Anywhere, anytime, with any device: scenario-based mobile learning in biomedical sciences

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Abstract: This paper reports on The Virtual Human Body (VHB), the latest project of a long running mlearning undertaking at The University of Queensland, Australia, in the use of scenario-based mobile learning in biomedical sciences. Improved learning outcomes coupled with enjoyable learning experiences suggests that the VHB is learning effective while offering active ‘anywhere, anytime, with any device’ learning opportunities. The project’s web-based design system allows the leverage of diverse, student-owned technology for academic benefit, permitting easy adaptation to new technologies, while literally providing a template for curriculum innovation, in terms of both flexibility of delivery, and dissemination to other curricula.

Keywords: mobile learning; interactive mobile learning; active mlearning opportunities; scenario-based mobile learning; biomedical sciences; emerging mobile technologies; smartphone interface.


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1 Introduction

Learning, as we have previously established (Ernst and Harrison, 2012), is an active process (Michael and Modell, 2003), and scenario-based learning is recognised as ‘active learning’ (Hwang et al., 2011a). Moreover, the efficacy of scenario-based learning in health science education is well documented (Hoffman et al., 2006, Thomas et al., 2009). The University of Queensland’s interactive scenario-based learning platform (SBLiTm) has a global uptake for scenario-based learning, and its effectiveness as a learning tool is well established (Breakey et al., 2008; Gossman et al., 2007).

Mobile learning is defined as learning that occurs at locations that are not predetermined, using mobile technologies (O’Malley, 2003). The widespread adoption of mobile learning technologies has facilitated the individualisation of student learning experiences, and diversification of instruction by teachers; it affords students access to multiple learning modalities, including interactive text; graphic, audio and visually-based resources; and offers the potential for multiple learning pathways (Looi et al., 2009). Indeed, in recent years the understanding of mlearning has changed: while the literature on mobile learning is both recent and modest (Koszalka and Ntloedibe-Kuswani, 2010), the use of technology to aid teaching and to engage learners is as old as the invention of the stylus.

There are multiple meanings and multiple understandings of the term ‘mobile learning’ (Traxler, 2007), and according to Wali et al. (2008, p.42), “many researchers rely on under-theorised conceptions of the topic, and those who have tried to refine the ideas involved have found this to be complex and difficult”. For the purpose of this project we propose that mobile learning “must view the learner as the one being mobile
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and not his/her devices! What needs to move with the learner is not the device, but his/her whole learning environment” (Laouris and Eteokleos, 2005), that “mobile learning [in biomedical sciences] can make valuable contributions to linking different learning environments” (Andrews et al., 2010, p.71), and that mobile learning is “part of a new mobile conception of society” (Traxler, 2007, p.5).

Consequently, the authors set out to design, develop and trial a scenario-based interactive touch-screen application for hand-held devices: a prototype template of a new web-based SBLiT™ interface for smart phones that offers active mlearning opportunities (Ernst and Harrison, 2012). We have previously found that both SBLiT™ versions offer high impact, active learning opportunities, and that the active mlearning version, utilising the SBLiT™ smart phone interface, was as effective as the desktop version (Ernst and Harrison, 2012). However, the SBLiT™ structure with its “Location”, “Items”, “Actions” and “Collection” windows, and similarly structured scenario-based learning tools, were found not to lend themselves for simple conversion to a mobile learning environment (Ernst and Harrison, 2012). Feedback pointed to difficulties accessing the SBLiT™ mobile prototype with a desktop-operated browser, and to general navigation difficulties. Ease of usage and navigability of mobile learning applications are instinctually vital. Thus we concluded that active mlearning opportunities in future are best offered by uncomplicated web-based mobile learning applications with a HTML and JavaScript touch screen interface (Ernst and Harrison, 2012).

Based on this conclusion, we migrated away from the SBLiT™ mobile prototype template and developed a new HTML-based touch screen interface for mobile learning in physiology, anatomy and pharmacology, the Virtual Human Body (VHB). As with the SBLiT™ mobile prototype, the VHB aims to offer high impact active learning opportunities (Kuh, 2008) away from formal teaching environments, and at times that suit the learner; the concept of ‘anywhere, anytime’ learning (Vinu et al., 2011), and with any device. Similarly, Wong and Looi (2011) stress the importance of making new technologies available across multiple portable and stable device types, to facilitate learning across multiple education opportunities (Wong and Looi, 2011). New information that can be “accessed or sensed anytime, anywhere and within any context” stimulates “sense making or sense creation”, and thus results “in facilitating more holistic seamless learning experiences and achieving more profound and sustainable learning outcomes” (Wong and Looi, 2011, p.2372).

Recognising the iterative nature of both curriculum development and delivery, and of technologies and their application to learning (Chance, 2010; Hwang et al., 2011a; Hwang et al., 2011b; Kranch, 2008; Muukkone and Lakkala, 2009; Taylor and Evans 2005), the aims of this project were to:

- To mobilise student demand for mobile learning, as evidenced by Andrews et al. (2009) and Andrews (2010), and the leveraging of diverse, but student-owned, technology for academic benefit using the project’s design of uncomplicated, easy to navigate web-based interfaces that ensures normalised access across handsets by working within the mobile browser environment;

- Recognise the near ubiquity of internet-enabled handheld devices using multiple operating platforms and systems (Johnson et al., 2012) and create active, high-impact, decision-based learning opportunities;

- Facilitate deep learning through consolidated understanding and application of learning in physiology, anatomy and pharmacology.
2 Method

The VHB was designed using the open source content management platform DotNetNuke. It detects the type of device and operating system that is accessing the VHB and automatically determines appropriate content modules, including multimedia elements (e.g., video and images), for each particular device type. This required the VHB to have two different formats of video for the same video content – one optimised for mobile devices, the other for desktop computers. The current VHB operates from the mlearn.science.uq.edu.au URL and requires the user to follow the official University of Queensland user authentication protocol.

It was introduced in semester one 2012 to second year health science students enrolled in BIOM2015 Physiology and Pharmacology of Human Disease (n=58) at The University of Queensland School of Biomedical Sciences as a review tool for students to prepare for the end of semester examination. However, word of mouth among the BIOM2015 students resulted in further students enrolled in other biomedical science courses (mainly DENT2052 Advanced Biomedical Sciences for Dentistry (n=72) and PHYL2062/63 Physiology I [for Physiotherapy and Speech Pathology] (n=224)) utilising the VHB as a review tool in preparation for their own, different end of semester examinations.

BIOM2015 Physiology and Pharmacology of Human Disease was a pathophysiology course that consolidated knowledge from ANAT1000 Systematic Anatomy for Health Sciences and BIOM1000 Physiology of the Human Body. The course offered physiology and related pharmacology specifically relevant to allied health professionals. Students were introduced to the physiology of major systems (nervous, respiratory, vascular, and endocrine) and how the process of ageing can disrupt these systems and lead to disease. Students were also introduced to common medicinal drugs used in the treatment of conditions mentioned in this course.

The VHB contained eight scenarios supported by multimedia resources and formative assessment tasks. All scenarios of the VHB complimented and expanded on existing prescribed texts and resources provided to students in the BIOM2015 Physiology and Pharmacology of Human Disease. The first scenarios explored anatomy and physiology in the context of blood pressure regulation and demonstrated how modern antihypertensive agents can be used to manipulate normal physiology. Specifically, students were faced with a person, who felt light-headed on standing up. Subsequently, students were directed through learning about the short-, medium- and long-term regulation of blood pressure, including the integrated roles of the baroreceptor reflex, and renin, angiotensin and aldosterone systems. In the subsequent scenario, the importance of blood pressure regulation was reiterated in the setting of hypertension. The hypertension scenario reinforced prior learning, and prompted students to explore the definition and long-term consequences associated with hypertension. Subsequent exploration of the mechanisms of action of commonly used medicines, including ACE-inhibitors, beta-blockers, calcium-channel blockers, and diuretics aimed to reinforce and challenge students’ understanding of previously learned knowledge and ensured the iterative nature of the scenarios. Similarly, asthma was used as a platform for respiratory anatomy, physiology and pharmacology teaching. Students hypothesised about causes of dyspnoea, and encountered graphic and text-based resources relating to the mechanics of breathing, physiology of gas exchange and pathophysiology of asthma. Knowledge acquisition was reinforced with interactive quizzes and pharmacology resources. Additional scenarios
pertained to regulation of metabolism through negative feedback loops, with a focus on blood glucose homeostasis. Here, the means by which disruption of normal regulatory mechanisms can manifest as diabetes mellitus was examined. Students extended their learning about diabetes to investigate acid-base homeostasis as it relates to diabetic ketoacidosis. Distractor hypotheses lead to pathways pertaining to anaemia, hypothyroidism, Cushing’s disease, alcohol intoxication, gastroenteritis, respiratory acidosis, lactic acidosis and renal tubular acidosis.

Each scenario commenced by presenting students with an action that elicited a response in the VHB. Alternatively, a sudden symptom (for example a headache or breathing problems) initiated a new scenario. Subsequently, students were presented with a number of hypotheses, as potential explanations for the initial response or symptom (see Figure 1), and asked to use physiological tools to test this. This pattern of “hypothesise, test and explain” was repeated, until the student reached the correct conclusion (see Figure 2). The distractor pathways of all hypotheses constitute authentic learning pathways in their own right, and encouraged learning related to the physiology of elevated intracranial pressure, head trauma, myocardial infarction and pulmonary embolus.

Figure 1 VHB commencement page of the diabetes mellitus scenario. The displayed image is an animated gif image illustrating the struggle of the depicted person to exercise (see online version for colours)
At various stages throughout the scenarios, students were presented with explanatory multimedia resources to complement the scenario, and were required to answer a series of formative multiple-choice questions (MCQs), in order to progress further. Similarly, students were offered a set of MCQs, to consolidate their learning at the conclusion of each scenario. As with the distractor hypotheses, all MCQ distractors were supported by detailed feedback, thus ensuring each MCQ constitutes an authentic learning activity.

Overall, the current VHB version contained 34 multimedia resources that complement the physiology and pharmacology taught in BIOM2015 Physiology and Pharmacology of Human Disease. Some multimedia resources also introduced the learner to physiological and pathological tests including measuring blood pressure by auscultation, glucometry, oral glucose tolerance testing, electrocardiography, spirometry, CT scans, and various blood tests. Most of these tests were practical components of BIOM2015 Physiology and Pharmacology of Human Disease, and its prerequisite BIOM1000 Physiology of the Human Body. These laboratory classes situated students learning, bridged the link between theory and practice, and provided a rationale for the relationship of the laboratory class to the aetiology of various disease states. Thus, they provided students with authentic learning experiences and taught health science-relevant skills. The multimedia resources utilised in the VHB that introduced these physiological and pathological tests were designed to reinforce these practical sessions. Transcripts of all multimedia resources were made available to the user, and all video files were playable either within the browser, or in extended full screen mode using the default video player of the device used (see Figure 3).
Quantitative evaluation was based on internet traffic statistics, student feedback on the perceived efficacy of active mlearning (online student questionnaire with five point Likert-type scales on SurveyMonkey embedded in the VHB), and on comparison of year-to-year learning outcomes as measured by course grade distribution. In addition, staff and student qualitative feedback on the VHB was sought throughout the project.

About half of the students that enrolled in BIOM2015 Physiology and Pharmacology of Human Disease in 2012, and in the previous year in 2011, also enrolled in NUTR2101 Nutrition Science at the same time. Thus, comparison of learning outcomes of this sub-cohort of students who enrolled both in BIOM2015 and NUTR2101 in 2011 to learning outcomes of this sub-cohort of students in both these courses in 2012 allowed a limited control for cohort variations between the years.
3 Results

The VHB was released on the 22\textsuperscript{nd} of April 2012. Between the release date and the end of the semester on the 23\textsuperscript{rd} of June 2012, 152 unique visitors visited the expended VHB a total of 384 times.

Table 1  Time on task by platform in 2012

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<th>Time on task by platform in 2012</th>
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<tr>
<td>Visits</td>
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<td>Pages/visit</td>
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<td>Average time on site</td>
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During this time in 2012, most visits were initiated from personal computers with a Windows operating system (52\%), followed by Macintosh devices (16\%) and Linux operated computers (3\%). Mobile devices accounted for 29\% of all visits. Of those, 80 visits were initiated by Android-based devices (72\% of all mobile device visits), followed by 24 visits initiated by iPhones (22\% of all mobile device visits). The remaining mobile device visits originated from iPads and Blackberry devices.

Twenty four students completed the online survey of the extended VHB in 2012. Of these, 20 students (83\%) owned a mobile phone capable of accessing the internet. The majority of surveyed students (66\%) used their mobile phone to access the internet daily. However, an equal percentage of surveyed students (66\%) accessed the VHB using their personal computer. In 2012, only 4 surveyed students accessed the VHB with their mobile phones.

The main reasons students gave for not accessing the VHB with their personal mobile devices were that they did not own an internet-enabled mobile phone, or that they did not wish to use their internet-enabled mobile devices for this learning activity. The surveyed students who did access the VHB with their mobile phone did so mostly via their own ISP. The principal location from which students accessed the VHB using their mobile devices was their private homes, followed by unspecified locations that allowed students short time frames for learning, for example while “commuting” or “waiting at the doctor’s surgery”.

All surveyed students in 2012 enjoyed the learning experience. Student feedback specifically praised the usability of the VHB with its uncomplicated, easy to navigate interfaces: over 70\% of surveyed students rated the VHB as “very user-friendly”. They also agreed that the VHB aided their learning of human physiology, and that the VHB has helped them prepare for the final examination. Over 70\% of surveyed students who did access the VHB using their personal computer still agreed with the statement that “Mobile learning applications such as the Virtual Human Body should be more widely used in university courses to aid to learning”.

Analysis of student performance as measured by summative assessment suggests that the number of students receiving a grade of 6 or 7 (on a 1–7 scale; 6 = distinction, 7 = high distinction) increased by 3\%, from 41\% in 2011 to 44\% in 2012, while the number of students receiving a grade of 4 or 5 (on a 1–7 scale; 4 = pass, 5 = credit) decreased by 10\%, from 48\% in 2011 to 38\% in 2012 (see Figure 4).

Student performance as measured by grade distributions of students who enrolled both in BIOM2015 Physiology and Pharmacology of Human Disease and NUTR2101 Nutrition Science in 2011 appears to be similar for both courses in that year (see Figure 5).
Figure 4  Percent grade distribution for BIOM2015 in 2011 (without VHB) and 2012 (with VHB), with $n=63$ (2011) and $n=55$ (2012); grade 1=fail, grade 2=fail, grade 3=fail, grade 4=pass, grade 5=credit, grade 6=distinction, grade 7=high distinction (see online version for colours)

Figure 5  Percent grade distribution for students enrolled in BIOM2015 (without VHB) and NUTR2101 in 2011, $n=22$; grade 1=fail, grade 2=fail, grade 3=fail, grade 4=pass, grade 5=credit, grade 6=distinction, grade 7=high distinction (see online version for colours)

Comparison of student performance as measured by grade distributions of students who enrolled both in BIOM2015 Physiology and Pharmacology of Human Disease and NUTR2101 Nutrition Science in 2012 suggests that performance by these students in BIOM2015 was slightly better than in NUTR2101 in that year (see Figure 6).
4 Discussion and conclusions

Internet traffic statistics reveals a good uptake of the VHB. However, the unexpected participation of students from other health science courses, although welcomed, does not allow us to measure participation rates based on tracking data. Mobile devices were used for almost 30% of all visits, which is similar to the mobile device traffic rate found in our original SBLiT™ mobile interface project (Ernst and Harrison, 2012). Interestingly, Android-based devices are now more common among the mobile devices used by students in this project. This may be due to cohort variations, but may also be partly the results of the recent increase of the market share of Android-based devices. According to a recent industry report, the market share of Android devices in Australia “has grown … from 32.2% in 2011 to 52% in 2012, while Apple IOS has fallen from 35.6% in 2011 to 35.3%” (Sadauskas, 2012). With about 30% of traffic originating from mobile devices we cannot not claim to have achieved our first aim of mobilisation of student demand for mobile learning, and the leveraging of diverse, but student-owned, technology for academic benefit. However, most recent findings are encouraging: mobile devices are now ubiquitous in business, communication, health, entertainment, and learning; both in terms of penetration (now at 127% in Australia), and in terms of data download volumes (PwC, 2013). Our own institutional data shows that 98% of students at The University of Queensland own and use smart mobile devices, and that the accessing of The University of Queensland’s institutional learning management system via mobile devices had quadrupled in the last year (Hendy et al., 2012).

About 16% of students who visited the VHB responded to the online student survey. It was hoped that the new iteration in 2012 would yield a greater survey participation rate as the new iteration itself is now universally accessible, which in turn has encouraged
higher uptake rates of this mlearning activity. In particular, students who accessed the VHB with their mobile devices are underrepresented in the survey. Tentative conclusions based on this limited student feedback include that students find the VHB user-friendly, that the VHB supports student learning of biomedical sciences, and that the VHB helps students to prepare for summative assessment. Further, students who only used their personal computer to access the VHB still perceive mobile learning applications such as the VHB as a desirable and beneficial component of their learning at university. In other words, students entertain, and habitually expect, to access learning resources anytime, anywhere and with any device. Solvberg and Rismark (2012) noted recently: “Students … make choices as to when they want to access the resources for learning purposes, where they will learn and how they will use the learning materials’ (p.24).” Do today’s students intuitively recognise – and opt for – what Wong and Looi (2011) call “holistic seamless learning experiences” (p.2372)?

The improved learning outcomes in 2012 as measured by grade distribution, while modest, may have been the result of students utilising the VHB for course content review and examination preparation. The VHB offers ‘anywhere, anytime, with any device’ active learning experiences. Thus, students were able to engage with the course content at times they desired, at places they preferred, and with a device convenient for them. As a result, students may have spent more time engaging with the course content. Moreover, the active mlearning activities of the VHB may have facilitated deep learning rather than surface learning that what would have taken place otherwise.

The student sub-cohort used to control for cohort variations between the years (students that were enrolled in both the physiology course and a nutrition course at the same time) did reveal a great cohort variation between 2011 and 2012. In 2012 these students seem to have achieved overall better learning outcomes when compared with the previous year. However, although these students achieved better learning outcomes in the nutrition course in 2012 compared with 2011, these students achieved even better learning outcomes in the physiology and pharmacology course in 2012 that included the VHB.

Questions used in summative assessment of BIOM2015 in both years were similar and aimed to assess understanding of core physiological and pharmacological concepts. While the use of identical questions with each cohort would have been ideal, the institutional policy of making public all past examination questions prevented this. Teaching staff and course content did not change between the years. Thus, improved learning outcomes in 2012 seem unlikely to be a consequence of variations in course content, staffing, delivery or assessment, with the exception of the VHB. Thus, while some of the observed differences between the 2011 and 2012 cohorts are likely to be due to differences between the cohorts, such as entry score, age, gender, and prior study, the overall improved learning outcomes in BIOM2015 in 2012 may also be attributable to the VHB given that the student sub-cohort used to control for cohort variations achieved better learning outcomes in the physiology and pharmacology course compared with the nutrition course.

We reaffirm that in the mobile learning environment, both the curriculum, and the technologies that support that curriculum, are iterative. The back end of the original SBLITM mobile interface was too maladaptive, forcing us to recognise the principle of platform ubiquity. This meant our learning activities needed to be scalable in order to be universally accessible. For instance, the current VHB version has two different types of video file for the same video content – one for mobile devices, the other for computers.
This is not a problem unique to mobile learning activities. In recent years traditional television broadcasters have had to shift to new viewing modes. In the process, they have discovered the need to scale their outputs for delivery on devices ranging in size from mobile phones to stadia screens (Zhou, 2012). Together, this convinces us of the benefit associated with the utilisation of a web-based design system that allows the leverage of diverse but student-owned technology for academic benefit. This permits simple and easy adaption to new technologies, while literally providing a template for curriculum innovation, in terms of both flexibility of delivery, and dissemination to other curricula.

In conclusion, the VHB seems to be effective learning while offering an enjoyable ‘anywhere, anytime, with any device’ active learning experiences, though students largely still preferred to access resources from their home device. However, the scenario-based VHB with its engaging mlearning resources also allows the establishment of a “flipped classrooms” approach (Brown, 2012; Stannard, 2012), and fosters the integration of learning into an increasingly mobile society.

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References


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