned and pedagogically sound framework that supports and enhances student learning (Garrison & Kanuka, 2004; Graham, 2006). Furthermore, Garrison and Kanuka (2004) argued that blended learning as a methodology has the capacity to be transformative, as well as support deep and meaningful learning experiences. Indeed, a major meta-analysis of online learning (U.S. Department of Education, Office of Planning, Evaluation, and Policy Development, 2010) reported that online learning appears to be as effective as conventional face-to-face teaching, but not superior. This meta-analysis further concluded that that blended approaches to teaching and learning that integrate face-to-face instruction with online activities have advantages, and these advantages may stem from the additional resources and learning time in combination with the collaborative opportunities available to students.

Blended Learning in Biomedical Science

Biomedical science is not a singular discipline, but a coalescence of bioscience, clinical, and medical disciplines that all focus on understanding the workings of the human body in health and disease. This conglomeration of disciplines, which includes anatomy, biochemistry, genetics, microbiology, molecular biology, and physiology, among others, have established themselves under the banner of biomedical science, primarily because skills and competencies from across all these discipline areas need to be applied and integrated in order to understand complex biological and medical processes.

Tertiary level education in many areas of biomedical science depends on engaging students with face-to-face, hands-on practical learning experiences, which are traditionally taught in a practical laboratory. The application of a blended learning approach to teaching biomedical sciences, such as the discipline specialty of biochemistry, offers opportunities to integrate a range of online asynchronous learning modalities with face-to-face learning and teaching, which can potentially promote active, student-centred learning and the development of essential problem-solving skills. Educators across the disciplines that comprise biomedical science have begun to apply innovative blended learning paradigms to their teaching and, in recent years, a number of positive reports showing that blended learning effectively reinforces and improves student learning have been published. Evaluation of blended learning in the teaching of human anatomy (Pereira et al., 2007) and anatomy and physiology (White and Sykes, 2012) suggested that a blended learning design was either as good as or more effective than traditional teaching in these disciplines. The use of blended learning approaches in biochemistry teaching indicates that online resources are extensively utilized by students, that students positively evaluate their experiences with blended learning, and that blended learning assists students to master conceptual knowledge and deepen the quality of their learning experiences (Macaulay, Van Damme, & Walker, 2009; de Fatima Wardenski, de Espindola, Struchiner, & Giannella, 2012; Varghese, Faith, & Jacob, 2012). Similarly, Bergtrom (2009) recounted that a blended learning framework in cell biology teaching offered greater opportunities for student engagement and active leaning than in a traditional face-to-face teaching mode. It has also been reported that the application of blended learning design to microbiology laboratory practical classes, through the combination of computer-aided instruction with wet practical exercises, improved student engagement and learning (Grando, 2010).

Building on these encouraging outcomes, it is evident that a blended learning design framework for teaching and learning of biomedical sciences has the capacity to:

- accommodate diverse student learning styles and engage students at a higher level of learning;
- promote students' abilities to assimilate and master biomedical concepts;
- integrate in-class (synchronous) learning with out-of-class (asynchronous) learning;
- enable student autonomy – to study in their own time and at their own pace – using 'on demand' online learning resources; and
- encourage students to evaluate their own learning and understanding through online quizzes that provide formative feedback on their performance.

Furthermore, the blended learning paradigm should also exemplify authenticity and directly engage the student with functioning knowledge in its context. For authentic assessment, learning needs to efficiently integrate with the teaching activity and optimize the ability of students to perform and achieve (Herington & Herrington, 2006). Importantly, blended learning enables access and personalization of student learning; it enables student access to learning resources and offers students flexibility to study in their own time and at their own pace – using 'on demand' online learning resources.

Applying Blending Learning in Introductory Biochemistry

Blended learning principles have been applied and incorporated into the design of the author's teaching in biochemistry, and in this section the set of teaching, learning, and assessment activities will be described with a goal of illustrating how a student-centred blended learning paradigm can effectively work to develop student comprehension and competency in biochemistry, and motivate students to achieve quality outcomes. The student cohort enrolled in this 2nd year biochemistry unit (LSB325 – Biochemistry) comes from multiple courses (Bachelor of Biomedical Sciences, Bachelor of Medical Laboratory Sciences, and Bachelor of Pharmacy). The combination of constructivist teaching strategies with an iterative process of reflection have established a blended learning framework that combines face-to-face teaching activities (lectures, tutorials, and laboratory classes) with asynchronous learning and teaching activities that are presented largely through the institutional online learning management system (Blackboard).

Regarding the case report presented in this paper, the face-to-face teaching and learning activities consisted of theory lectures, focused tutorials, and experimental practical classes, which amounted to 5 hours per week in most weeks of the teaching period. The assessment activities consisted of progressive assessment (40%) and invigilated examinations (60%). The progressive assessment comprised multiple formative assessment tasks, which also contributed to the summative assessment. Formative feedback on the continuous assessment was returned to the students with their mark. Marking and return of the formative feedback was provided in a timely manner (within a time frame of 2-3 weeks), so that students could act on the feedback to improve future performances. The invigilated examination component (60%) of this unit consisted of a mid-semester progress examination (15%) and a final examination (45%) in the end-of-semester examination period. The progress examination, although summative in nature, was also used as a formative assessment opportunity, in that a post-examination formative feedback tutorial session was held 2 weeks after the progress exam. In this session each question was analyzed and answered, and the context of the answer in the teaching and learning material, and the thought processes that should be involved in reaching the correct solutions to the questions were highlighted. Importantly, the teaching and learning activities were constructively aligned with the assessment activities and student learning is supported by feedback on the continuous assessment items, feedback on the progress examination, and through practice question banks uploaded to Blackboard.

Teaching and Learning Activities in a Blended Biochemistry Teaching Unit

Lectures (face-to-face) with lecture notes available online. Lectures still provide a meaningful and effective mode of supporting student learning (Bligh, 2000; Wolff, 2013) and this conjecture was endorsed by regular lecture attendance of between 50-60% of students. The lectures were supported by copies of the lecture notes (as slides and handouts in PDF format) posted to the Blackboard site at least 48 hours prior to the class time. Active, problem-based lecture models promote student engagement and attendance (Wood, 2009) and, in this context, the lecture model has been redesigned to incorporate a degree of active student engagement and interaction through the in-class formative assessments that build understanding of threshold biochemical concepts. These in-class formative exercises were not included in the lecture notes uploaded to Blackboard site, so students attending lectures would gain an enhanced learning experience.

Lecture podcasts (mp3) and Adobe Presenter presentations available online (Fig. 1). The decision to use educational podcasts in the biochemistry courses that the author teaches was driven primarily by the objective to provide downloadable online resources that support and reinforce the conceptual teaching and learning in biochemistry. Importantly, the podcasts summarized and emphasized the key learning concepts from the lecture material and complemented the lecture notes uploaded to Blackboard. The author has advanced the use of podcasting throughout the teaching of biochemistry and studied students' attitudes to the perceived usefulness and benefit of educational podcasts (Hartfield, 2009; 2011). The outcomes indicated that students readily accept and embrace educational podcasts to reinforce their learning and understanding in the area of biochemistry. Moreover, it is strongly evident that students perceive podcasting as a quality educational tool that offers convenience, flexibility, and portability (mobile learning), and that this overall experience enhances the study and learning environment. These findings are corroborated by other reports (Aguiar, Carvalho, & Carvalho, 2009). As a further development, the author has experimented with Adobe Presenter. Adobe Presenter is a plug-in for Microsoft PowerPoint that enables instructors and course developers to add audio narration, audio/slide synchronization, and interactive features to their presentations. Adobe Presenter compresses the file size of the presentation; converts each slide to a separate Flash file, thus making it extremely suitable for online delivery; and generates files that are easy to download and use online, deliver on CD, or viewed with Adobe Reader (version 9 or more recent).

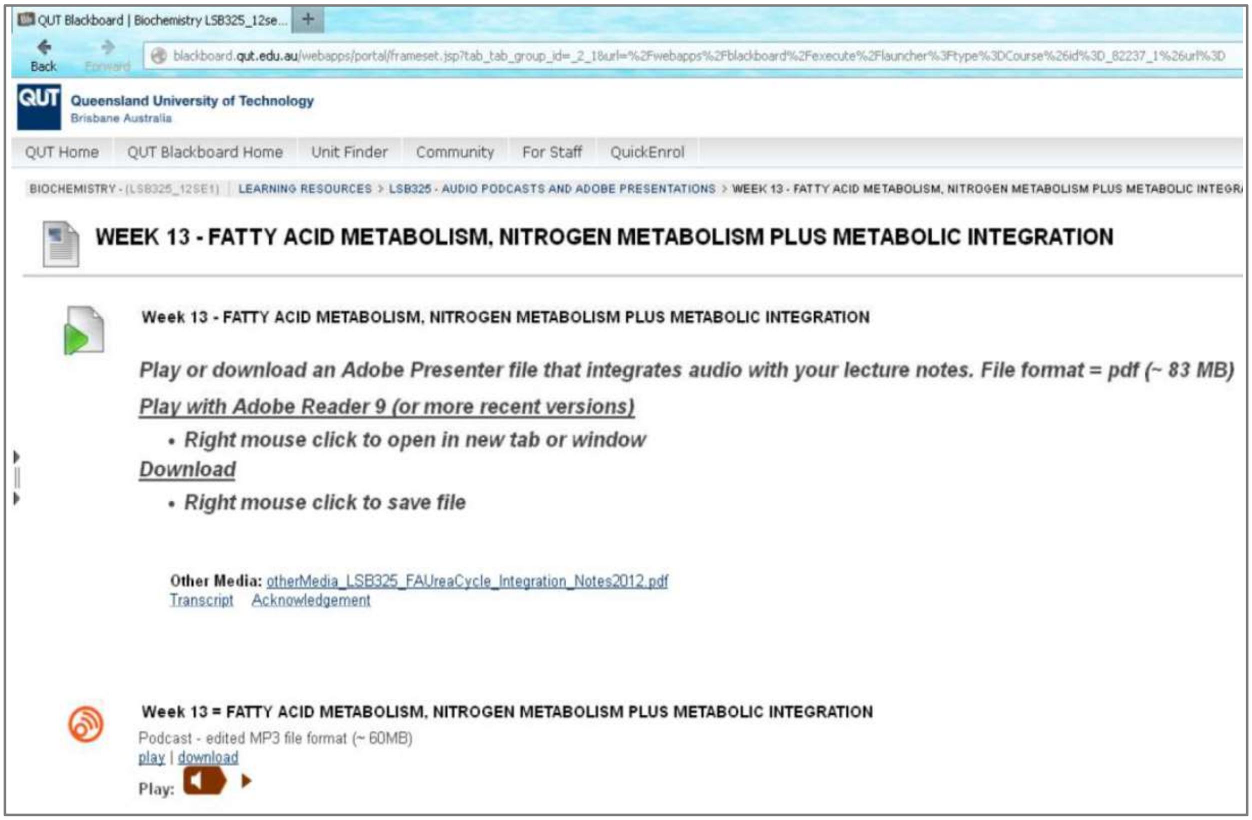

Figure 1. Screenshot of Blackboard folder containing an uploaded podcast and Adobe Presenter files as resources to support the introductory biochemistry lectures.

Class tutorials (face-to-face) to support exam preparation and completion of progressive assessment items. Tutorials played a major role in integrating the teaching and learning activities with the assessment activities. Tutorial sessions (5-6 one hour sessions) served to reinforce material presented in lectures, provide a forum for students to gain assistance with progressive assessment and revision for examinations, and provide formative feedback on the progress examination. Tutorials were optional and attended by 50-70% of enrolled students, depending on the topics being covered in the tutorial.

Practical laboratory classes with extensive practical support, data analysis, and data interpretation support available online. Biochemistry is a practical laboratory-focused discipline and, as such, the practical component was an integral part of the unit. Students attended weekly two hour practical sessions and were required to maintain an accurate and reflective practical notebook. The task of writing up the laboratory notebook was a major homework task that can be relatively time consuming for students. This component of the unit was part of the progressive assessment, and laboratory notebooks were inspected by tutors on a weekly basis and collected on two occasions during the semester for marking. The laboratory notebooks were returned promptly (usually 1 week) with formative feedback. Since a major part of the progressive assessment was embedded in the practical classes, online support for practical preparation, data analysis, and data interpretation on Blackboard was extensive.

Self-assessment multiple choice and short answer question quizzes available online. Multiple choice and short answer quizzes that related to the lecture content were posted on Blackboard every week. These allowed for formative self-assessment and revision before exams. Feedback and model answers were provided to students on Blackboard as a second file that is posted the following week.

Textbook resources, web-based animations, review of foundational concepts available online. At the start of semester, a review of pre-requisite foundational concepts for biochemistry was posted on Blackboard. Relevant textbook chapter resources were posted regularly on Blackboard to support student learning. These were downloadable resources and received a considerable number of online visits from the enrolled students. In addition, a number of web-based animations from external online sites that focused on major concepts and themes were made available (hyperlinks) to support student learning. The language, terminology and names of many molecules and biochemical processes is very specific to developing an effective knowledge and understanding of biochemistry, and it is possible that access to a glossary of biochemical terms could prove a useful aid for student learning.

Weekly announcements communicating information about teaching, learning and assessment activities (Blackboard and class emails). Announcements detailing administrative issues, the teaching and learning activities, and assessment due dates were posted regularly (at least weekly) via the Blackboard announcements page and through the group email list to keep all students informed and up to date with progress in the unit.

Overall, the teaching, learning, and assessment activities were designed in a constructively aligned framework, in such a way that student learning and understanding was developed and supported, and students were motivated to achieve quality outcomes with respect to grades through authentic assessment experiences. The effectiveness and success of these blended teaching, learning, and assessment approaches for introductory biochemistry were evidenced by the grade outcomes achieved by cohorts of students over the period 2010 – 2013 (Table 1).

Table 1. *Distribution of Grade Outcomes for Students Enrolled in Introductory Biochemistry (2010-2013)*

		Grade Outcomes (% of enrolled students)				
Year	**Cohort Size**	**Fail (<49%)**	**Pass (50-64%)**	**Credit (65-74%)**	**Distinction (75-84%)**	**High Distinction (85-100%)**
2010	193	1.6	16.5	41.1	31.8	9.0
2011	185	2.2	25.9	42.2	24.3	5.4
2012	184	6.5	25.0	34.2	25.0	9.3
2013	**129**	**1.6**	**25.6**	**31.8**	**37.1**	**3.9**

Conclusion

The teaching of biomedical science critically depends on practical laboratory-based learning activities. For this reason, teaching of biomedical science in a fully online mode is particularly challenging, and teaching approaches that blend face-to-face (synchronous) learning activities and asynchronous online learning activities may be the best way forward to establish active student-centred learning with the transformative potential of online learning tools and technologies. Many biomedical science educators are applying blended learning design to the delivery of their teaching, and this report has described the effective and successful delivery of an introductory biochemistry teaching unit using a blended learning approach that constructively aligns the teaching, learning, and assessment activities. Importantly, a blended learning teaching design facilitates access and personalization of student learning, develops student autonomy, and responsibility for self-directed learning, as well as flexibility to study in their own time and at their own pace using 'on demand' online learning resources.

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