

Capturing dynamic presentation: Using technology to enhance the chalk and the talk

Sven Venema and Jason M Lodge
Griffith University, Australia

Despite rapid changes in the ways in which university courses are being delivered, lectures have remained a common feature of many courses. The lecture is problematic for many reasons, not the least being that it does not encourage interaction. The current project attempted to address this problem by implementing 'digital ink' into lecture sessions. The approach used in this study is innovative because the handwritten component of the content was written on top of content created in advance and presented in PDF form. The response from students was overwhelmingly positive. During the course of the implementation, a number of teething problems were encountered; suggestions for overcoming these problems and future enhancements are also discussed. Digital ink provides a potential avenue for increasing interaction in lecture sessions whilst not limiting the capacity for capturing all aspects of the session.

Introduction

Higher education is currently facing a period of rapid change. Technology is forcing a re-evaluation of many pedagogical methods that have been prevalent in universities for centuries. The current edition of the Horizon Report (Johnson, Adams, & Cummins, 2012) highlights a number of factors that are leading to unprecedented changes in the delivery of higher education in the near future. Fundamental changes in the ways in which students engage with information and manage their studies whilst living increasingly busy lives are creating substantial challenges for traditional pedagogy. Of particular concern is that economic and institutional forces are creating substantial barriers to the development of new modes of learning in these settings (Johnson et al., 2012). The project presented here is an attempt to bridge the widening gap between traditional pedagogy and new modes of learning.

As higher education has evolved over time and new techniques and technologies enter into consideration and common use, one practice remains unchanged – lectures. So long as students continue to come to campus to study and both physical and academic resources remain finite, lectures are likely to continue to feature in higher education for some time to come. While a wide range of technological enhancements have been made in terms of the experience of on-campus students (c.f., Ellis, Ginns, & Piggott, 2010), beyond the use of presentation tools such as Microsoft PowerPoint, little enhancement has been made to the delivery of lectures (Deslauriers, Schelew, & Wieman, 2011). With lectures increasingly falling out of favour but at the same time continuing to be necessary under some circumstances, a lack of innovation is stifling the effectiveness of this teaching mode.

That is not to say that there have not been developments in the way 'slideware' (i.e., presentation tools such as Microsoft PowerPoint and Apple Keynote) are being utilised in lectures. Over time, these tools have moved lectures further away from traditional 'chalk and talk' pedagogy towards a more immersive multimedia experience. Apperson, Laws, and Scepansky (2002) assessed student perceptions of increased multimedia use in slideware presentations and found that students generally perceive the use of slideware as helping to increase their interest in the content and making the content clearer (see also Tangen et al., 2011). This suggests that these moves have had a positive impact on the student experience of lectures and imply that effort spent on innovating lectures can have constructive outcomes for students.

Although there have been extensive developments in the way slideware is being used in lectures, the use of these tools has not always been effective and might partly explain why the lecture is becoming less useful for students. For example, slides that include large volumes of text are distracting and multimedia content that does not directly relate to the learning outcomes interferes with learning (Tangen et al., 2011). Scott (2011) suggests that handwritten aspects of the traditional pedagogy, the 'chalk' if you like, have benefits that are difficult to replicate using the very linear approach to presenting content enforced

by slideware. Thus, despite the potential for slideware to enhance the lecture experience for students, these technologies are not always applied in the most effective ways. For example, Bartsch and Cobern (2003) found that excessive use of pictures and sound effects in slideware presentations is detrimental to later test performance. The benefits of the more traditional techniques have been replaced by methods with uncertain pedagogical merit. In other words, the introduction of multimedia presentation using slideware does not lead to reliable improvements in learning outcomes (Apperson et al., 2004).

Context

Within the context of these broader issues concerning the ways in which lectures have evolved over time, there are also some discipline-specific issues that impact on the effectiveness of lecture presentations. In some disciplines, it is more effective to create dynamic diagrams and other handwritten content during a lecture. For example, Scott (2011) argues that written equations, charts and diagrams create effective dynamic presentation of the content of economics courses that cannot be delivered in the same way using slideware. It is therefore reasonable to suggest that this could be the case for other disciplines where handwritten displays are beneficial, and are still used extensively.

Although it is useful to create diagrams and drawings during lectures, the use of a whiteboard creates several difficulties. The first of these is that the lecturer spends a substantial proportion of the lecture session with his or her back to the class and can often write in a way that is difficult for students in all parts of the room to see, either due to the size of the text, choice of colour, or the legibility of the lecturer's writing. These issues create difficulties in maintaining engagement with the class. One of the most basic principles of good presentation technique is to face the audience and maintain as much eye contact as possible (c.f., Race, 2007). Writing on a whiteboard (or blackboard) in a lecture does not always effectively allow this to happen (Exley & Dennick, 2009) and the 'whiteboard and talk' method is therefore not ideal. Again, this is an issue that decreases the effectiveness of lectures and thus could be contributing to the demise of the lecture as a way of engaging students.

A second complication associated with presenting handwritten content in lectures arises due to the difficulty in capturing content written on a whiteboard. Many institutions either encourage or require some form of lecture capture via podcasting or 'videocasting' etc. This is no doubt in part due to increased emphasis on flexible delivery of course content (Woo, et al., 2008). The difficulties arise because it is often expensive to record a lecture session using video production beyond screen capture and any session including slideware and content written on a whiteboard is either omitted completely or is difficult to see unless it is recorded by a competent camera-person. This only adds to the cost of complete capture of hand-written and slideware presentations.

Other technologies might provide possible solutions to these issues. Of these, the most promising appears to be 'digital ink'. Iribe, Nagaoka, Kouichi, and Nitta (2010) successfully used hand-drawn diagrams and notes on presentation slides and found that this supplementary information improved learning. In order to determine whether such an approach would be useful within a lecture, an alternate mechanism for delivering and recording handwritten content was introduced into a first year computer architecture and networking course. The following discussion explains the current delivery methods used in this course and focuses on the outcomes of implementing a USB writing tablet as an additional tool for delivering content in lectures. The project reported here therefore has dual aims, to firstly discuss some of the challenges in implementing technology such as 'digital ink' into lectures and, secondly, to provide a preliminary report on the effectiveness of the implementation of this technology. The overarching aim is thus to provide a foundation on which academics and educational developers can consider implementing similar innovations in response to challenges in their own contexts.

Current design

The USB writing tablet was implemented in a first year computer architecture and networking course undertaken by information technology and multimedia students at an outer metropolitan university in Australia. The course is offered concurrently across three campuses and is a core subject for students studying the Bachelor of Information Technology.

The learning aims of the course are to give students the necessary theoretical and mathematical foundations to allow them to progress to more advanced courses, particularly those related to programming. Laurillard (2002) suggests that one of the main goals of academic learning is to give students the opportunity to reflect on their own experiences in order to come to an understanding of the way the discipline knowledge is represented. In the course that is the focus of this study, students learn about literacy and numeracy as well as the underlying structure and operation of a modern computer. An example of the learning objectives is to develop an understanding of computer software/programs and how they are executed in the context of the underlying hardware and operating systems.

The course is delivered in a number of different formats. All students are required to attend lectures to cover the theoretical content and laboratory sessions for covering applied aspects of the course content. The assessment is currently separated into four parts, involving a weekly in-class assessment of laboratory work, a small computer architecture design project, two in-lecture quizzes at the start and end of semester, and a final examination.

The specific lecture sessions that are being analysed cover the theoretical content of the course in a large group setting. The applied aspects of the course are covered in detail in laboratory sessions so the lectures are heavily weighted in favour of theory and use a discipline-based or traditional method according to Toohey's (1999) outline of different teaching approaches. A specific example will be used as a representative course aim for the purpose of the current proposed implementation. The specific learning objective that will be discussed is the synthesis and application of the properties of binary data. This content has been delivered in a series of three lecture sessions using slideware in combination with extensive writing on the whiteboard. This is due to the need to demonstrate multiple examples of binary number manipulation and means that the role of the teacher in these sessions is to demonstrate and explain rather than facilitate constructive learning. It is therefore a good example of the transmission approach used in this discipline. Although this teaching method is not what is generally considered best practice and that an approach based on the shared construction of knowledge might lead to better outcomes, student feedback from previous years suggests the lectures are effective. Furthermore, feedback strongly suggests that the material written on the whiteboard is generally considered the most useful component of the lectures. It is therefore problematic if this aspect is not captured in any lecture recording.

The broader learning environment in which the course in question sits is constrained by a number of factors. The cohort is relatively large and spreads across multiple campuses (total of 250+ students), the available space for teaching is not ideal and the content of an introductory computer architecture course is, by necessity, fact driven as opposed to content that might be more amenable to deep learning. The theoretical component of the course is not assessed as thoroughly as the practical component but students need to have developed a reasonable understanding of the inner workings of a computer before they can attempt the practical exercises. Evidence suggests that encouraging deep engagement in information technology courses is difficult at the best of times (Baeten, Kyndt, Struyven, & Dochy, 2010) and the prevailing teaching approach has been transmission, as discussed. There is scope for the applied aspects of the course to be covered in the laboratory sessions and these aspects constitute more than half the assessment for the course, suggesting a move towards a more project or problem-based learning approach. Although positive steps are being taken to move to a more constructivist approach to learning in the course, the traditional lecture remains.

The cohort of students who typically enrol in the course is made up mostly of male students with a higher than average proportion of school leavers. Arguments have been made that students who elect to study sciences like information technology are less socially inclined than students in other disciplines (Smart, 1997). Students in this cohort have a strong tendency to bring laptops and/or mobile devices into lectures and this is problematic in terms of ensuring they do not get distracted, a considerable risk when students bring laptops into lectures (Fried, 2008). Although there is a high level of engagement with technology and a relatively young cohort, it cannot be assumed that the whole class has high levels of digital literacy, particularly as this is a first year course (see also Kennedy, Judd, Churchward, Gray, & Krause 2009). Because of this, any resource supplementary to the lecture must be developed so that any student can adequately access and utilise it.

Dynamic presentation capture

It is evident that the ability to understand the inner workings of a computer and how it manipulates data is a central component of the course and is essential background knowledge for students to complete their assessment. Writing on the whiteboard in class allows the lecturer to demonstrate this process but this component of the lecture cannot be captured for later review and it impairs the engagement between the lecturer and the students. This is problematic and digital ink may help to resolve this issue.

Although there has been some interest in the use of tablet PCs as a presentation tool (e.g., Mock, 2004; Scott, 2011), the newer generation of mobile tablets (e.g., iPad) are not as adept at blending traditional presentation techniques commonly used in lectures with new approaches to incorporating dynamic content. For example, mobile tablets could be effective for writing or drawing and could be adapted to present slideware in a lecture theatre but are unlikely to be able to effectively do both simultaneously. Similarly, current mechanisms of capturing written content in a lecture such as recordable whiteboards or overhead projectors are difficult to integrate with other content such as lecture slides and audio. This leads to a situation where other mechanisms need to be considered that will cost-effectively capture the lecture material, including the components written by the lecturer whilst simultaneously allowing the lecturer to remain engaged with the class. A potential solution to this problem is provided by USB writing tablets and software that allows for 'digital ink' to be displayed on the screen of a computer and projected using existing projection equipment in lecture rooms.

Introducing a writing tablet into lectures

The current study involved the introduction of a writing tablet into two lectures for the first year computer architecture course in question. A small component of one lecture was used to trial the technology before delivering a full 2-hour lecture using the writing tablet. The trial was therefore an assessment of a resource-based solution to a problem of content delivery and involved the introduction of both hardware and software. The study involved integration of handwritten components of the lecture into what was captured on the computer screen and this was projected in tandem with existing slideware presentations. The entire content was then recorded using screen and audio capture software on a laptop and added to the university learning management system as an ongoing resource for students.

In order to implement this, there were several additions required to the standard equipment available in lecture theatres. The complete set of tools required to implement this approach to lecture capture is outlined in Table 1 with general availability of equipment in standard lecture theatres mapped against the required equipment.

Process

After initial testing, writing directly onto the pre-existing slideware presentation was found to be ineffective due to the limited amount of available space on most slides. Consequently an alternative approach to delivery was investigated. Inserting blank slides into an existing slideware presentation and writing on these was an improvement but usually required excessive switching back and forth between the content slide and the marked up slide. Switching between slideware and another program to write on proved cumbersome and could also become disorienting for students.

Reworking the slides as a series of PDF pages with working space incorporated into the content proved to be an effective way to integrate the hand-written and electronic content. Pages to be displayed were split into two parts with either the top or the bottom of the page displayed at any one time in attempt to reduce the amount of switching between content. The benefit of this approach is that only information relevant to the current concept is displayed at any given time. However, this approach comes at a cost of reworking the slides into an alternative format and somewhat reduces the flexibility of handwritten working out as it requires careful preplanning of how best to use the available space. This process could be improved upon in future offerings by choosing the most appropriate software for a particular task, such as Microsoft Paint for drawing images, etc. Figure 1 shows reworked slideware content prior to marking up with handwritten annotation. Figure 2 illustrates the same content after marking up with handwritten annotation. The mark-up of the slide and associated audio is captured and recorded live to video, giving

students the opportunity to view both the problem solution and the process that was followed to generate it.

Table 1
Required equipment for implementing digital ink into standard lecture setup

Equipment	Model	Purpose	Cost	Standard (Y/N)
Laptop with Microsoft PowerPoint and Adobe Acrobat	Dell Latitude E6400	Platform to run slideware, PDF viewer, connect tablet, and perform screen and audio capture	\$1400US	N
Screen and audio capture software	Bandicam V1.6.1.3 www.bandicam.com	Software to capture a synchronised video output and audio input stream of the laptop	\$39US	N
Tablet and stylus	Wacom Bamboo Fun	Hardware connected to the laptop to capture handwriting for overlaying on the laptop display	\$250US	N
Microphone	Plantronics Voyager 975 Bluetooth headset with carry case and charger	In-ear low profile microphone for capturing lecturer audio	\$167US	N
Audio visual projector with laptop input		Built in hardware for projecting laptop audio and video		Y

- Computer data
 - Data can be converted to sequences of 1s and 0s
- Representing binary integers (177)

128 <i>(2⁷)</i>	64 <i>(2⁶)</i>	32 <i>(2⁵)</i>	16 <i>(2⁴)</i>	8 <i>(2³)</i>	4 <i>(2²)</i>	2 <i>(2¹)</i>	1 <i>(2⁰)</i>
1	0	1	1	0	0	0	1
- Converting from binary to decimal

+ + + + + + + =

Figure 1. Projected example prior to annotating.

- Computer data
 - Data can be converted to sequences of 1s and 0s
- Representing binary integers (177)

128 <small>(2⁷)</small>	64 <small>(2⁶)</small>	32 <small>(2⁵)</small>	16 <small>(2⁴)</small>	8 <small>(2³)</small>	4 <small>(2²)</small>	2 <small>(2¹)</small>	1 <small>(2⁰)</small>
1	0	1	1	0	0	0	1

128
32
16
.
177

- Converting from binary to decimal

$$128 + 0 + 32 + 16 + 0 + 0 + 0 + 1 = 177$$

Figure 2. Projected example after annotating.

Methodology

The method used for this study was an educational design approach. Reeves (2006) argues that this approach allows for an exploration of the particular pedagogical issue to be addressed and provides the most appropriate method for investigating the utility of technology in education. Reeves recommends a four stage process including an analysis of the pedagogical problem, exploration and development of possible solutions followed by iterative cycles of enhancement and finally reflection on the implementation. The current study followed this approach with the framing of the problem and investigation of solutions discussed above. The testing and enhancement cycle required the collection of data from students to determine whether or not the innovation is effective from their perspective. The method of data collection is therefore described below.

The main objective of this study was to determine whether or not students would engage with material presented using 'digital ink' as a pilot for application in situations where a similar pedagogical problem exists. This required evaluation of engagement within the lecture session and with the recorded videos of the lectures. Ellis et al. (2010) argue that student perceptions of e-learning innovation should be the central consideration when implementing a new technology. The current study therefore relied on consistent and regular feedback from students about both the in-class delivery of the lecture and on the recording of the lecture loaded onto the learning management system. Students were surveyed about the lecture and were given the opportunity to give feedback about the lecture recording. The purpose of garnering this feedback was to determine whether or not students perceived that the implementation of the digital ink enhanced their experience of the lecture, assisted with clarifying the concepts and assisted with their learning overall. These factors were all considered important in determining whether or not the innovation adds anything to the student experience. The total number of downloads of the recording were also monitored.

Ethics approval for surveying the students was granted by the university ethics committee. The survey consisted of nine quantitative questions with options presented in a five-point Likert scale from 'strongly disagree' to 'strongly agree'. These questions asked about whether the material was presented in an organised and interesting way, about the overall satisfaction with the lecture and a series of questions specifically about how useful and easy to engage with the handwritten material was. Open-ended questions asked students to give feedback about the best aspect of the lecture, the aspect most in need of improvement and a question about their impressions of the handwritten content.

Results

A total of 64 students agreed to complete the survey at the end of the lecture session. This represents 28% of the total number of students enrolled in the course during the time in which 'digital ink' was implemented. The responses of students at the end of the lecture session including handwritten elements presented using the tablet were overwhelmingly positive. Students agreed that the lecture was interesting, organised and that the handwritten elements of the lecture were easy to see and a useful addition to the lecture. The responses to the quantitative questions are illustrated in Figure 3.

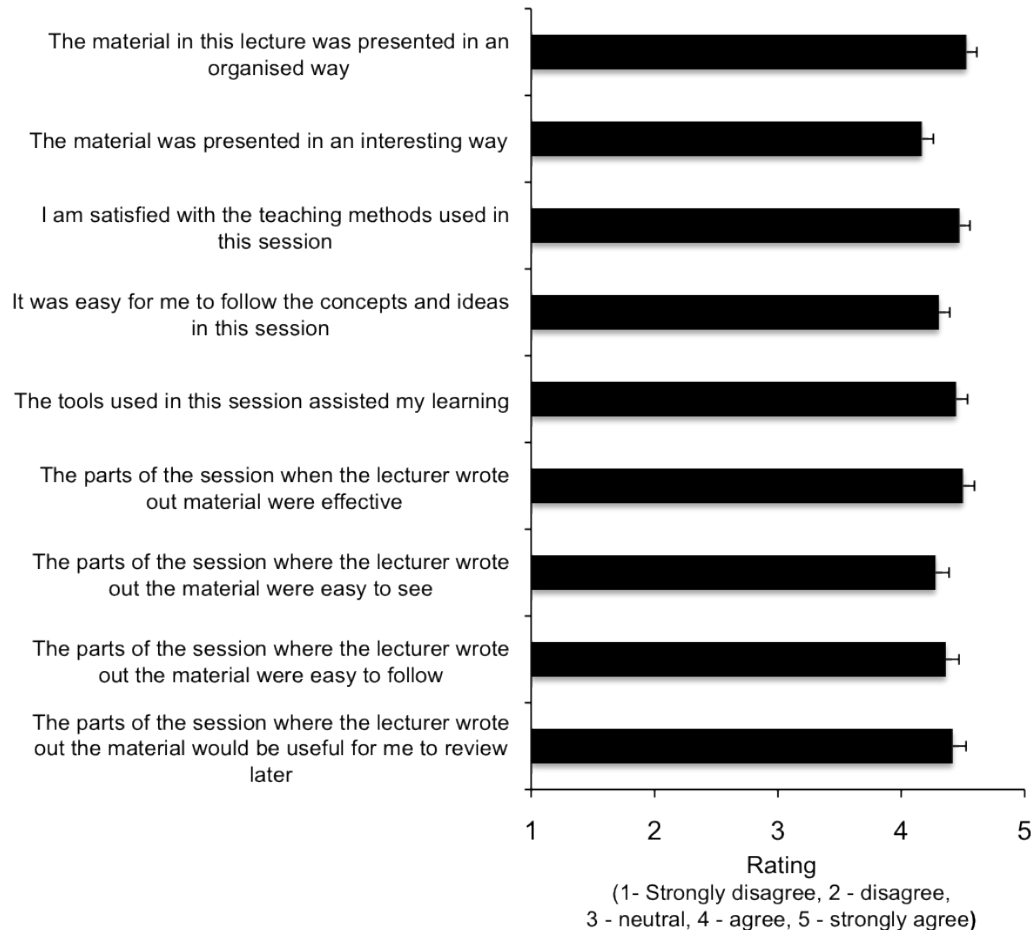


Figure 3. Mean (SE) responses to survey questions administered at the end of the lecture session (N=64).

Over half of the students (53%) who commented on the best aspect of the lecture specifically mentioned the tablet as being the best aspect of the lecture with several students stating that "the tablet was a great idea". Most of the remaining comments indicated satisfaction with the entire method of delivery used in the session. Very few students commented on any aspect of the lecture that needs improvement and the comments that were recorded related to the scheduling (3 comments) and environmental conditions (2 comments) of the session. When asked to give specific feedback about the use of the tablet, students were again positive. All students who commented on the use of the tablet except one stated that the tablet helped their understanding with a representative comment being "because examples were made easier and more enjoyable to understand". The one negative comment related to experience in the use of the tool with the student expressing that "understanding and confidence with the tablet needs improving". Given that this is a new approach to adding handwritten content to the more established approach of using slideware, the negative comment is perhaps not surprising. The technology in question has not been developed to maturity (c.f., Paulk, Weber, Curtis, & Chrissis, 1995) but provides a starting point from which a more mature technology can be developed.

At the time of semester when the videos of the lectures in question were made available, a total of 225 students were enrolled and had access to the files through the university learning management system. Two unique video sessions were available to students. Both covered standard material presented in class as discussed. A separate access point was created to allow students to access the videos for revision purposes. The number of times this link was clicked-through was also tracked. In total, these videos were accessed 593 times including multiple accesses by the same students. Table 2 includes the breakdown of the total number of individual accesses across the three videos.

Table 2
Breakdown of Accesses of Lectures Including 'Digital Ink'

	Video 1	Video 2	Revision link
Number of unique accesses	85	74	N/A
Total number of accesses	290	195	108

As this cohort of students had not previously had access to the recording of lectures, it is difficult to determine whether or not the number of accesses is representative of what would be expected if all lecture sessions were recorded. A follow-up survey attached to the learning management system attracted 31 responses. The mean responses to the follow-up survey are displayed in Figure 4.

The survey responses again suggest that students were satisfied with the lecture recordings and found them useful for revision purposes. The qualitative comments again reflected this high level of satisfaction with students commenting that the "parts that were written out that cannot be shown in normal lecture slides" were the most effective part of the recording. Another student commented that "the visual on what the lecturer was writing and talking about made it extremely useful and was as if he was writing on the whiteboard making it very easy to follow". There were very few negative comments about the recordings with one student suggesting that the resolution was too low and another that the video was only able to be played with a specific type of video playing software. Ultimately, the feedback about the lecture session and recording of the session were both consistently positive.

Although engagement levels were not measured directly, the results presented here suggest that students were satisfied with the technology implemented in these lectures. Students generally felt that the lectures and the use of the digital ink were effective. The responses to the items asking them about the level of difficulty and whether or not students found the innovation used in the lecture assisted their learning were also predominantly in the agree to strongly agree range. In summary, the results from the surveys suggest that students' experience of the lecture and ability to engage with the material presented in these lecture sessions was enhanced through the use of this innovation.

Discussion and key findings

The results of this study suggest that students benefited from this innovation. Students generally agreed or strongly agreed that they found the lectures organised and engaging. Furthermore, they also stated that the concepts were easy to follow and they felt that the teaching methods used enhanced their learning. Consequently, it would appear that, at least in the opinion of the students who attended these lectures or downloaded the recordings, the lectures using digital ink were engaging and lead to improved learning outcomes. The aim of the current study was to determine whether or not digital ink would be a worthwhile addition to lectures of this type, the response from students would suggest that indeed the addition of this innovation is a useful endeavour.

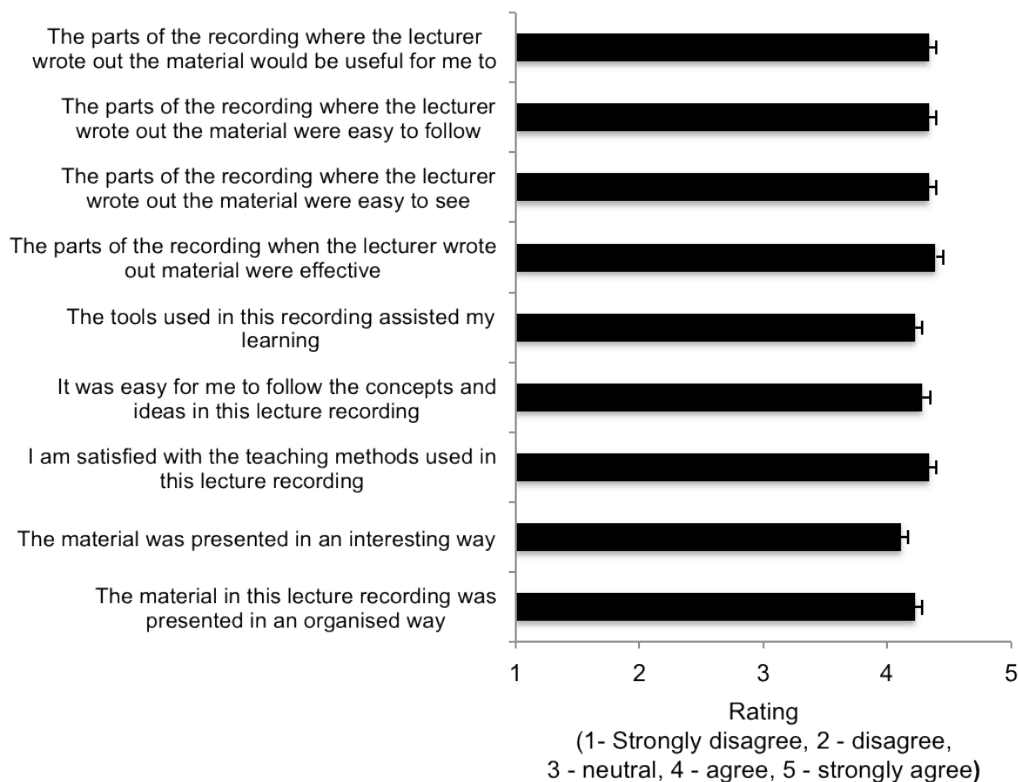


Figure 4. Mean (SE) responses to survey questions administered in the learning management system (N=31).

It is recognised that the content-driven approach underpinning the current project was not ideal and that a more interactive approach to the lessons would be preferred (see also Revell & Wainwright, 2009). The solution was developed within the framework proposed by Gosper, Woo, Muir, Dudley, and Nakazawa (2007) meaning that the curriculum, the wider organisational context and the technical aspects of the project were considered holistically. The current project has thus been shaped by several factors leading to the proposed solution. Firstly, the first year cohort in this course has about 250 students and by necessity, classes must be delivered in a large lecture theatre as per the current school and university norms. Mounting evidence suggests that lectures are not the ideal forum for the dissemination of course content (Deslauriers et al., 2011) but the introduction of the writing tablet was a solution to a problem designed to work within the practicalities of a campus-based delivery program as it currently exists. The implementation is therefore viable within the current organisational context but it also works within the technical context in that it is relatively easy to implement and integrates with existing university infrastructure.

The implementation of a writing tablet enhances the current process for delivering the curriculum in lieu of the larger shift in organisational culture within the discipline that would be required to modify the teaching approach to one more akin to social constructivism (as per Bates & Poole, 2003). Although an ideal solution would be to increase interactivity in the lecture sessions, introducing a writing tablet is simple to implement and enhances current practices without forcing large-scale organisational or curriculum change.

Ultimately, the current project exists within a larger program that could also benefit from the implementation of 'digital ink' into lectures. The success of the current project in terms of the level of reported student engagement, suggests that it should be considered for wider adoption across the degree program and then across the university. McNaught, Whithear, and Browning (1999) argue that the greatest potential for the implementation of technological innovation in university programs comes through coordinating the implementation across a degree program at least creating a system of innovation

rather than discrete projects. It is thus hoped that the current project will lead to wide scale adoption of digital ink in information technology courses.

Although there is growing dissatisfaction with the lecture as a viable learning and teaching approach, there is evidence here to suggest that innovative ways of using technology to alter the ways in which information is disseminated in such forums can have benefits. An ideal approach would involve greater interaction to allow students to construct their own knowledge.

Limitations

Although the implementation of the tablet in these sessions appears to have been well received by students, a number of issues were experienced whilst attempting to capture the handwritten component and should be noted for further work in this area. It is hoped that the inclusion of these limitations will ensure that future implementations of similar tools are forewarned of potential problems.

The quality and resolution of the projector can limit the effectiveness of writing directly onto the laptop display. A projector resolution of 800x600 (standard low resolution) will significantly limit the amount of screen real estate available for writing and may also restrict the types of software that can be used to capture and display hand-written information. In addition, to ensure the writing is legible, the handwriting has to be quite large with a relatively large pen thickness, further reducing the available screen real estate.

A standard lecture is generally one hour and recording both audio and video for this length of time can result in large file sizes and long download times for students even if recording at low quality. Longer lectures will exacerbate this and in some instances may even cause the recording software to malfunction due to file size limitations. For the trial, the video was captured full screen at 5 frames per second, 10% quality, and the audio was 48 kilohertz mono at 46 kilobits per second. These lower quality settings resulted in file sizes of approximately 96 Megabytes for each one hour lecture whilst retaining clear video and audio content.

It is also worth noting that to view the recording, the student must have video playing software that can play the format (video codec) that is used to record the lecture. Some computing platforms may not have suitable video playing software.

If sufficient care is taken to set up the tablet and record the lecture in a way that leads to manageable file sizes and formats that are accessible to most students, the issues encountered in the current project can be overcome.

Conclusion

Given that there are limitations on physical resources and on academic time, the use of a tablet in a way similar to that described here has the potential to increase real-time interaction and flexibility in terms of the visual input of a lecture session. The lecture might not become extinct any time soon so the current project is one example of the ways in which greater interaction can be induced in sessions of this type in the meantime to ensure the greatest possible benefit for students.

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Corresponding author: Sven Venema, s.venema@optusnet.com.au

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