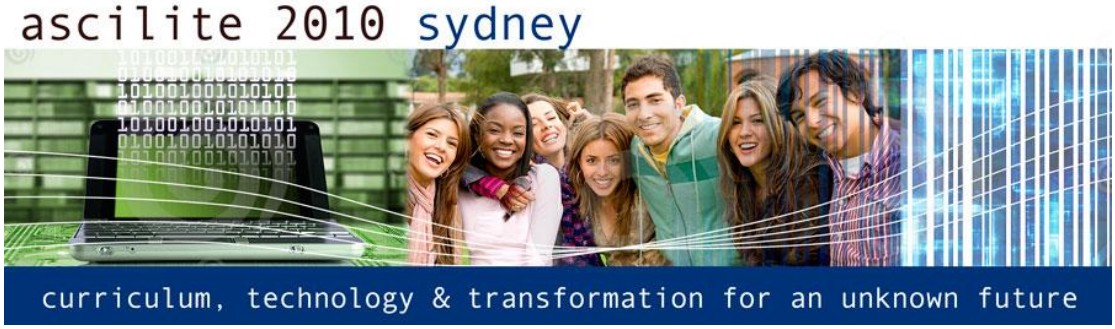

Using academic analytic tools to investigate studying behaviours in technology-supported learning environments

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Increasing flexibility in higher education is being provided to meet the needs of a diverse student body. Technologies such as lecture-capture systems have been employed by many universities to provide on-demand access to recorded lectures. This paper describes research into how students engage with lecture-capture technologies such as Lectopia as they study in blended learning environments. It reports on the development of an academic analytic tool to examine Lectopia usage logs to identify usage patterns among students in three units across two universities. A theoretical model of usage patterns has been developed to tentatively explain studying behaviour. Preliminary results suggest that patterns of use of Lectopia vary greatly across the student cohorts studied.

Keywords: student engagement, technology-enhanced learning, lecture-capture systems, study patterns, e-learning, academic analytics

Introduction

The last decade has seen a fundamental shift in the nature of teaching and learning in higher education in Australia, brought about, in part, by increasing student diversity and lifestyle pressures (Anderson, 2006; Australian Vice-Chancellors' Committee, 2007; Phillips, Gosper, McNeill, Woo, Preston & Green, 2007), and the widespread uptake of educational technologies. The primacy of the traditional lecture/tutorial approach to university teaching is being challenged (Jones, 2007; Phillips, 2005) and the boundaries between face-to-face and distance education are being blurred (Woo et al., 2008).

Students are demanding flexibility in time and space in order to be able to study effectively. They want to access their learning activities in ways which fit in with their work and family commitments (Maor & Volet, 2007; McInnis & Hartley, 2002). Meeting these student needs has placed some pressure on universities as evidenced in a study by Anderson (2006) which reported that 78% of Australian

university students found that work impacted on their study, and 40% felt that their university did not cater well for students in paid employment.

Educational technology use is widespread at universities in a range of formats and purposes. It provides a level of flexibility sought by students, as a supplement to traditional face-to-face teaching (Harris, Yanosky, & Zastrocky, 2003), in what is called blended learning (Lefoe & Albury, 2004). Tools in widespread use are learning management systems (LMS) and lecture recording systems (in Australia, predominantly BlackBoard and Moodle; and the Echo 360 product Lectopia, respectively).

The introduction of Lectopia and similar technologies has been one response to the need for flexibility of access. Not surprisingly, Lectopia is gaining in popularity, particularly with students finding that their needs for flexibility have not been met by traditional on-campus teaching paradigms. Recent studies have confirmed students‟ appreciation of the convenience and flexibility offered by anytime, anywhere access to lectures (Fardon & Neville, 2003; McNeill et al., 2007). In this paper, we describe an investigation of students‟ use of a lecture recording system across three different units of study in two universities.

Research on student responses to lecture-capture systems

This research builds on an earlier study investigating the use and impact of Lectopia and similar technologies across four Australian universities from the perspectives of both students and staff (Gosper, et al., 2008). The project found that both staff and students appreciated the flexibility these technologies provided for accessing lectures as well as for supporting their learning as a whole, including distance students, those with disabilities and from non-English speaking backgrounds. The majority of students, regardless of enrolment mode, age and gender, perceived that Lectopia made it easier for them to learn and helped them achieve better results. Students found Lectopia valuable because of the convenience (they don‟t need to attend), the flexibility (it fits with their busy lifestyle), and because it acts as a safety net when they couldn‟t attend. Students also used Lectopia as a tool for learning – to pick up on ideas missed in lectures, revise for exams and revisit complex ideas. Of the students using Lectopia, over 75% indicated that they used it because they could not attend classes, for reasons ranging from timetable clashes, work and/or family commitments, and caring responsibilities. Some students use Lectopia to replace lecture attendance, some don‟t use it at all, preferring to attend lectures, while others do both.

Staff views, while still positive about their experiences of using Lectopia, were significantly less positive than students in regard to the benefits for learning and for achieving better results (Phillips, et al., 2007). Many staff were concerned about falling attendance at lectures and a perceived lack of engagement by students, findings also reported by Massingham & Herrington (2006). One of the concerns was that students would delay listening to lectures until they needed to prepare for examinations, thereby missing an opportunity for ongoing learning and correction of misconceptions (Goldberg, Haase, Shoukas, & Schramm, 2006). On the other hand, some staff had much more positive perceptions of Lectopia, particularly those who had taken a whole of curriculum perspective and effectively integrated Lectopia and other technologies into their units of study (Gosper et al., 2008).

This previous research identified the implications of Lectopia and similar technologies for learning, including a mismatch between staff and student perceptions of its effectiveness. Importantly, it identified changes in relation to lecture attendance patterns and the emergence of a new dynamic between face-to-face lectures and recorded lectures. The research identified that a whole of curriculum approach was needed to understand these changing behaviours, but it was not designed to explain these behaviours in any greater depth.

Broad research agenda

This paper reports on an initial stage of a larger research agenda which is based on the premise that not enough is known about tertiary students‟ studying behaviour in technology-supported learning environments. This research will examine how students study in units that make thoughtful use of technologies to provide flexibility in teaching and learning and cater for an increasingly diverse student cohort. The aim is to holistically examine the overall technology-enhanced learning environment and the interrelationships between the elements of the curriculum, rather than just the role of a single

technology. The broad research question we are interested in is „How do students engage with well-designed blended learning environments to study and to learn successfully?"

In order to address this question, we are developing a methodology which includes new tools to extract technology usage data, combined with traditional mixed methods. This paper concerns itself mainly with the development of one of the tools - a Lectopia usage data analysis tool, and initial trialling of this tool in case studies. This tool will be used to observe and identify different student behaviour patterns. The ultimate aim is to better understand what is an effective environment for blended learning.

Academic analytics

Despite calls for its use in the early 1990s (Kozma, 1994; Salomon, 1991), one source of data that has been under-utilised in e-learning research is usage logs from e-learning applications – automatically captured data which record who accessed what, and when – termed academic analytics (Goldstein & Katz, 2005; Oblinger & Campbell, 2007). The analysis and reporting of this data, and its use to diagnose and improve student learning, is just emerging (Dawson, Macfadyen, & Lockyer, 2009; Dawson, McWilliam, & Tan, 2008). Academic analytics provide direct evidence of student behaviour, in contrast with other approaches (e.g., surveys and interviews) which provide indirect evidence, filtered by the perceptions of the student (Salomon, 1991).

Early examination of usage logs began with custom-built interactive multimedia learning systems with built-in usage tracking (Judd & Kennedy, 2001; Kennedy & Judd, 2004; Phillips, 1997). As web-based learning management systems evolved, work began to use usage log data to understand how students engaged with e-learning environments, for example in Biology (Phillips & Baudains, 2002; Phillips, Baudains, & van Keulen, 2002). Further work involved analysing institutional usage patterns of the myriad tools available through learning management systems (Dawson et al., 2008; Phillips, 2006).

Reimann and Kay (2010) have used interaction network diagrams to analyse social networks formed through team interactions during wiki contributions. The visualization tool they developed provides data about students" interaction behaviour, which is particularly important when the learning goals involve collaborative learning (Bonk & Cunningham, 1998).

More recently, the focus has moved to the development of a tool to monitor and evaluate the formation and ongoing development of student social networks by extracting data from online discussion forums and visually displaying the resultant social networks (Dawson, 2006a, 2006b; Dawson, Bakharia, & Heathcote, 2010).

Student engagement and study patterns

In this work, ultimately, we are interested in learning. However, the process of learning is relatively difficult to observe. What is easier to observe is studying. Goodyear and Retalis (2010) maintain: "it is useful to distinguish between learning – which we take as a label for a set of psychological processes which lead to greater competence or understanding – and studying – which is a useful descriptor for a set of real-world activities in which people engage, for the purposes of intentional learning" (2010, p. 8)

Goodyear and Retalis (2010) posit that "learning processes are tightly bound up with" (p. 12), but are not the same as studying activity. Our interest in this research is in the activity of intentional studying, observed initially through academic analytic measures, and interrogated through interviews with students.

The tertiary learning literature strongly supports the view that deep approaches to learning are more appropriate than surface approaches (Biggs, 1999; Gibbs, 1992; Ramsden, 1988, 1992). Students choose either a surface, deep or strategic approach depending on their motivation and the content and context of learning as well as the perceived demands of the learning task (Ramsden, 1992, pp. 48-49). The design of a unit of study is clearly an important factor in students" choice of study approach. While many university lecturers may intend to develop understanding and critical thinking in students, Ramsden contends that "it is in our assessment practices and the amount of content we cover that we demonstrate to undergraduate students what competence in a subject really means" (Ramsden, 1992, p.

72). That is, if a unit is perceived by students to elicit a surface learning strategy, then students will use this strategy, despite the intentions of the lecturer.

Since Carroll‟s (1963) early model of factors contributing towards academic achievement, educators have recognised the importance of time-on-task as an indicator of success in learning. However, evidence shows that many higher education students fail to use their learning time wisely, e.g., Kuh (2001), for reasons such as lack of motivation, immaturity or simply not knowing how to learn effectively. Indiana University‟s research on student engagement proposed five essential strategies for facilitating student engagement in university studies (Kuh, Laird, & Umbach, 2004, p. 30):

1. Increasing student-faculty interaction;
2. Engaging students in active, collaborative learning activities;
3. Encouraging more achievement-oriented „time-on-task‟ among students;
4. Setting high academic challenge; and
5. Providing continuous timely feedback.

Learning skills texts (Marshall, 2006; Marshall & Rowland, 2006) also have a strong focus on organisational, planning and time management skills, as well as the importance of ongoing study and review of learning materials. These considerations have informed our development of theoretical types of study behaviours, below.

Research design

This research follows a pragmatic paradigm of inquiry, using a mixed methods‟ design (Cresswell, 2007), which combines quantitative and qualitative methods in a single study. Because we are investigating the curriculum as a whole, rather than technologies in isolation, we recognise the need to take account of each case study‟s particular context. Three cases are being investigated at two Australian universities:

- Education undergraduate unit. Enrolment: ~300 students. Internal (200 at two campuses), external (100).
- Psychology undergraduate unit. Enrolment: ~65 internal students.
- Environmental Studies postgraduate unit. Enrolment ~70. Mix of internal and external students.

These case study units were selected because the unit coordinators made extensive use of technology and displayed an interest in promoting effective on-line learning environments. The Lectopia tool described in the next section is being applied to each of the case study units.

The overall research design, which is beyond the scope of this paper, involves several additional steps. The Lectopia data will be combined with readily available BlackBoard reporting data to obtain a „picture‟ of how students study in the case study units. A sample of students will be selected based on diversity in usage patterns. These students will be approached for a semi-structured interview about their study behaviours. Those that consent will be presented with their usage data from Lectopia, and with the reports available through BlackBoard. The interviews will probe their study behaviour – in other words, why they behaved in the way they did.

The following sections discuss the elements of this research which have been completed at the time of writing, the development of the Lectopia usage analysis tool and the theoretical model of usage patterns.

Tool development

The Lectopia system automatically records all access to the system in various database tables. Initial prototyping on a copy of the database with a Structured Query Language (SQL) database query tool led to the identification of the data required for analysis. This included:

- The student user name, passed through an authentication system
- The date and time of access to a recording (a hit)
- Unit specific details (unit code, unit name, lecturer, etc.)

- A unique identifier for each recorded lecture in that unit, including the lecture date and time
- Information about the format of the recording which was accessed (streamed or downloaded; audio or video; bit rate; and file format).

SQL queries were written to produce this information, which was downloaded and imported into Excel for manipulation. Our particular interest was the pattern of behaviour by day or week. The access dates and times were converted into the week or day of the teaching period in which they occurred. The number of hits per week (or day) was graphed against the week (or day) of semester for the entire class and for individual students, and it became clear that there were very different patterns of use across students.

Once this prototyping stage was complete, the process was automated through the development of a server-side PHP script with a simple web-based interface. This script works on a single unit of study, and displays all relevant data in tabular (and downloadable) form, together with a summary graph. Figure 1 shows an example of such a graph, which has been annotated with information specific to that case study unit. The web interface continues with a listing of all students in the unit, ordered according to a heuristic which displays the heaviest users first, as shown in Figure 2.

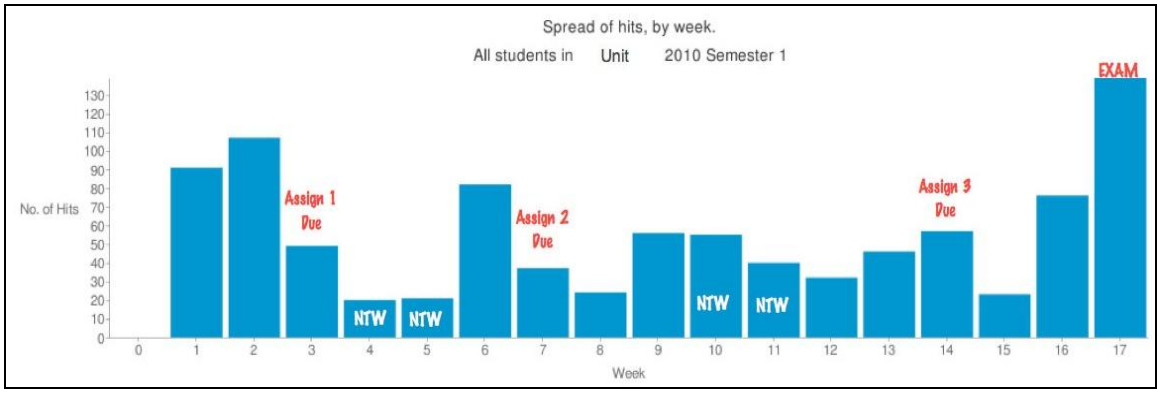


Figure 1: Example of a graph produced by the Lectopia analysis tool indicating hit frequencies for all students in a unit across all weeks of a semester, including non-teaching and examination weeks

Student Num	Hits *(H)*	Days with Hits *(HD)*	Date Span *(DS)*	H * HD * (DS +1)
66441	48	16	97	75264
79925	47	14	110	73038
23096	35	10	106	37450
24573	23	9	107	22356
94722	18	11	110	21978
95486	41	5	105	21730
16289	18	11	108	21582

Figure 2: Menu to overview the usage patterns of individual students

Clicking on each student number displays a graph of the pattern of use of that student, for example, those who use Lectopia regularly, those who use it rarely, and those who use it in bursts.

After this prototyping, the analysis tool was implemented on a live system ready for application to the three case studies in Semester 1, 2010. As we use the tool, we find new ways to interpret its outputs,

and this currently needs to be done manually in Excel. As we refine our ideas, we will progressively embed them in the web-based tool.

False hits

One issue which has arisen is determining the implications of „false hits", that is, multiple hits on the same lecture during a period of less than the length of the lecture. These are most likely to be caused by technical problems, but whatever the cause, the student cannot listen to the same recording twice at the same time.

The impact of false hits can be seen on the left of Figure 2, where there are a disproportionate number of hits in the first and second week of semester, when, in this case, only two lectures had been recorded. Closer inspection of the data revealed that, over the entire semester, the percentage of false hits was 28%, but in Week 1 it was 53%, and in Week 2, 43%. It is evident that the number of false hits decreased as students tried out and became accustomed to the Lectopia system. In our case studies, therefore, we need to manually remove false hits using Excel functions.

Theoretical categories of student study behaviour

Results from our previous study (Gosper et al., 2008) indicated that academics perceived class attendance by students as an important success factor, although students did not necessarily agree. As part of the research process, throughout the semester, we took attendance records in two case study units, and surveyed students in the third unit towards the end of semester about their attendance patterns. As the semester neared its end, Lectopia usage data was collated and cross-referenced against attendance data. This process enabled us to develop an indication of student behaviour, based on two dimensions:

- attendance and non-attendance at lectures; and
- use or non-use of Lectopia .

This section discusses how we reviewed and developed further selection criteria, based on students' patterns of use of Lectopia. Drawing on information gained from the literature review regarding the topic of study behaviour, we can make some tentative predictions about student study behaviours that might be effective, and those that might not. These predictions, while hypothetical, are not intended as „hypotheses" in a testable, statistical sense – we do not yet understand the analytic research parameters for this (Salomon, 1991). Such predictions are meant simply to develop an emergent theory. For example, we describe four possible profiles of student behaviour below:

1. *Attends lectures and does not use Lectopia*
   A student in this category takes a traditional approach to university study. No evidence is readily available about revision behaviour.

2. *Attends lectures and uses Lectopia*
   We may predict that a student who attends lectures and revises after lectures will perform well in assessment, assuming that the assessment addresses deep learning. A student might *conscientiously* use Lectopia for that revision.

3. *Does not attend lectures and uses Lectopia*
   Academics in our previous study were concerned that students who do not attend classes, and use only Lectopia, might not perform as well as students who do attend. The concern was that students would miss out on the peripheral and „incidental" communication that occurs before, during and after class, because Lectopia only records the teacher"s presentation, and not conversations. However, students in that study told us that they *conscientiously* used Lectopia even though they did not attend classes.

4. *Does not attend lectures and does not use Lectopia*
   We might predict that a student who is *disengaged* from lectures and lecture recordings would perform poorly, for example, an internal student who does not attend lectures and does not listen to Lectopia. On the other hand, as is often the case with mature-aged external students, such a

person may have the necessary motivation and self-regulatory skills to succeed when working solely on their own with any print-based materials. This example, in particular, highlights the many contextual factors that can influence student success.

A further category of behaviour which we might expect to see was identified by Phillips (2002) in a study of the impact of LMS usage behaviour on student learning. This is *cramming* behaviour, where a student only engages with unit materials in the last days before an assessment. We predict that such a student will perform less well, unless the assessment is designed to simply elicit surface approaches to learning.

The examples above describe several generic Lectopia usage patterns that are derived from the literature about student learning. We can categorise these as: conscientious, cramming, and disengaged. Initial observations of the online Lectopia analysis tool also suggest some categories of behaviour that can distinguish more precisely between student activities. This conceptual categorisation, therefore, is derived from a mix of existing theory, and theory that is developing around our work. Ten different usage behaviours are proposed to date (summarised in Table 1). Conscientious and high-achieving students access Lectopia regularly. Good-intentioned and repentant students have some weeks of regular use, at either the beginning or end of the teaching period. Other students access recordings in blocks – they are binging users. A sub-category of bingers are the free-timers, who access recordings during non-teaching weeks. Crammers leave their engagement with recordings until just before the examination period. Other students may access recordings once or not at all, or their pattern of use may not fit any of the other categories.

Table 1: Potential categories of study behaviour in Lectopia-supported learning environments

Category	Typical Profile
Conscientious	Students access the current lecture in the majority of weeks where there is a lecture posted
High-achieving	Sub-category of *conscientious*. Students access the current lecture in the majority of weeks where there is a lecture posted and revisit most of the lectures
Good-intentioned	Students start with a regular/weekly access pattern for the first part of the course, and this reduces during the semester
Repentant	A systematic profile, or extended activity is recorded sometime after Week 5 of the semester with little or no activity before this
Binging	Students access multiple lecture recordings in a single week followed by weeks with no access
Free-timers	Sub-category of binger. The majority of the hits fall during weeks where there are no new lectures posted/semester breaks etc.
Cramming	Students have the majority of their usage in the two weeks immediately prior to major exam/assessment tasks of the course
One-hit wonders	Students have only a single successful access of a single lecture
Random	No typical profile
Disengaged	No Lectopia activity - Student Number is present on enrolment list with no hits on the Lectopia system

These categories provide indicators of behaviour, but they do not explain that behaviour. For example, binging students could be very effective in balancing their study, work and family commitments, doing concentrated study when they have the opportunity. On the other hand, a binging student could be falling behind in their work because of poor time management and prioritisation skills, and their efforts could be ineffective. The interview data in our research will provide more information on individual students" motivations for study that cannot be detected by the usage data alone.

Results

Figure 3 presents some data produced by the Lectopia analysis tool for individual students which illustrate some of the behaviour patterns listed in Table 1. It is clear from Figure 3, that there is great variation in patterns of use across the student cohort. We are currently identifying students who display

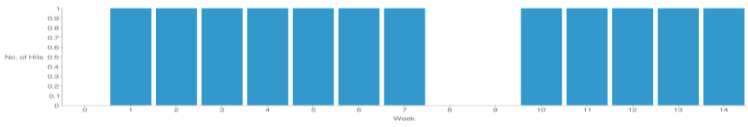
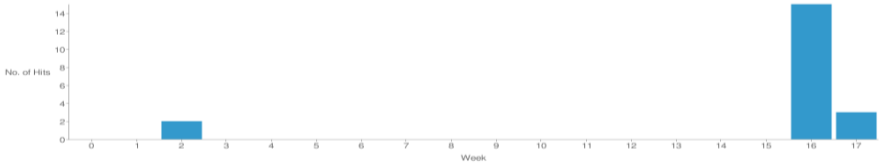
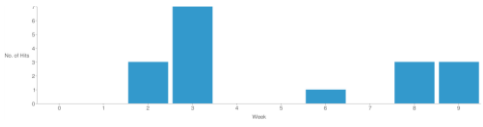
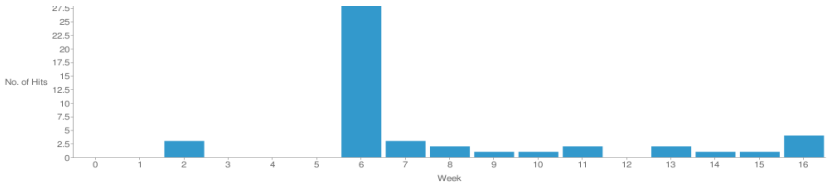
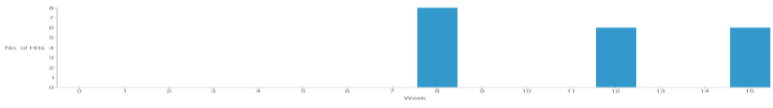
different usage behaviours, and cross-referencing this to their class attendance records. This will be used to identify our sample to be interviewed.

Work is continuing to develop algorithms to predict the behaviour categories in Table 1, so we can build functionality into the tool which will automatically categorise student behaviour. At the same time, we are looking at alternative ways of displaying the data, so that the teacher can see at a glance:

- the format of each hit (download/stream/MP3/MP4, etc.)
- the timing of each hit (hits in the first day/within seven days/after seven days)
- the type of each hit (whether it is an initial hit or a repeat hit on a recording)
- the number of the lecture that is accessed in which week

We intend that these more detailed representations of student use will both assist our research, and, in the future, provide a useful diagnostic tool for teachers. Ultimately, teachers should be able to access this tool as part of the staff interface to Lectopia and its successor Echo360 product. They can use it to reassure themselves about what their students are doing, and to identify potential at-risk behaviour.

Figure 3: Different categories of usage behaviour displayed by the Lectopia usage analysis tool

Conscientious	
Crammers	
Good-intentioned	
Repentants	
Bingers	

Conclusion

This paper has described initial stages of research into how students engage with technologies such as Lectopia as they study in blended learning environments. We briefly described our research design and its use of academic analytic tools to complement a mixed-methods approach. The main focus of this paper was on the development of an academic analytic tool to examine Lectopia usage logs to identify study behaviour patterns. This tool was trialled among students in three units across two universities. A theoretical model of usage patterns has been developed to tentatively predict studying behaviour and graphs were presented which indicate that patterns of use of Lectopia vary greatly across the student cohorts studied.

The work reported here is a preliminary phase of an ongoing research agenda. We hope that this work will give us a better understanding of what students actually do in blended learning environments, and how this might be effective in meeting their educational goals.

Notwithstanding the convenience and increased flexibility of anytime/anywhere resources, learning from the lecture is a pedagogical issue that is capable of stirring fierce debate among educators. Some claim that providing recordings of lectures is simply replacing one outdated instructional method with a technology-based version of the same thing. Others argue that we can all learn from expert opinion. In pursuing the line of enquiry described in this paper, we position ourselves in the latter camp, but insist that learning from the lecture is not sufficient in itself to facilitate engaged learning. Our interest is in how students use the flexibility of the Lectopia recorded lecture to learn and engage with the ideas in their units, and to explore the other factors in their learning contexts that enable learning.

We believe that the design principles and „working theories" which emerge from this study will spark many other questions about technology-related studying. Questions have already emerged that we will not be able to answer in the current study, but suggest exciting ideas for further research. For example, we have accepted an implicit assumption that technologies such as Lectopia recorded lectures will be accessed individually, whereas lectures attended live are with others. Is there a role for group access of recorded lectures, such as in study groups, enabling further research of group engagement (c.f. Chen, Lattuca, & Hamilton, 2008)? Further, the role of the teacher is an important factor in student engagement, particularly with regard to timely feedback (Kuh, Laird, & Umbach, 2004). The teacher"s involvement with remote students who are accessing technologies, but are not physically present in lectures, is another area of interest for further research.

As this research continues, we hope that it will provide guidance for both staff and students about how best to design, and engage with, technology-supported tertiary learning environments.

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