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Multimedia interactive eBooks in laboratory bioscience education

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ABSTRACT

Bioscience students in the UK higher education system are making increasing use of technology to support their learning within taught classes and during private study. This experimental study was designed to assess the role for multimedia interactive eBooks in bioscience laboratory classes, delivered using a blended learning approach. Thirty-nine second-year students on a Biomedical Science undergraduate course in a UK university were grouped using an experimental design into alternating trial and control groups and provided with pre-configured iPad tablet devices containing multimedia interactive eBooks. Data collection involved weekly surveys including quantitative and qualitative responses, and analysis of summative assessment marks. Analysis of the results using descriptive statistics methods showed that students made extensive use of eBooks in practical classes and over 70% of students agreed that the eBooks were beneficial for learning. However, less than 40% of students indicated a preference for eBooks over traditional paper protocols for practical-based classes. Although the eBooks were well used by students, they had no statistically significant effect on assessment marks. Overall, the study highlighted the positive feedback from students relating to multimedia interactive eBooks for supporting students' learning, but illustrated that there are other factors affecting adoption of new technologies.

Introduction

Blended learning

Technology has been heavily integrated into students' daily lives (Jones, Ramanau, Cross, & Healing, 2010). Increasingly, educational institutions provide students with digital learning resources to support face to face learning (Johnson et al., 2016). This approach, known as blended learning (Sharpe, Benfield, Roberts, & Francis, 2006), exploits learners increasing access to a broad range of technologies, such as laptop and desktop computers, tablet devices, smartphones and software applications (Chen, Seilhamer, Bennett, & Bauer, 2015; Littlejohn, Falconer, & Mcgill, 2008; Morris, Lambe, Ciccone, & Swinnerton, 2016). Blended learning is defined in various forms within the literature, but a useful working definition

is as follows: 'an appropriate mix of face-to-face and online learning activities, using traditional instruction, guided support and independent learning, underpinned by the use of digital technologies and designed using strong pedagogical principles, to support learner engagement, flexibility and success' (Morris & Laurillard, 2015). There are many blended learning approaches in operation within the higher education sector, ranging from provision of online supplementary resources, use of in-class technologies and use of digital communication and collaboration tools, through to use of technology to support assessment and feedback (Naismith, Lonsdale, Vavoula, & Sharples, 2004; Sharpe et al., 2006). Blended learning draws on a range of pedagogical approaches, including social constructivism, cognitivism and learner-centred activity (Beetham & Sharpe, 2013a).

According to the extant literature, benefits of blended learning include ease of access to information, flexible learning, collaboration, communication, engagement and improvements in educational attainment (Henderson, Selwyn, & Aston, 2015; Huang, Hu, & Yang, 2015; Morris et al., 2016). Students also benefit by learning key digital literacy skills, for example assimilating, recording and sharing information sourced online (Beetham & Sharpe, 2013b; Lopez-Fernandez & Rodriguez-Illera, 2009; Roussinos & Jimoyiannis, 2011).

Mobile learning

Mobile learning (m-learning) has been defined as, 'e-learning that uses mobile devices' (Pinkwart, Hoppe, Milrad, & Perez, 2003) and 'learning supported by mobile devices, ubiquitous communications and intelligent user interfaces' (Sharma & Kitchens, 2004). Through the increased availability, sophistication and use of mobile devices, m-learning has the potential to offer improved efficiency and effectiveness in teaching and learning, alongside improved learning outcomes and employability skills (Cochrane, 2011; Conde, Muñoz, & García, 2008; Fuller & Joynes, 2015). For example, studies describing the benefits of tablet computers illustrate positive student perception of the learning environment created by the devices, as well as positive effects on students' performance (Al-Emran & Shaalan, 2015; Enriquez, 2010; Morris et al., 2016). Pimmer, Mateescu, and Gröhbiel's (2016) review of 36 empirical studies of the outcomes associated with mobile and ubiquitous learning confirmed previous reviews that the majority of studies have found positive effects on learning, although they do add that most studies in this area are limited in that they involve the use of mobile learning as an instructionist approach.

However, there are also a number of studies noting that multi-tasking using mobile devices during class time can be disruptive to individual learning (Tossell, Kortum, Shepard, Rahmati, & Zhong, 2015) and to other learners in close proximity (Fried, 2008; Hembrooke & Gay, 2003; Sana, Weston, & Cepeda, 2013), and that use of digital technologies can encourage superficial learning (Henderson et al., 2015). Despite these drawbacks, increased use of technology in all aspects of life is growing rapidly, and, increased use of technology within the Higher Education system prepares students for the requirements of our knowledge-based society (Chatterton, Rebbeck Qtls, Rebbeck, & Jisc, 2015). However, there are still barriers to adoption of digital technology and blended learning approaches within the Higher Education sector, largely due to staff resistance and lack of infrastructure investment (Graham, Woodfield, & Harrison, 2013).

Role for eBooks in technology-enhanced learning

With the rise of software tools such as 'iBooks Author', teachers are now able to easily create interactive and multimedia digital eBooks for use on mobile devices (Glackin, Rodenhiser, & Herzog, 2014; Martinez-Estrada & Conaway, 2012; van der Velde & Ernst, 2009). Advantages offered by eBooks include easy access to on-demand content, interactivity, multi-modal content, loss/theft prevention, search functionality and low physical space requirements (Connaway, 2003; Denoyelles, Raible, & Seilhamer, 2015). However, despite these reported benefits, the 2013 ECAR study of undergraduate students and information technology found that there was no significant change in students' reading or study habits when provided with digital versions of textbooks (Dahlstrom, Walker, & Dziuban, 2013). It appears that added interactivity in eBooks has not necessarily been used by students simply because it is present, and print textbooks appear to be more popular with students than eBooks in most (Lam, Lam, Lam, & McNaught, 2009; Woody, Daniel, & Baker, 2010), but not all studies (Rojeski, 2012). Additionally, eBooks which are not significantly more personalised or outcome-focused are not as well received as traditional printed textbooks (Woody et al., 2010). There have been few studies evaluating the impact of teacher-produced multimedia interactive eBooks on student learning (Mikroyannidis, Domingue, Third, Smith, & Guarda, 2015), and this study offers important insights into student perceptions of interactive, multimedia rich eBooks.

Theoretical framework and research questions

Despite the potential affordances of eBooks to enhance student learning, there is little evidence of their impact on learning. Therefore, this empirical experimental study was designed to contribute to the body of knowledge about non-publisher-produced multimedia eBooks and to assess students' use and perceptions of eBooks in practical science classes. The underpinning theoretical model for the study was the Technology Acceptance Model (Davis, 1989), originating from the Theory of Planned Behaviour, and most recently described as the Unified Theory of Acceptance and Use of Technology (UTAUT). Davis' Technology Acceptance Model states that perceived usefulness (PU) and perceived ease of use (PeU) of a technology solution lead to positive attitudes, which in turn leads to an increased behavioural intention to use the technology (Davis, 1989). This model is now able to account for up to 52% of variance in usage intentions of new technology using the UTAUT model (Venkatesh, Bala, & Hillol, 2008; Venkatesh, Morris, Davis, & Davis, 2003). These findings provided the theoretical background to develop a study in which an easy to use and useful technology intervention could be tested with a student cohort, with the intention of investigating whether the cohort adopted the technology. UK-based higher education undergraduate science students on a practical training course were provided with tablet devices pre-configured with a range of apps suitable for learning, and containing a range of multimedia, interactive eBooks designed from paper-based practical schedules. An experimental mixed method research study was designed to assess the impact, if any, on students' assessment scores when provided with eBooks, compared to traditional paper-based practical schedules. It also assessed whether students' themselves perceived the eBooks as useful to their learning. Three primary research questions guided this research:

(1) When provided with multimedia-based interactive eBooks as a supplementary resource, to what extent do students use them and do they find them useful?

(2) Does the availability of eBooks in taught classes enhance students' perceived and actual learning of practical science?

(3) What factors impact students' adoption of eBooks during a short-term technology deployment?

Study methodology

Study design

All participants were second-year biomedical sciences students at the University of Leeds, and were selected from the same practical skills module, which lasted eight weeks. Second-year participants were selected due to research showing participants in this year of study are more amenable to altering their studying habits (Morris, Ramsay, & Chauhan, 2012). Ethical permission for the study was provided by the University of Leeds Research Ethics Committee. Thirty-nine of 43 participants enrolled on the module agreed to take part in the study. All participants were inducted into the study via written information and a training session. The research design followed an experimental approach and participants were randomly split into two groups: group A ($n = 17$) and group B ($n = 22$). All participants had similar prior academic achievements and had not worked in these groups, or had significant contact with multimedia interactive eBooks, prior to the intervention. Groups attended practical classes on Mondays (group A) or Thursdays (group B) throughout the module. Participants in each group received iPads for separate four-week trial periods – group A received devices for the initial four-week period of the module. Group A used iPads for the 'Immunofluorescence' (weeks 1–2) and 'Cutaneous Testing' (weeks 3–4) practical classes, whilst group B used iPads for the 'Snail Brain Electrophysiology' (weeks 5–8) practical class. During each group's trial period, each participant had full ownership of an iPad and was allowed to take it home.

To assess any difference in assessment outcomes when students were using eBooks and tablet devices, assignment scores were compared. For the immunofluorescence and cutaneous testing assignments, group A used eBooks and served as the trial group, whilst group B served as the control group. For the snail brain electrophysiology practical assignment group B used eBooks and served as the trial, whilst group A served as the control group. In both cases, students in the trial group had access to a digital version of the practical schedule on the Virtual Learning Environment (VLE), and students in the control group had access to all multimedia and quiz elements used in the eBooks as individual learning objects within the VLE.

Participant demographics

There were 27 females and 12 males. Participants ranged from 18 to 25 years old; the mean participant age was 20.3 ± 1.3 years and there was no statistically significant difference in age between the groups. Group A ($n = 17$) contained 12 females and 5 males, whose average age was $20.4 \pm .4$ years. Group B ($n = 22$) contained 15 females and 7 males, with an average age of $21 \pm .2$ years.

Production of eBooks

eBooks were produced from pre-existing printed practical schedules using the 'iBooks Author' program on an Apple Macintosh computer. When producing the eBooks, the practical schedules (largely text-based) were supplemented with interactive multimedia elements (e.g. images and instructional videos) and interactive, multiple choice question (MCQ) quizzes, using principles of instructional design. The eBooks were checked by the academic responsible for the practical, and tested by a small number of participants before use in the trial. The eBooks are freely available online as Open Educational Resources (see: https://store.jisc.ac.uk/#/resource/8177 and /8176 and /8178).

Device configuration

The study made use of 25 Apple iPads (1st generation, 16gb, Wi-Fi and 3G). The eBooks were pre-loaded on to the devices, along with a total of 30 educational and social networking apps. The purpose of each app was either organisation, learning resources, communication and collaboration, studying aid or functionality. Devices were locked, preventing students from adding additional apps, in order to keep their usage mainly educational; however, as browsers were not controlled, students could access any web content via the Internet. Between the two trial periods, iPads were re-configured, wiped of personal data and re-loaded with eBooks relevant to group B's practical classes. Links to surveys used for data collection were added to the home screen of each device.

Instruments

Two survey instruments were developed and piloted with a small number of individuals ($n = 3$) before deployment to the study sample groups. The first survey containing three questions relating to demographics and course details, and seven multiple part, multiple choice questions relating to participants' opinions on the value of technology in education and current technology usage was administered at the outset of the study. The survey included statements about use of technology with Likert style multiple choice responses (see Table 1 for details) The second survey related to eBook usage and was administered at the end of each weekly practical class; it contained 11 multiple part, multiple-choice questions and one open question and collected participants' opinions on the design, components, and use of the eBooks. The open question related to problems using the eBook and how it might have been improved, the results of which will be used to discuss other factors which impact on the adoption of new technologies.

Data collection

Data were collected from participants in the trial group in the form of surveys (described above), and scores from practical assignments. Participants provided data voluntarily and anonymously. Participants completed the initial demographic survey once at the start of the trial and completed the eBook usage survey at the end of each weekly practical class. Practical assignment scores were collected after marking by the relevant academics. All data were collected using only participants' student ID numbers in order to protect their privacy

Table 1. Participants' opinions on the usage of technology in their learning.

Area of usage	Overall (n = 39)	Group A (n = 17)	Group B (n = 22)
Used a mobile device at least 1–3 times a week for study purposes (6 pt Likert 'Every day' to 'Never')	64% (25)	64.7% (11)	63.6 (14)
Experienced with tablet devices (5 pt Likert 'Very experienced' to 'Never used before')	46% (18)	47.1% (8)	45.5% (10)
Own a tablet device (Yes/No)	28.3% (11)	29.4 (5)	27.2 (6)
Used own tablet device for study purposes at all (5 pt Likert 'More than 60 min a day' to 'Never')	73% (8; total n = 11)	80% (4; total n = 5)	66.7 (4; total n = 6)
Use online search engines regularly for study purposes (6 pt Likert 'Every day' to 'Never')	97% (38)	94% (16)	100% (22)
Used Leeds VLE regularly for study purposes (6 pt Likert 'Every day' to 'Never')	100% (39)	100% (17)	100% (22)
Used Microsoft Office suite regularly for study purposes (6 pt Likert 'Every day' to 'Never')	85% (33)	77% (13)	91% (20)
Used email regularly for study purposes (6 pt Likert 'Every day' to 'Never')	87% (34)	88% (15)	86% (19)
Used multimedia resources regularly for study purposes (% SA/A) (5 pt Likert 'Strongly Agree' to 'Strongly Disagree')	67% (26)	71% (12)	64% (14)
Online quizzes with feedback enhance learning (% SA/A) (5 pt Likert 'Strongly Agree' to 'Strongly Disagree')	97% (38)	94% (16)	100% (22)
Online learning resources should be more interactive (% SA/A) (5 pt Likert 'Strongly Agree' to 'Strongly Disagree')	87% (34)	82% (14)	91% (20)
It is hard to find suitable software applications to support learning (% SA/A) (5 pt Likert 'Strongly Agree' to 'Strongly Disagree')	85% (33)	76% (13)	91% (20)
Don't need technology to learn (% SA/A) (5 pt Likert 'Strongly Agree' to 'Strongly Disagree')	10% (4)	6% (1)	14% (3)
It takes too long to learn how to use software (% SA/A) (5 pt Likert 'Strongly Agree' to 'Strongly Disagree')	18% (7)	18% (3)	18% (4)
Laptops are too bulky to carry around campus (% SA/A) (5 pt Likert 'Strongly Agree' to 'Strongly Disagree')	77% (30)	71% (12)	82% (18)
Tablet devices are too expensive for students to purchase (% SA/A) (5 pt Likert 'Strongly Agree' to 'Strongly Disagree')	67% (26)	53% (9)	82% (18)
Participants should be issued with a device loaded with all resources need for learning at the start of their degree programmes (% SA/A) (5 pt Likert 'Strongly Agree' to 'Strongly Disagree')	72% (28)	59% (10)	77% (17)

and maintain anonymity. Participants were asked to provide data through weekly eBook surveys to assess any changes in their perceptions, behaviours and usage of eBooks over the trial period. Responses from week 4 of both groups were omitted due to poor compliance.

Device distribution

Devices were issued to participants at the beginning of their respective trial periods, along with a charger and protective cover. Participants also completed consent forms and iPad release forms. At the beginning of each trial period, a presentation was given to the participants highlighting the aims of the study, the potential uses of the device for learning and practical instructions on using the device.

Data analysis

Participants completed surveys using links installed onto each iPad. These data were collected using a secure survey tool called 'Bristol Online Surveys', and manipulated and coded using Microsoft Excel. Multiple choice questions were coded by applying a value to each response (e.g. Strongly agree = 5, Agree = 4, No Opinion = 3, Disagree = 2, Strongly Disagree = 1), and calculations of % agree are presented. Where appropriate, data are presented as median or mean ± standard deviation. Coded data were analysed using IBM SPSS version 22. Data were checked for normality using the Shapiro–Wilk Test (SPSS) and where possible data from both groups were aggregated. The Chi-squared test was used to test for statistical differences within categorical [survey] data, and the unpaired t test was used for numerical data (e.g. examination marks). Surveys were analysed for reliability using Cronbach's Alpha (demographic survey alpha = .67; eBook survey alpha = .74). Cronbach's Alpha is acceptable for the ebook survey but is bordering acceptability for the demographic survey (George & Mallery, 2008), and should be borne in mind as a potential limitation of the study. Qualitative responses in surveys were analysed manually by coding responses and sorting these into themes, using inductive thematic analysis (Boyatzis, 1998). This consisted of adopting a bottom-up approach, of reading through the 13 responses to develop themes, which were then applied to all responses. When reporting overall data for eBooks, participants' responses were averaged over the two or three weeks of the trial (i.e. there were a total of 55 responses: $n = 22$ electrophysiology, $n = 15$ cutaneous; $n = 18$ immunofluorescence). When reporting data across weeks of the trial, each participant's weekly responses were analysed separately (Table 3).

Results and discussion

Tablet experience and current technology usage

Results from the technology usage survey ($n = 39$) illustrated that participants were already making significant use of mobile devices to support learning (see Table 1), with 28.3% owning a tablet device, and the majority (77%) agreeing that laptops were too bulky to carry to campus. Participants were regular users of online search engines, the institutional VLE and Microsoft Office software (Table 1), but made less use of multimedia resources (e.g. YouTube) to support learning. Generally, participants had existing experience of using

Table 2. Participants use of the eBooks.

		eBook			
		All eBooks (n = 55)	Cutaneous (n = 15)	Immunofluorescence (n = 18)	Electrophysiology (n = 22)
Total time eBook	Median	15	15	15	27.5
used	Average	32.6 ± 25.1	28.5 ± 23.1	27.5 ± 17.3	39.4 ± 30.6
Video time	Median	5	5	5	9.2
	Average	7 ± 4	5.3 ± 1.3	5.3 ± 1.2	9.6 ± 5.4
Slideshows	Median	8.3	5	10	5
	Average	10.3 ± 7.2	9 ± 5.4	10.8 ± 6.5	10.7 ± 8.9
Text	Median	10	5	10	5
	Average	12.7 ± 9.7	13.3 ± 11	11.8 ± 6.7	13 ± 11.1
Quizzes	Median	5	5	5	5
	Average	6.6 ± 3.7	6 ± 3.9	7.5 ± 4.3	6.4 ± 3.2

Notes: These four questions asked participants for how long they had used the eBooks each week, using a 5 pt Likert scale from '0–10 min' to '41 min and over'.

mobile devices and believed that technology supported and enhanced their education, particularly when resources included quizzes and interactivity (Table 1). There were no statistically significant differences (Chi-squared test) between participants' responses from Group A and B in the technology usage survey.

The majority of participants used tablets or mobile devices at least 1–3 times a week to help them study – integration of technology into their daily lives and studies is readily apparent as has been noted previously in the literature (Jones et al., 2010; Morris et al., 2016). Participants did not make extensive use of tools such as referencing software and specialised learning apps – preferring instead to take a more 'generalised' approach towards using familiar tools in their studies (Lam, Lee, Chan, & Mcnaught, 2011; Lam, McNaught, Lee, & Chan, 2014). The majority of participants' opinions towards the use of technology in education were positive. In particular, participants expressed the opinion that they need technology to help them learn and that they would prefer more interactive online resources, in line with previous studies (Dahlstrom et al., 2013). In particular, participants perceived online quizzes as very useful learning tools.

Usage and perceptions of eBooks

Overall, participants reported using the eBooks during practical classes for a median time of 15 min (range 10– 83 min; average 32.6 ± 25.1 min; n = 55; Table 2). There were no statistically significant differences between the overall times each group spent on the eBooks (t test; Table 2). Also, there were no statistically significant differences between times spent on individual components (videos, slideshows, text, quizzes) within the eBooks (median between 5 and 10 min; Table 2). The overall time spent using the eBooks reduced over the course of the trials and was not statistically significantly (data not shown).

Participants' views about the quality of the eBooks were generally positive over the trial period (Table 3), with the majority of participants agreeing that they were useful and informative (69%), enjoyable to use (65%), well designed (85%) and easy to navigate (65%). There were no statistically significant differences (tested using Chi-squared test) in participants' views between the eBooks or between weeks (Table 3). Encouragingly, over 70% of participants indicated that eBooks were beneficial to their learning (Table 3). However, participants

Table 3. Participants' perceptions of eBooks by eBook and by week.

Statement	Overall all eBooks % (n)*	eBook^	By participant % (n)	Week 1 all eBooks % (n)	Week 1% (n)	Week 2 all eBooks % (n)	Week 2% (n)	Week 3 all eBooks % (n)	Week 3% (n)
I found the eBook very useful and informative	69 (55)	E'phys	73 (22)	90 (40)	93 (15)	74 (35)	86 (7)	n/a	56 (16)
		Cut	53 (15)		78 (9)		62 (13)		n/a
		Immuno	78 (18)		94 (16)		80 (15)		n/a
I found the eBook useful and enjoyable to use	65 (55)	E'phys	73 (22)	78 (40)	93 (15)	74 (35)	86 (7)	n/a	63 (16)
		Cut	60 (15)		56 (9)		77 (13)		n/a
		Immuno	61 (18)		75 (16)		67 (15)		n/a
I found the design of the eBook attractive	85 (55)	E'phys	82 (22)	95 (40)	100 (15)	91 (35)	86 (7)	n/a	81 (16)
		Cut	87 (15)		89 (9)		92 (13)		n/a
		Immuno	89 (18)		94 (16)		93 (15)		n/a
I found it easy to navigate through the eBook	65 (55)	E'phys	55 (22)	80 (40)	80 (15)	80 (35)	71 (7)	n/a	56 (16)
		Cut	73 (15)		78 (9)		85 (13)		n/a
		Immuno	72 (18)		81 (16)		80 (15)		n/a
I found it preferable to use the eBook over a paper protocol	33 (55)	E'phys	41 (22)	43 (40)	53 (15)	37 (35)	43 (7)	n/a	44 (16)
		Cut	20 (15)		44 (9)		31 (13)		n/a
		Immuno	33 (18)		31 (16)		40 (15)		n/a
I think that the addition of using eBooks in future laboratory classes would benefit my learning	73 (55)	E'phys	73 (22)	75 (40)	80 (15)	83 (35)	86 (7)	n/a	69 (16)
		Cut	67 (15)		67 (9)		69 (13)		n/a
		Immuno	78 (18)		81 (16)		87 (15)		n/a

*% = % agreeing or strongly agreeing with the statement, n = sample number.
^Abbreviations: 'e-phys' – Electrophysiology eBook; 'Cut' – cutaneous testing eBooks; 'Immuno' – Immunofluorescence eBook.

did not show a strong preference for using the eBooks over paper protocols; overall, an average of 33% of students agreed that eBooks were preferable to paper protocols (Table 3).

Previous findings have suggested that eBooks need to offer students a clear learning advantage if they are to be of value (Connaway, 2003; Lam, Lam, & McNaught, 2010). In this study, multimedia and interactive components were incorporated into the design of each eBook, at points at which they were considered to support conceptual understanding, improve knowledge retention and support skills training. Participants used all of interactive components in each eBook – highlighting their openness to interactivity, especially when appropriately structured around specific elements of each practical, and they agreed that the eBooks were well-designed and easy to navigate. However, the results showed that this interactivity is not necessarily used simply due to its presence: an average of 33% of students preferred eBooks to the paper protocols, presumably highlighting participants' tendencies to revert to a more traditional resource where this interactivity does not offer enhanced benefit (Denoyelles et al, 2015; Woody et al., 2010). These findings are possibly explained by students' need to adapt to both a new format and a new reading process, or may reflect their indifference to technology-enhanced learning approaches (Carliner, 2010). Well-designed eBooks use principles of instructional design to provide clear and useful information to readers in a well-structured, accessible and appropriate fashion (Chong, Lim, & Ling, 2009; Lonsdale & Armstrong, 2010). In this study, resources were provided in multiple formats (e.g. text and multimedia form), and multimedia was used to enhance understanding of conceptual information, provide detail and give examples; benefits which have been identified by students in other studies, alongside flexibility in time and place (Henderson et al., 2015) . Chong et al. showed that adopting these principles has a positive impact on readers' use of eBooks (Chong et al., 2009). Therefore, in line with other studies, this research suggests that interactive resources such as eBooks should support and not replace traditional protocols.

Impact of eBooks on academic performance

For each practical (and subsequent assignment) in the module, one group had access to an eBook and tablet device (trial group), and the other group did not (control group). The trial and control groups swapped half way through the module to ensure equity of experience for the students involved in the study. Therefore, it was possible to compare the assessment scores for assignments completed by students using eBooks and tablet devices to support their learning, versus students who only had access to paper-based resources and VLE materials. When tested using a Student's unpaired t test, there was no statistically significant difference between the assignment scores between trial and control groups for any of the assignments in the module. For the immunofluorescence assignment, the average mark of group A (trial group) was 79.5 ± 11 ($n = 17$) and for group B (control group) the average mark was 79.6 ± 11.5 ($n = 22$; $p > .05$). For the cutaneous sensitivity assignment, the average mark of group A (trial group) was 62.9 ± 12.5 ($n = 17$), and the average mark of group B was 65.1 ± 6.6 ($n = 22$; $p > .05$). For the snail brain electrophysiology assignment, the average mark of group B (trial group) was 63.3 ± 7.2 ($n = 22$), and the average mark of group A (control group) was 62.0 ± 6.2 ($n = 17$; $p > .05$).

This study demonstrated that providing students with eBooks did not enhance assessment marks, which were very similar between both sets of control and trial groups. Given that

the eBooks were offering supplementary material to that already available, and provided content in alternative formats (e.g. multimedia), changes in assessment marks may not have been expected. Data collected during the study demonstrated that students found the eBooks useful during the classes, and students with access to eBooks did not do any worse in assessments than students using traditional, paper-based resources.

Participants' qualitative responses about eBooks

As part of the eBook survey participants were asked to identify problems with using the eBooks and suggest improvements to their design and construction. Thirteen qualitative comments were received over the course of the trials, and these were coded within three main themes: usability, usefulness and teacher involvement. Within the theme of usability, there were six comments: three were about the speed of the eBook software on the device:

> 'It was quite slow at loading the slides.'
> 'It's really slow when trying to navigate and find slides quickly'
> 'It was a bit slow to start up and move between the slides.'

The other three comments around usability were on specific issues of using the eBooks:

> 'I also found it difficult to start using the integrated slideshow because the pages on the eBook kept moving instead of the slides in the slideshow'
> 'Some spelling, grammar errors made some slides confusing'
> 'Takes getting used to!'

Within the category of usefulness, there were five comments. Three of these stated that the eBook wasn't as useful as the paper protocol, and the other two related to not using the eBook:

> 'I did not use the ebook in today's session'
> 'Just wasn't as useful as a paper protocol'
> 'No problems, just didn't feel the need to use it'
> 'No problems, I just didn't use the ebook for this lab as the protocol really simplifies the experiment'
> 'I prefer to have a paper protocol in practical sessions'

Within the category of teacher involvement, there were two comments which suggested that there should have been more encouragement from the teachers to use the materials in the eBooks as part of the practical class:

> 'Have the lecturer ask us to refer to the ebook more as we plainly used the lecture slides on the vle.'
> 'We should be encouraged to use them more.'

Whilst these comments are necessarily negative (due to participants being asked to identify problems with the eBooks) they are usefully instructive about how to drive up adoption of eBook technologies within the student population.

Conclusion

This study provides much needed data about the value of eBooks for students' learning in Higher Education settings. Overall, returning to the first research question, the trial indicated that participants valued the addition of multimedia interactive eBooks as a resource

to enhance their learning and studies, but not as a replacement to existing paper-based learning resources. In relation to the second research question, the data presented in this study suggest that the availability of multimedia interactive eBooks in class were perceived by participants to be beneficial to their learning. However, whilst students perceived them to be beneficial to their learning, there was no evidence of an improvement in assessment marks during this study. With respect to the third research question posed as part of this study, a number of factors appeared to contribute to students' willingness (or otherwise) to adopt eBooks during this short-term deployment, in line with findings from recent technology adoption studies (Venkatesh et al., 2008, 2003). Primarily, students made judgements about the usefulness of the eBook over the paper-based resources when planning their approach; the majority of students reverted to the traditional paper-based resources. These judgements were probably based on their prior knowledge and experience, their engagement with the learning activity and their desired outcomes. These views are in line with earlier studies and have been particularly evident in students' usage of mobile devices (Dahlstrom et al., 2013). Also, adoption of the eBooks appeared to rely on the usability of the eBook; whilst overall the participants reported that they were easy to navigate, qualitative feedback indicated that the usability of the eBook was sometimes problematic. Finally, adoption of the eBooks appeared to rely on strong support from academic teachers; some participants actively requested the teacher to encourage them to use the digital materials. This is particularly important due to the fact it has been suggested that the development of innovative pedagogies depends on teachers' interpretation of the value of the technology (Price & Kirkwood, 2013) and that there is a correlation between technology integration and teacher variables such as belief in the technology's usefulness (Sang, Valcke, van Braak, Tondeur, & Braak, 2010). Without an evidence-based understanding of the learning gains, many teachers are reluctant to implement educational technology into their courses, since the simple addition of technology to educational environments does not necessarily improve learning.

In conclusion, this study illustrates that technology implementations need careful consideration before deployment, to understand the intended learning benefit, the pedagogic rationale, student training needs and practical considerations. The results of this study provide us with valuable insight into how the implementation of tablet devices can be optimised to enhance student learning maximally.

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