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COMPLETING THE LOOP:

Returning Meaningful Learning Analytic Data to Teachers

A Handbook for Educators and Learning Analytics Specialists

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EXECUTIVE SUMMARY

The Completing the Loop project investigated how learning analytics can be delivered to university teachers in meaningful ways that can help improve teaching and learning practices. With the increase in the use of technology to support teaching and learning in higher education, there is a greater opportunity to use the data generated in technology-based learning systems to inform the enhancement of student support and curriculum design. However, academic teachers are not always familiar with the capabilities of this technology, and existing data reporting interfaces are not always user-friendly or tailored to academic needs. The aim of this project was to investigate ways that this data could be used to provide feedback to teachers about student engagement and performance in online learning systems.

Our approach was based on two principles. The first is the idea that learning analytics can help facilitate 'conversations' between teachers and students, as outlined in Laurillard's (2002) conversational framework. The second principle is that meaningful interpretation of the outputs of learning analytics requires an understanding of learning design (or the pedagogical intent behind learning activities).

The project involved three phases:

1. Interviews with university teachers to a) understand what types of analytics they may find useful for design of their curriculum, and b) to help address any educational challenges they may face in their teaching. Interviews were held with 12 teachers from three participating universities (University of Melbourne, Macquarie University, and the University of South Australia).
2. The development of an open-source, online tool (the 'Loop Tool') designed to help teachers to articulate their learning design and visualise data from learning managements systems (LMS) in ways that are meaningful to them.
3. The implementation and evaluation of the Loop Tool with teachers at each of the participating universities.

Interviews conducted in the first phase of the project revealed that teachers were most interested in analytics that focused on student engagement with resources in the Learning Management System (LMS). Teachers wanted to understand how students accessed resources in the lead up to instructional 'events' such as a lecture or an assessment task. Several teachers also wanted to be able to create groups of students or resources to get a more granular understanding of patterns of engagement. It became clear from the interviews that the limited use of technology tools in teaching would impact upon the availability of data for analytics. The interviews also revealed that there was some concern about teachers' ability to effectively interpret and act upon learning analytics outputs.

An output of the first phase of the project was the development of a conceptual framework that brings together learning analytics and learning design. The framework links the teaching and learning context, types of analytics (e.g., temporal, tool specific, and cohort dynamics), and intervention support tools, while recognising the central role of the teacher in this process. More details about this conceptual framework can be found in Chapter 3 of this handbook.

The design of the Loop Tool was based on findings of the interviews conducted in Phase 1 of the project as well as a review of existing learning analytics tools and the profile of the courses to be used in the tool pilot in Phase 3. The tool was built using Python, Django, Pandas and

MySQL. It supports data imports from both Blackboard and Moodle learning management systems. The Loop Tool contains two components: (1) the Pedagogical Helper Tool which enables teachers to articulate their learning design, and (2) the Learning Analytics Tool which presents visual representations of the data from the learning management system.

An initial pilot of the Loop Tool in three courses showed that the tool could provide useful analytics to the participating teachers, especially in terms of student engagement with resources. The teachers all found the tool easy to use and made use of it throughout the semester to provide feedback to the course cohort, as well as individual students, and to review learning resources and activities. The frequency of use ranged from access several times a week by one teacher to access only at certain points in the semester related to key assessment tasks. All of the pilot teachers indicated a desire to continue to use the Loop Tool to support their teaching in the future.

While the successful development and pilot roll-out of the Loop Tool achieved the main aim of the project, the investigation unearthed some interesting tensions that can affect how learning analytics are used in education. For instance, interactive elements of learning activities are often not captured by online learning systems. There is not always clear alignment between the educational challenges that teachers wish to address, how these translate into the design of learning activities, and how these are subsequently represented through the technological tool (e.g., LMS). Such tensions highlight the importance of a deep understanding of the research, evaluation or investigative questions that are to be addressed, before engaging with the data.

The outcomes of the Completing the Loop project help advance the use of learning analytics in Australian higher education in educationally-informed and practical ways. The Loop Tool and associated resources, such as this handbook, are freely available for educational institutions to use and adapt to their own context. By making the Loop Tool open-source we hope that a community can be established that will continue to develop, expand and innovate the tool to provide the greatest possible benefit to teaching and learning practice.

For more project information, current updates and access to the source code for the Loop Tool visit: **http://melbourne-cshe.unimelb.edu.au/completing-the-loop**.

1: OVERVIEW

The contemporary student body in Australian universities is increasingly diverse in age, cultural and socioeconomic background, motivation and general experience with technology. University teachers are increasingly reliant on, and expected to use, a range of technologies to support student learning, both on- and off-campus. Designing and delivering online learning activities that are well-aligned with desired outcomes and also accommodate diverse student needs is a key educational challenge for teachers. This project sought to identify common situations and challenges students encounter when learning online, and determine what types of learning analytics teachers may find helpful as they address these challenges. These insights were then used to develop a web-based analytics tool with the aim of supporting teachers to more easily interpret learning analytics to help them improve teaching and learning practices.

In this project, we have used the definition for learning analytics as proposed by the Society for Learning Analytics Research (SoLAR):

"the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs."

Learning analytics has the potential to be a powerful tool for improving higher education. However, further work is required to understand how such analytics are adopted to inform and improve teaching practice. This project targeted the practical problem of how to better support effective teaching and student learning online. At the same time, we wanted to understand the needs and perceptions of teachers in higher education to ensure that learning analytics can be genuinely useful in teaching and learning practice.

This handbook outlines the main activities and findings of the Completing the Loop project. It brings together the work undertaken over the last two years by the multi-institutional project team as a resource for teachers and learning analytics specialists. In addition to outlining the theory behind our approach, the handbook provides a manual for how to use the Loop Tool. The appendices also include important technical information for institutional implementation of the open-source Loop Tool.

Overview of the Completing the Loop Project

The Completing the Loop project began in the 2014 academic year and continued through to mid-2016. The project team consisted of members from the University of Melbourne, Macquarie University and the University of South Australia.

The project comprised three phases:

Phase 1

In the first phase of the project, we collated perspectives from teachers about educational challenges and situations for which they felt learning analytics could be useful. Interviews were conducted with 12 university teachers across the participating institutions. These teachers were chosen from a wide range of disciplines and class sizes to gain a broad representation of the potential use cases for learning analytics in higher education. The outcomes of these interviews were analysed to inform the development of the learning analytics tool in Phase 2.

Phase 2

The main goal of Phase 2 was to develop an online open-source tool to support teachers' access to meaningful data about their students' online engagement and performance. Design specifications for this tool were developed based on the outcomes of the interviews conducted in Phase 1 and on the profile of the courses that were to form part of the pilot in Phase 3. The tool was designed to have two key parts: (1) a 'pedagogical helper' tool to help teachers articulate their pedagogical design in terms of key learning outcomes, activities and the related technological tools used to facilitate these; and (2) a learning analytics tool that provides visual summaries of data from learning management systems (Blackboard and Moodle) for teachers to use to support teaching and learning practices and design.

Phase 3

The third phase of the project involved a pilot of the learning analytics tool developed in Phase 2. The pilot took place in three medium-sized courses, one at each of the participating universities. Throughout this pilot phase, data was collected about how the teachers intended to use the tool as well as how they did actually use it in practice. The pilot study also allowed for the identification of bugs and usability issues with the tool.

Structure of the Handbook

This handbook provides an overview of the Completing the Loop project, including its background and context, the findings from the research in Phase 1, information about the design, development and implementation of the Loop Tool, and a discussion about what this project contributes to the role of learning analytics in higher education, now and in the future. Each chapter deals with one of these key features:

Chapter 2 explores the context for the project. It begins with a consideration of the potential role of learning analytics in higher education followed by an introduction to the field of learning design. The section concludes with an argument for the importance of integrating learning design and analytics to support teachers' meaningful interaction with data from learning management systems. In particular, there is a focus on the way this can "complete the loop" to provide feedback for conversations on improving teaching and learning.

Chapter 3 reports the findings of the interviews conducted across the three participating institutions used to scope the needs and wants of teachers in relation to learning analytics. It highlights the key themes that emerged and the impact these had on planning for the design of the Loop Tool.

Chapter 4 provides an overview of the Loop Tool and the design principles that informed its development. This is followed by a detailed outline of the functions of the two main components of the Loop Tool: the Pedagogical Helper Tool and the Learning Analytics Tool.

Chapter 5 describes the pilot case studies used to evaluate the effectiveness and usability of the Loop Tool. The outcomes from each of these pilot cases are reported and changes made to the tool as a result are outlined.

Chapter 6 discusses the implications of this project for the fields of learning analytics and learning design. It explores the fundamental tension facing the use of learning analytics in higher education and how we can deal with this tension in a way that can be beneficial to teaching and learning.

Chapter 7 outlines future directions for the role that learning analytics can play in higher education. It also considers future directions for the Loop Tool and its continued development in the open-source community.

In **Appendix A** we provide a technical manual for the implementation of the Loop Tool. This outlines the architecture of the tool, explains how data exports from courses are handled, and provides instructions on how to install and configure the tool.

Intended Audience

We sought to provide outcomes that are of potential benefit to a wide range of stakeholders in higher education, and a learning analytics solution that is compatible with a range of learning management systems. This handbook is specifically targeted at three key groups:

- Teachers: The Loop Tool is designed to help teachers with educational difficulties and situations they face within online learning environments. It can provide them with access to new forms of data on their teaching, and students' learning activities. Using these data, teachers can offer targeted feedback to students, plan educational interventions from a basis of evidence, and identify areas for curriculum review. This handbook provides both a theoretical overview of the potential for learning analytics in teaching and learning, and a practical manual for the use of the Loop Tool. The case studies provide examples of how the Loop Tool can be used in teaching, as well as practical tips for teachers on the "dos" and "don'ts" of learning analytics.
- Educational design staff: The Loop Tool can be used by educational designers to aid discussions with teachers about learning design and evaluation. The Loop Tool helps to provide evidence for how particular learning activities are used. This can be very useful for evaluating the effectiveness of learning activity design. It may also assist in identifying areas of the design that require further review, or redesigning. The findings of the projects piloting the Loop Tool also highlight practical considerations in the design and implementation of learning activities in learning management systems.
- IT management and developers: For those responsible for decision making and implementation of the Loop Tool, the handbook provides an overview of its functionality and a technical framework for implementation in your institution. The case study descriptions of implementation will assist university IT departments to decide how best to deploy this technology within the institution. This information can also assist in determining the required support for teachers to be able to effectively use the tool to support their teaching and learning activities.

2: BACKGROUND AND CONTEXT

Introduction

The ways in which students engage with the university and experience learning have significantly changed over the past two decades. Higher education is now a 'mass' education system and uptake of technology in teaching and learning by university staff and students has dramatically increased (James, Krause, & Jennings, 2010; Norton, Sonnemann & McGannon, 2013). Student learning interactions are now routinely technology-based, and technology is an essential part of the contemporary university study experience. Students are frequently expected to undertake independent and self-directed learning activities online. However, while online learning activities are becoming more prevalent, students can and do encounter difficulties in this learning context.

Previous research has indicated that students often have difficulty interpreting activities set by their teachers and maintaining their engagement with online activities (Kennedy & Judd, 2007; Waycott, Dalgarno, Kennedy & Bishop, 2012). Moreover, teachers often have difficulty "seeing" or recognising the challenges students face when learning online. With online learning predicted to grow in higher education nationally and internationally (Feenberg, 2015; Picciano, 2015), the sophisticated and innovative use of learning analytics is likely to become an increasingly important and valuable tool in supporting effective academic teaching and student learning online (Gašević, Dawson & Siemens, 2015).

Learning Analytics

Growth in the use of technology in teaching has given institutions and individual teachers unprecedented opportunities to monitor and analyse how students interact with online content through the 'digital traces' they leave. The collection, measurement, analysis and reporting of such digital traces is referred to as learning analytics (Siemens & Gašević, 2012). Existing work in learning analytics has shown much promise for understanding and optimising learning processes, outcomes, and environments (Baker & Siemens, 2014). To date, much of this work has been dedicated to the development of predictive models of academic success (Gašević, Dawson, Rogers, & Gašević, 2016). These can enable early identification of students who are at risk of failing and/or withdrawing from an academic degree program or course. Such predictive models have been integrated into systems such as Course Signals to provide feedback to both students and instructors (Arnold & Pistilli, 2012). In addition to establishing broad predictive models of student academic performance and retention, considerable research effort has been devoted to further our understanding of the learning process. For example, investigating student patterns of behaviour through social network analysis (Bakharia & Dawson, 2011), discourse and textual analysis of online discussion (Kovanović et al., 2016), and detecting learning strategies (Winne, 2014; Dalgarno, Kennedy, Bennett, 2014).

Growth in the use of learning analytics has invited attention to how analytics data are presented, notably through learning analytics dashboards. Learning analytics dashboards and other presentation tools assist users in making data-informed decisions, and this has become a critical area of learning analytics research and development (Verbert, Duval, Klerkx, Govaerts, & Santos, 2013; Verbert et al., 2014). Dashboards can provide insight into varied aspects of learning, allowing visualisation and interpretation of concepts such as structures formed in social networks (Bakharia & Dawson, 2011), activities in social media (Santos, Verbert, Govaerts, & Duval, 2013), and the effectiveness of learning designs implemented in courses (Ali, Hatala, Gašević, & Jovanović, 2012).

Some studies have evaluated the effectiveness, usability, usefulness, and efficiency of different dashboards (Verbert et al., 2013). Unsurprisingly, well-designed dashboards are very important for achieving desirable outcomes in higher education. For example, the *Course Signals* dashboard was found to increase student retention (Arnold & Pistilli, 2012). Likewise, Corrin and de Barba (2014) showed that students have difficulties in interpreting statistical results presented in commonly available learning analytics dashboards. Nevertheless, few studies have offered empirically validated principles for the design of learning analytics dashboards. This project explicitly addressed this issue by focusing on the needs of instructors to receive actionable feedback on the effectiveness of their learning designs.

Learning Design

Following the widespread adoption of digital technologies in higher education in the early 2000s, research in the field of learning design has focused on how educators can effectively make use of these technologies to support teaching and learning innovations, as well as share and adapt these ideas of high quality practice. These two main aims of the learning design field have translated into the concept of learning design having both a process and a product focus.

The process of learning design refers to the teacher's task of conceptualising, planning, and organising teaching and learning experiences. In higher education, these teaching and learning experiences comprise a series of learning activities within a subject, unit or course. When designing, teachers define learning activities in their course and specify the resources, pedagogical supports and technology tools that will help students engage in these activities. This "...requires them to draw together their specialist domain expertise with appropriate teaching strategies, while integrating the range of digital technologies that are now commonplace in higher education" (Bennett, Agostinho, & Lockyer, 2016, p. 1). During this process, university teachers and learning designers make critical design decisions that are influenced by student-related factors (e.g., their knowledge of current and past students in their courses), teacher-related factors (e.g., their own beliefs about and experiences of teaching and learning), and contextual factors (e.g., advice from colleagues, institutional policies and resourcing) (Bennett, Agostinho, & Lockyer, 2015; Laurillard et al., 2013). The complexity of this design task demonstrates how university education has evolved from the idea of teaching as knowledge transmission to teaching as a design science (Laurillard, 2012).

The product or outcome of the design process can be a formal description that articulates the pedagogical intent of the teacher. These are frequently represented as text and/or illustrations known as learning designs or patterns. Such learning design representations have been the focus of significant research effort exploring optimal design formats, taxonomies, and applications. A central challenge for the field of learning design research has been to develop and apply standard learning design descriptions in multidisciplinary university contexts where there is no common language for education (Waters & Gibbons, 2004; Agostinho, 2009). Thus, fundamental to this field is the importance of teachers describing their teaching and learning activities and resources, technology-based tools and support mechanisms in sufficient detail to enable these learning designs to be shared and adapted by other teachers within their own context, as well as to allow the originator of the learning design to reflect on his or her own educational approaches.

While the learning design field has not developed one commonly accepted form of description, the research work has demonstrated that learning design "... representations do act as frameworks that teachers may use when designing their courses. These frameworks can be seen as facilitating the concept of constructive alignment…" between learning outcomes and the learning activities, resources and technologies that the teacher designs for students to meet those outcomes (Lockyer, Agostinho, & Bennett, 2016). What the learning design representations do not tell the teacher is exactly how the student engages with the activities to meet those outcomes.

Integrating Learning Analytics and Learning Design

Integrating work from the fields of learning design and learning analytics can provide educators with the ability to gauge whether their pedagogical intentions are realised through the actual learning actions and behaviours of students. Ellis and Goodyear (2010) highlight the need to distinguish between 'designed' and 'actioned' learning – put simply, we cannot assume that students will experience learning as designed. In essence, learning analytics capture the interactions of students within digital learning environments. They can provide some insight into what students are actually doing with the learning activities teachers create for them.

At the same time, we cannot fully understand students' learning processes through learning analytics without an understanding of the design intent of the learning activity. While generally speaking students' learning processes are defined and influenced by both internal (e.g. motivation, prior knowledge, and cognitive load) and external conditions (e.g. learning design of tasks, degree of peer interaction, attributes of the study context), the external conditions associated with learning design were the primary focus of this project. Learning analytics in and of themselves do not help us make meaning of the learner's experience without an understanding of the teacher's goals as determined by the learning design; "interpretation of the analytics thus requires alignment with the original teaching context if it is to be useful as feedback on whether the learning design has achieved its intent." (Lockyer, Heathcote & Dawson, 2013, p.1446).

In addition, students' learning behaviour does not necessarily provide insight into their thinking and cognition (see Kennedy, 2004). Although sometimes students' thinking or cognition is captured in learning analytics data (e.g., text responses most notably, but also data like students' answers to multiple choice questions), in the main, learning analytics capture behavioural responses from which cognition needs to be implied. For example, the act of logging into the LMS and accessing PDF text does not necessarily mean that a student has read or understood something from that text. Significant caution must therefore be exercised when interpreting learning analytics data, to avoid using them as potentially unreliable behavioural proxies for learning. Reference to learning design can help teachers consider what is being measured by different tools within online learning systems to ensure that the metrics are interpreted appropriately and not beyond their scope.

In summary, useful advances in educational technology research and practice can potentially be made by integrating the fields of learning design and learning analytics, provided that the learning design is sufficiently well described so that learning analytics data can be meaningfully interpreted.

Completing the Loop

The aim of this project was to "complete the loop" by returning meaningful data to teachers to inform teaching and learning interventions. The idea of creating a tool to bridge a gap in the feedback loop between teachers and students was inspired by Laurillard's (2002) Conversational Framework. This framework proposes that students' learning processes need to be supported by an iterative loop of interaction, dialogue and feedback between teachers and students. A learning interaction begins when a learning activity is designed and presented by a teacher to students. The students then engage with the activity (e.g., read a learning resource, participate in a discussion, etc.) using their current understanding of the topic. The ways that students engage produces a form of feedback to the teacher on which they can reflect and act. It may be that the teacher decides to re-present material, provide some form of remediation, or provide further feedback to students. This action initiates a new loop or cycle.

Learning analytics can play a part in this conversational feedback loop by providing teachers with information about students' activities and engagement with learning tasks so they can reflect on student learning processes. This information can be used by teachers to provide feedback to students or as evidence to inform changes and improvements to learning resources and/or learning design. It can be used to provide interventions for all students in a course, or to identify individual students who may need additional support. The conversational framework provides a way to consider how learning analytics can be used to support both students and teachers in creating a better environment for learning.

3: TEACHERS' PERSPECTIVES

Overview of the Study

The first phase of the study explored teachers' perspectives on the potential of learning analytics to address teaching and learning issues relating to the online learning environment. A series of interviews were completed which aimed to:

1. Determine how learning analytics could be used to assist teachers to address common educational challenges; and
2. Provide information to inform the design specification of the web-based analytics tool.

A total of 12 interviews were held with teachers, four from each of the three participating universities. A purposive sampling approach was adopted to ensure a spread of disciplines (e.g., arts, sciences, professions) and class sizes (e.g., fewer than 50, 50-100, more than 100). Participants were asked to describe the learning designs they used in their course at both broad (i.e., course structure and curriculum) and granular (i.e., design of particular learning activities) levels. They were then asked to explain how they used technology-based tools to support these learning designs. This was followed by an exploration of any issues or challenges that the teacher or their students faced in the classroom and/or in online learning environments. Participants were then asked to consider ways that learning analytics could be used to address these challenges.

As teachers often have difficulty articulating their needs in relation to learning analytics (Corrin, Kennedy & Mulder, 2013), examples of learning analytics reports and dashboards were shown as prompts for participants to consider ways in which existing and new types of analytics could address their teaching and learning challenges. The interview concluded with a discussion of the actions that participants could take, and would be prepared to take, in response to the analytics to address the educational issues and challenges they identified.

Main Themes

A thematic analysis was conducted on the interview transcripts and several themes were identified. The six main themes will be considered here.

Basic Needs

We expected that teachers would request learning analytics solutions of varied sophistication (e.g. basic frequency counts through to more advanced analyses and visualisations). Perhaps surprisingly, the majority of requests for learning analytics were relatively basic in nature. These requests were influenced by factors such as class size, teaching methods, the level of technology use, existing data reports available and time to engage with the data. Some teachers had already considered what data interested them and had set up manual processes to access and analyse these data themselves. A few relied on standard reports provided through the learning management system. Others acknowledged that they would like to know more about students' activities within their course, but didn't have a sense of what was possible in terms of available data and suitable analysis techniques.

Engagement Analytics

Many requests from teachers focused on analytics that related to engagement. Most common was the request to see the frequency of access to particular resources or groups of resources. In particular, access to lecture notes and recordings was identified as important to teachers as measures of student engagement. There was also interest in seeing how many students read course announcements and discussion board messages. The ability to see when the students accessed the resources in relation to a class time or assessment deadline was also requested by several teachers, as was the ability to look at the proportion of students accessing resources in the sequence set out by the teacher in the learning design (e.g., accessing particular resources prior to and in preparation for a particular learning task or assessment).

Some teachers wanted to delve into more specific engagement details. For example, for video resources, they were interested in how often students accessed a particular video, and how long they persisted with watching. For videos that were accessed multiple times, one teacher requested the ability to relate student behaviour with demographic details such as international/domestic status. The analysis of multiple accesses to resources was said to be useful for identifying areas that might be more challenging to students, highlighting the need for improved or additional resources relating to these topics.

Clustering of Student Groups

A common request was the ability to look at engagement and performance patterns for certain groups of students. For instance, teachers were curious about possible differences in patterns of engagement for students who downloaded lecture videos, compared to those who streamed them online. One teacher asked for the ability to compare engagement and performance statistics of one cohort with another, to see whether changes to assessment or course design had an impact. Another asked to be able to compare general engagement and performance levels with other courses within the degree program, or to be able to track a single student across several courses to assess trends in performance. Several teachers wanted to be able to create engagement profiles (e.g., those who constantly accessed the LMS vs. those who only accessed resources at peak times) to see if these correlated with differences in student performance. Another suggested that it would be useful to visualise the proportion of the course resources accessed by different student groups.

Limited Use of Technology Tools

The sample in this study included teachers from across different disciplines and with different class sizes and teaching approaches. Notably, most participants said that they made only limited use of technology to support their teaching and learning activities. This may be a result of the predominantly blended nature of teaching and learning in the three participating institutions. All teachers interviewed made use of an LMS to deliver resources to students, and the majority (10 out of 12) of courses provided lecture capture. Most courses (9 out of 12) used a discussion board. However, this was often an optional area for course communication rather than integrated into the curriculum. Only five out of 12 teachers used online quizzes and only one-third used Turnitin for assessment submission. Other technologies such as blogs, wikis, clickers, Twitter and Facebook were only used by one or two teachers. Across these courses, technology was used primarily as a delivery mechanism rather than for deep interactions which impacts the availability of data.

Multiple Data Sources

Teachers offered several suggestions for combining data about students gathered from the LMS with data from other sources. For example, some participants asked whether it would be possible to compare patterns of access to resources with feedback from student evaluation surveys in order to help determine which resources were most effective and identify new resources that might be required. Other examples included the ability to compare students' patterns of engagement with demographics from the student information system and attendance data. Another related concept was the request to be able to create other data sources such as mapping assessment items (e.g., quiz questions) to particular competencies in order to perform analyses on individual students or on a group's performance.

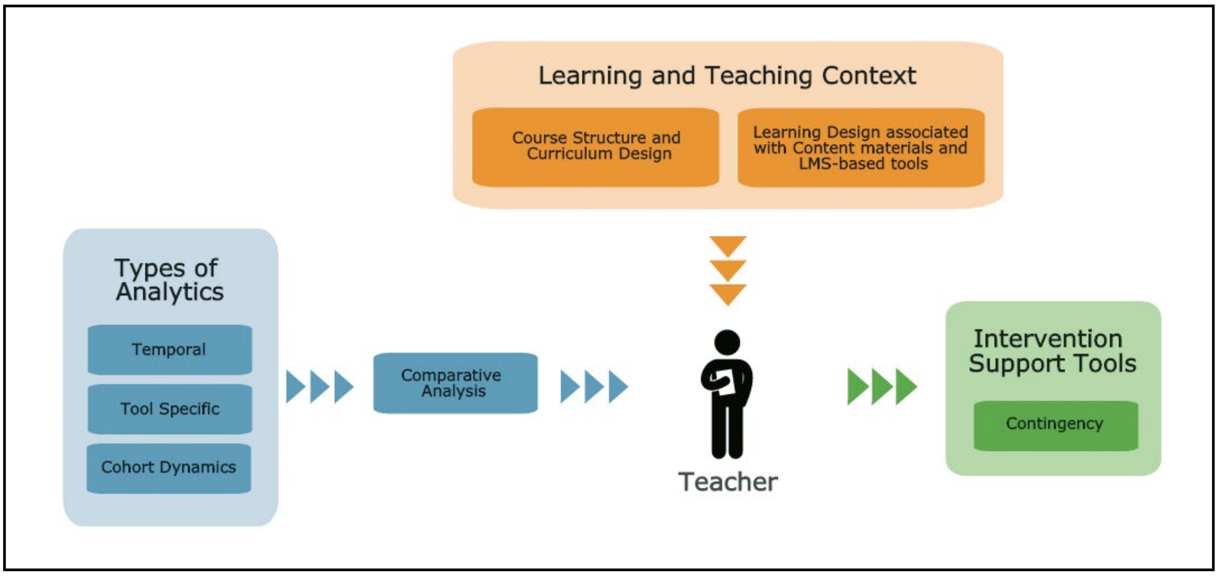
Ability to Interpret and Act on Data

Several participants expressed concern about their ability to interpret data and analytics about student activity. They identified a significant need for training in this area, both in relation to interpreting analytics as well as increasing knowledge of the types of analytics that could be useful for improving their practice. However, even if the teacher had the ability to interpret the data, there was concern about the time it would take to collect, analyse and develop actions based on the learning analytics data. This was especially important in larger courses where teachers felt that time and personnel resources were prohibitive to using analytics in a proactive way to identify and intervene with students at risk.

Conceptual Framework

The results from the interviews conducted with staff combined with the case summaries of each of the Phase 3 pilot courses were used to inform the development of a conceptual framework bringing together learning analytics and learning design (see Figure 1). Within the framework, the teacher plays a key role in linking the teaching and learning context with the analysis of the data to inform decision making around feedback and course design. Bringing together teachers' enacted practice (i.e., learning designs) and different types of analytics in a framework like this can inform the development of analytics tools to provide more meaningful representations of data for teachers.

FIGURE 1: The Learning Analytics for Learning Design Conceptual Framework



The framework consists of five dimensions:

1. Temporal analytics: analytics that show patterns of engagement and access to resources across a particular time period or in relation to a defined single/recurring learning event.
2. Tool-specific analytics: analytics that relate to activities conducted using specific tools within a learning management system such as quiz tools, discussion boards, etc.
3. Cohort dynamics: analytics that provide information about patterns of access, engagement and/or performance of an individual student or a group of students.
4. Comparative analytics: analytics that allow teachers to compare different types of activities that may occur within the same or different time periods.
5. Contingency: analytics that facilitate the identification of an individual, group or multiple groups of students that meet a certain set of predefined parameters.

A more detailed explanation of the development of this framework and its relation to the design of the Loop Tool can be found in Bakharia et al (2016).

4: THE LOOP TOOL

The Loop Tool was developed to integrate teachers' pedagogical intent, as articulated by their learning design, with students' learning processes, captured through learning analytics. Design principles were established to guide the development of a tool that combined knowledge from previous literature and existing tools with the findings from the interviews conducted during the first phase of this project. The resulting Loop Tool included two main elements: a Pedagogical Helper Tool and a Learning Analytics Tool. The Pedagogical Helper Tool enables teachers to articulate the connections between learning outcomes, learning design and learning technologies used. The output of the Pedagogical Helper Tool is a map to guide teachers when interpreting data from the Learning Analytics Tool. In turn, the Learning Analytics Tool presents visual representations of data from the learning management system, highlighting important aspects related to the learning design of each course.

Further information about the Loop Tool is available at the project website http://melbourne-cshe.unimelb.edu.au/completing-the-loop. The following sections present detail of the design principles that guided the development of the Loop Tool, including the pedagogical helper and learning analytics components.

Design Principles

Four influences informed the design of the Loop Tool. Firstly, Laurillard's conversational framework (as presented in Chapter 2) recognises that learning involves interaction. Translating this concept into an analytics design requires graduating from simple access counts to focus on analytics that provide more detailed information about student interactions with learning activities and resources. The second, and related, notion is that in order to understand the output of learning analytics there needs to be an understanding of the learning design that underpins the activities and tasks that students are engaging in online. Third, the Loop Tool is both fuelled and constrained by the functional affordances of the particular technology-based tools and LMS that teachers and students are using. This in turn determines what forms of data can be exported and visualised by the Loop Tool. Finally, findings from the interviews conducted during the extensive investigation phase of this project with university teachers across the participating institutions resulted in the Learning Analytics for Learning Design Conceptual Framework presented in Chapter 3.

Based on these main influencers, four design principles were created to guide the Loop Tool development. Table 1 presents each of these principles as well as their rationale, tensions to consider, and how they can be operationalised within the project to address these tensions.

TABLE 1: **Design principles that guided the Loop Tool development.**

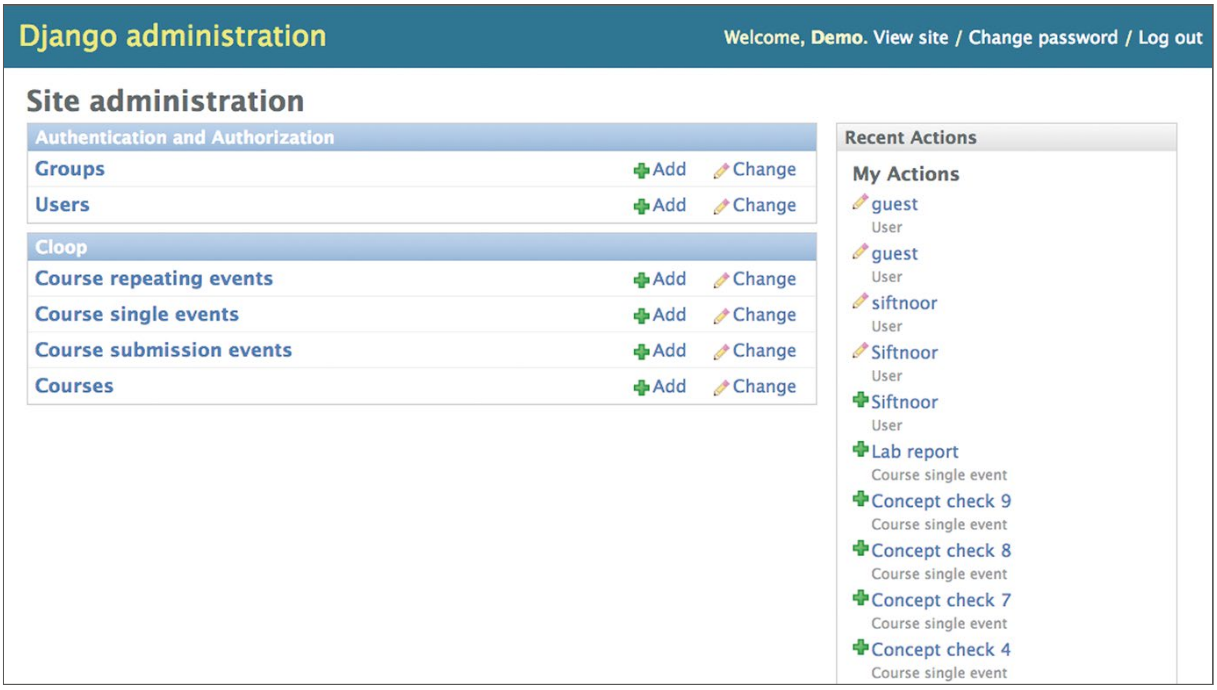
PRINCIPLE	RATIONALE	TENSIONS TO CONSIDER	OPERATIONALISATION
Apply learning analytics to data from common LMSs	Required by most universities in Australia Teachers already use LMSs, mainly Moodle and Blackboard	Moodle and Blackboard have limitations on what data is provided and when Although Moodle and Blackboard are similar, they have some technical differences	Develop a tool for both Moodle and Blackboard as similar as possible to each other
Learning analytics must be linked to learning design	Teachers should acknowledge their learning design before accessing and interpreting analytics	The terminology associated with technology-based tools may be more familiar to teachers than learning design terminology	Have a learning design component of the tool that enables teachers to "acknowledge" or describe their pedagogical intent Link the acknowledgement to a technology-based tool Use the technology-based tool as a doorway to learning analytics
Accommodate common teaching practices	Diversity of ways to set up a LMS for the same learning design Diversity of technology/ tools used by teachers	Some teachers have shown interest in getting basic learning analytics, without a clear connection to the learning design	Allow basic access/use data to be returned to teacher Also allow sophisticated activity-based data to be returned to teacher
Provide timely sets of learning analytics data to teachers	Teachers want learning analytics for particular time periods	Not clear what is the appropriate and feasible timing of learning analytics reports	Allow a period of time to be specified by the end user

It was decided that the Loop Tool would (1) accommodate data from the two most commonly used learning management systems (LMS) in Australia: Moodle and Blackboard, (2) have two interconnected components: one focusing on learning design and one on presenting learning analytics visualisations; (3) present both basic and more sophisticated learning analytics; and (4) allow data to be updated and displayed in a flexible way.

Overview

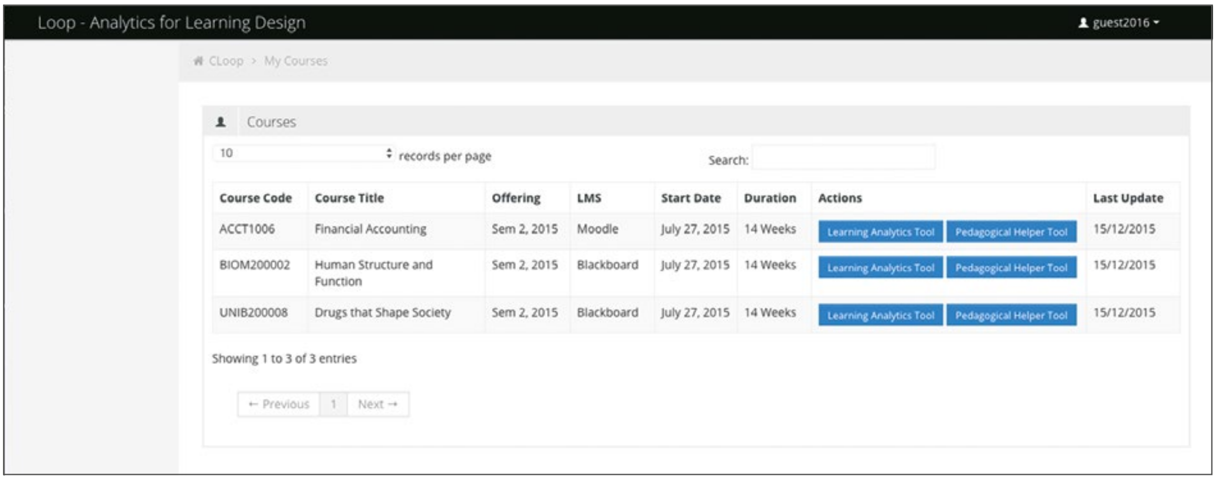
Once the Loop Tool has been implemented at an institution (see Appendix A), the tool may be accessed through a server or URL (as determined by each institution). There are two levels of access for users in the Loop Tool: administrator and educator. The administrator can create new users, group users according to their permissions to facilitate user management, grant access for specific courses, create courses to use the Loop Tool, and create events for courses. Events are defined as key instructional activities that represent milestones for a course related to the learning design. There are three types of events in the Loop Tool: weekly repeating events (e.g., a lecture every Tuesday), single events across the semester (e.g., a field trip in week 4), and submission events (e.g., an online quiz that is available online from week 7 until week 9). Figure 2 presents a screenshot of the administrator homepage.

FIGURE 2: The administrator homepage



The educator profile allows teachers access to one or more courses. This gives users access to the Pedagogical Helper Tool and the Learning Analytics Tool for all courses they have permission to view. Figure 3 presents a screenshot of the educator homepage.

FIGURE 3: The educator homepage

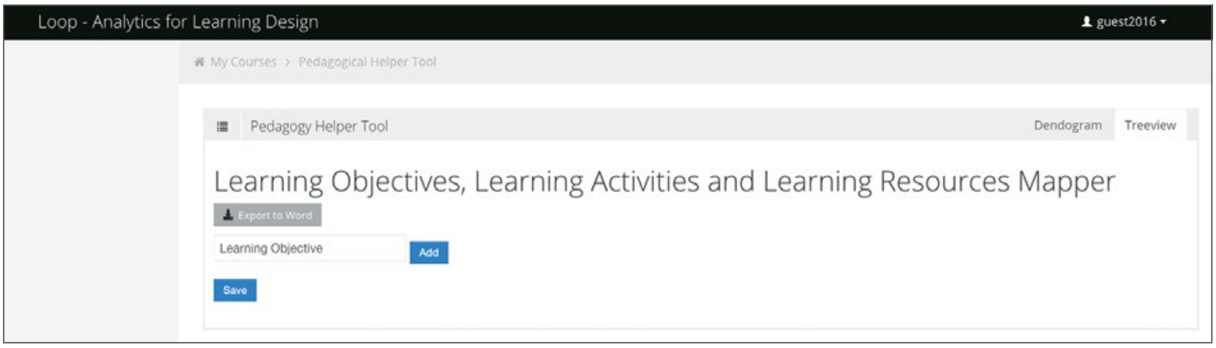


The following sections provide an overview of the Pedagogical Helper and Learning Analytics components of the Loop Tool.

Pedagogical Helper Tool

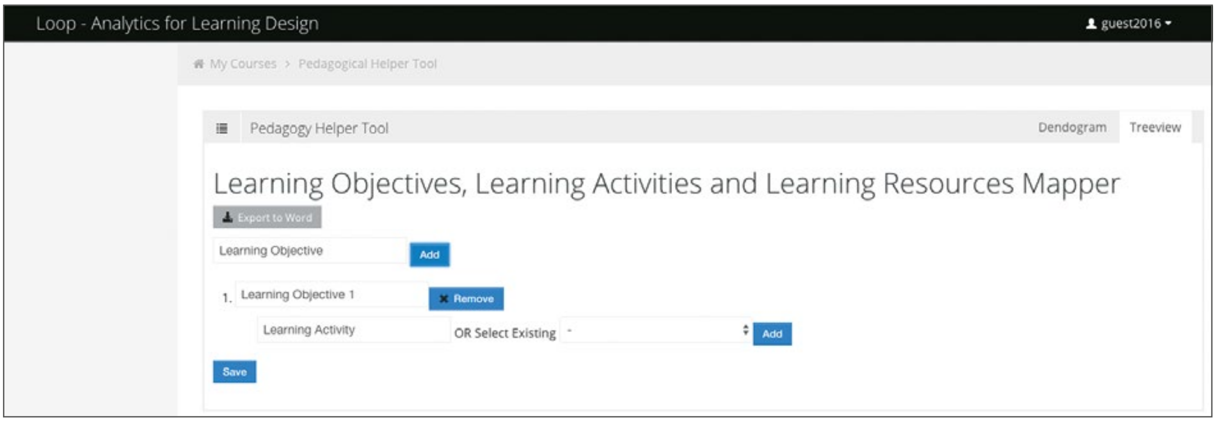
The Pedagogical Helper Tool provides a space for teachers to articulate the association between the learning objectives, learning activities and the technologies used in their course. The first step is to add the learning outcomes of the course. A teacher may add as many learning objectives as necessary.

FIGURE 4: Adding a learning objective in the Pedagogical Helper Tool



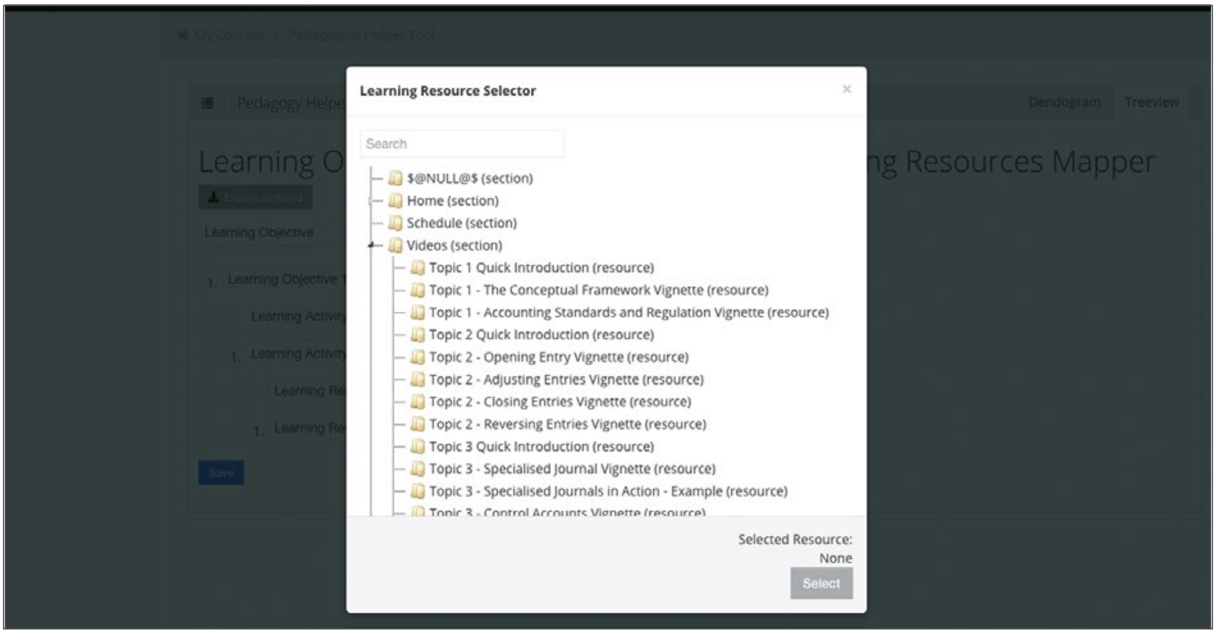
For each learning objective the teacher can then add one or more learning activities designed to help students to achieve that objective (Figure 5). For example, a learning activity could include a pre-reading for a lecture or an online interactive module that the students are required to complete.

FIGURE 5: Adding a learning activity associated with a learning objective



Finally, for each learning activity one or more learning resources can be defined (Figure 6). If the learning resource is something that is available to students via the LMS, the teacher can select it from a list of LMS resources by clicking on the 'Course Structure' button. If the learning resource is not available on the LMS the teacher can enter a name for the resource in the text box so that it can still be represented on the learning design map.

FIGURE 6: Adding learning resources to a learning activity



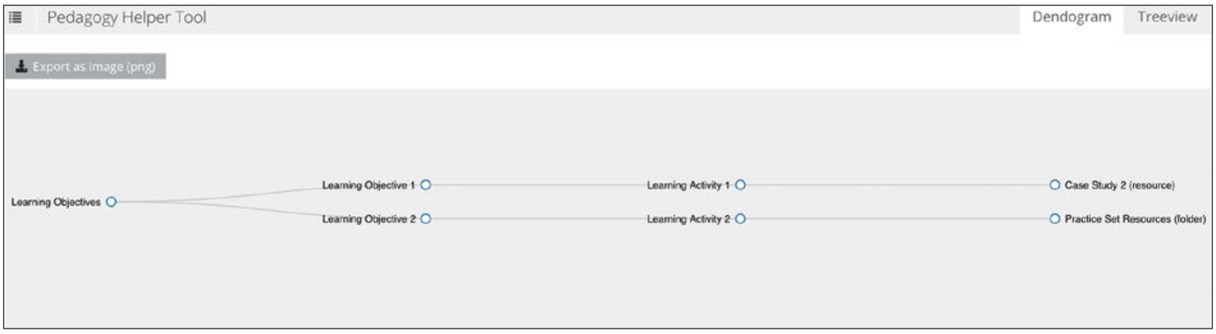
Once a learning activity or resource is added to the Pedagogical Helper Tool, it becomes available to be selected for other learning outcomes or learning activities. This allows a learning activity to be easily associated with two or more learning outcomes, and a learning resource to be associated with two or more learning activities.

The connections created between learning objectives, learning activities and learning resources can be exported as a table in a Microsoft Word document, as illustrated in Figure 7, or a dendogram, as shown in Figure 8. These represent the main output of the Pedagogical Helper Tool: a text/visual map linking learning design (represented by learning objectives and learning activities) with learning analytics (represented by the learning resources). This map can be used as a point of reference by teachers when exploring data in the Learning Analytics Tool.

FIGURE 7: Word document output of the Pedagogical Helper Too

Learning Objectives	Learning Activities	Learning Resources
1. Learning Objective 1		
	2. Learning Activity 1	
		456750. Case Study 2 (resource)
2. Learning Objective 2		
	2. Learning Activity 2	
		456710. Practice Set Resources (folder)

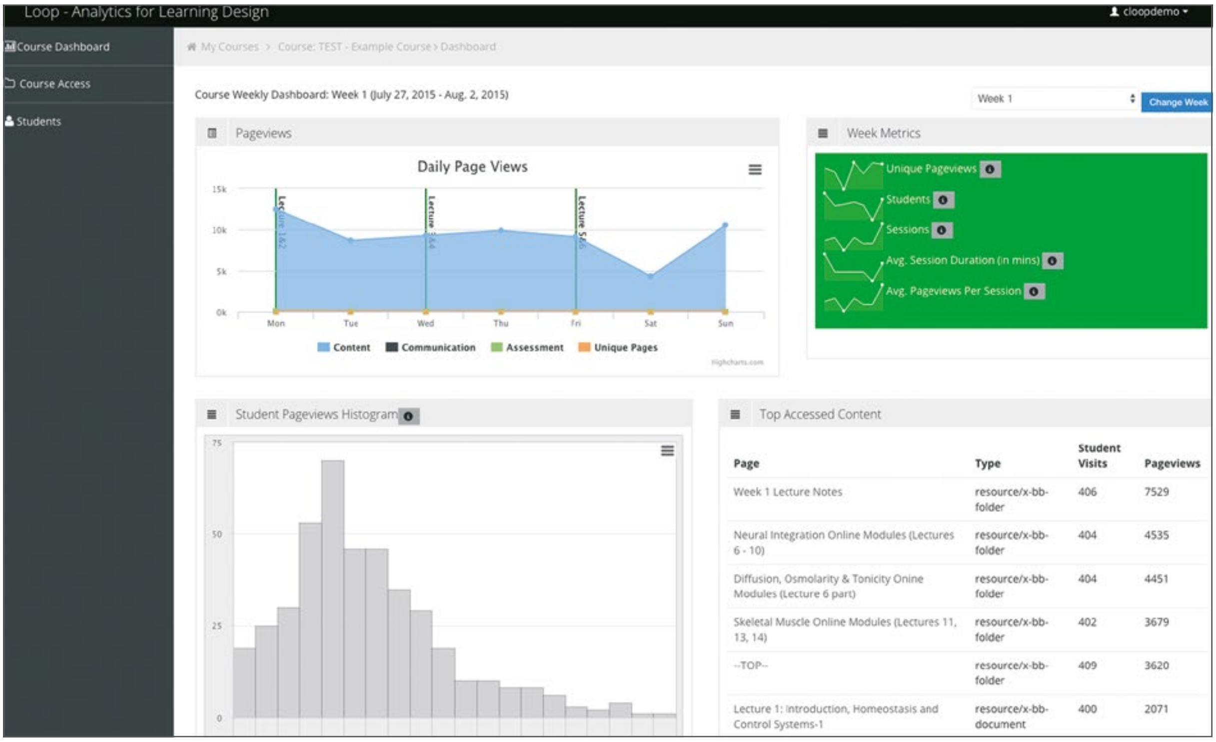
FIGURE 8: Dendrogram output of the Pedagogical Helper Tool



Learning Analytics Tool

The Learning Analytics Tool is designed to display LMS data to teachers in meaningful ways. There are three main sections that make up the Learning Analytics Tool: course dashboard, course access, and students. The course dashboard presents a summary of all students' interactions with the LMS over different weeks or an overall view of the whole course. The course access section presents access data for the content, communication and assessment resources in the LMS. The students section allows drilling down to specific students and exploration of their interactions with the LMS throughout the course. These sections are easily accessed from the Learning Analytics Tool menu on the left of the screen, as presented in Figure 9.

FIGURE 9: The Learning Analytics Tool dashboard (with menu items on the left-hand side)



Information buttons (represented by the letter “i”) are available throughout the Learning Analytics Tool to provide additional support. When hovered over, these buttons provide more detailed information about specific features of the tool.

Course Dashboard

The course dashboard gives an overview of students’ interaction with the LMS via different graphs and tables. At the top of the dashboard, the Pageviews graph shows students’ interactions with the LMS for a specific week (Figure 10) or overall across the course (Figure 11). The choice of view (by week or all) can be made using the drop down menu on the top right-hand side of the screen followed by clicking the “Change Week” button to refresh the visualisations. The Pageviews graph shows a total count of students’ access to the pages within different sections of the LMS categorised by content, communication and assessment. The content, communication and assessment categories show the total number of times pages in that category were accessed, including repeat visits to the same page. The unique pages category represents the total number of overall unique pages accessed each day. Clicking on the title of these labels (content, communication, assessment, unique pages) will remove or add these details to the graph. This is useful to focus on a single category or compare between two or more categories.

FIGURE 10: Pageviews graph (weekly view)

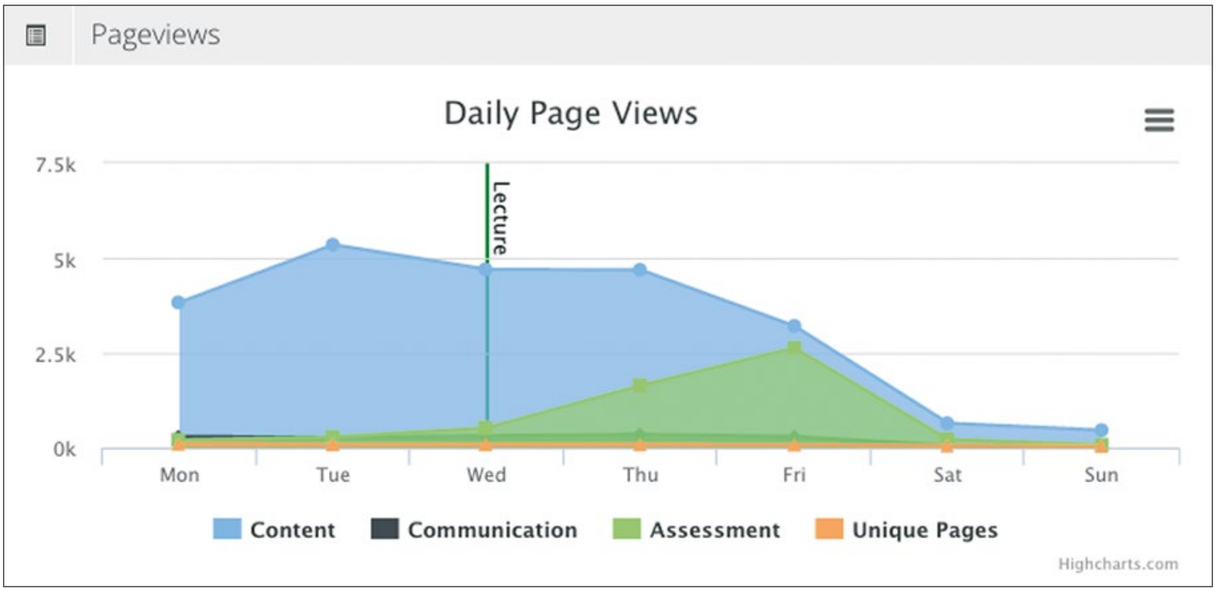
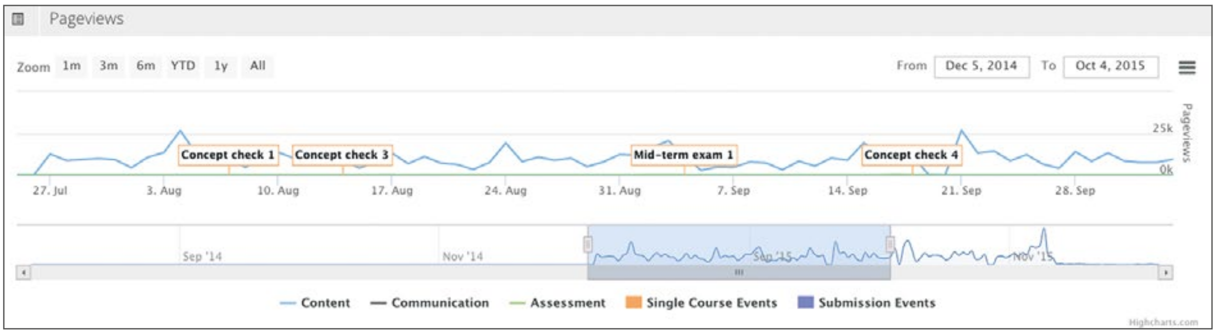


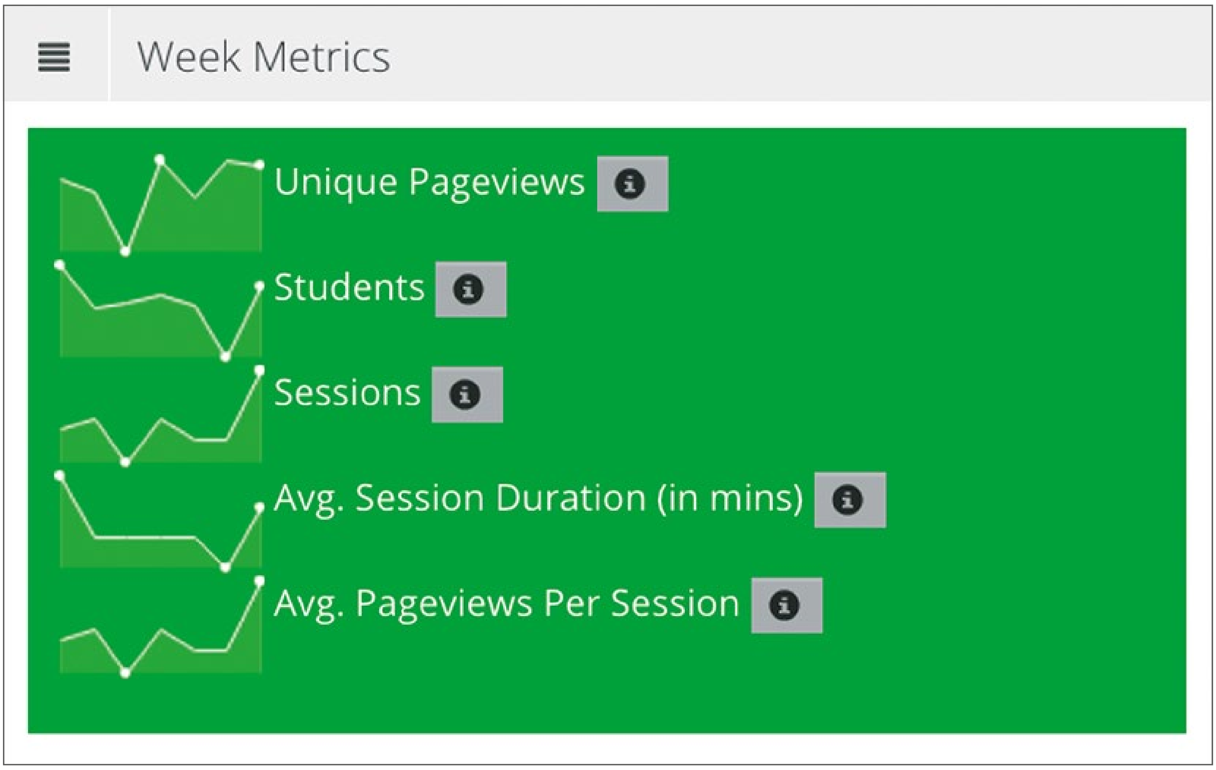
FIGURE 11: Pageviews graph (overall course view)



As part of the Pageview graphs, instructional events are displayed to give a point of reference for interpreting access patterns. In the weekly view graph, recurring events (e.g., lectures, tutorials, etc.) are displayed as green vertical lines (see Figure 10). On the overall course view graph, the events are represented by labels above the relevant dates (see Figure 11).

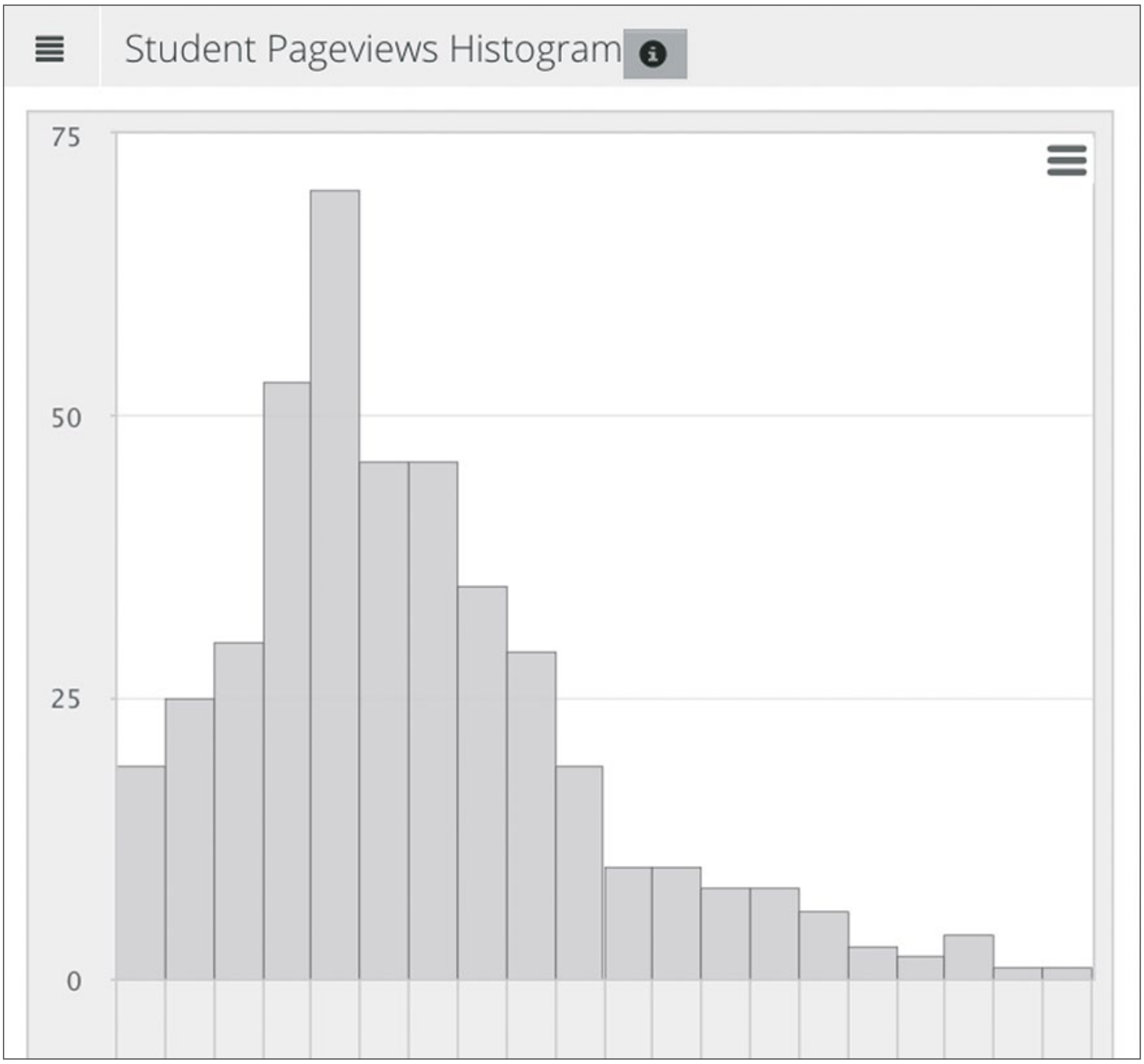
The week metrics box presents snapshots of how students interacted with the course each day of the selected week (Figure 12). The unique pageviews graph displays the number of non-repeating views across the whole site. The students graph presents the number of unique students who accessed the LMS across the week. The session graph shows the number of LMS sessions per day in the selected week. A session is defined as a period of time where the time between clicks is less than 40 minutes. The final two graphs in the week metrics box present the average session duration in minutes and the average number of pageviews per session across the selected week.

FIGURE 12: Week metrics box with five graphs



The student pageviews histogram shows the number of unique students who have viewed a certain range of pages in that week (Figure 13). This graph allows teachers to identify the distribution of students' access patterns in the LMS. For example, in some weeks students may access the LMS and only visit a few pages, with the distribution concentrated on the left side of the histogram. While in other weeks students may access the LMS and visit a broader range of pages, with the distribution concentrated on the right side of the histogram. Unusual or unexpected patterns can be easily identified and may prompt further investigation of students' interactions with the course.

FIGURE 13: **Student pageviews histogram with number of unique students on the vertical axes and range of unique access to pages on the horizontal axes**



In addition to the graphs, the dashboard also includes four tables: top accessed content, top course visitors, communication access, and assessment access. These tables allow teachers to quickly identify the most accessed resources and the most active students (based on number of page accesses) in the LMS for the selected period of time. The top accessed content table (see Figure 14) lists the most accessed content, including the name of the page, the page type, the number of student visits and number of pageviews. The top course visitors table ranks students with the highest level of access to the LMS and includes their names and number of pageviews. Below these two tables are communication and assessment access tables which list the communication and assessment resources accessed. The communication table includes discussion forum names, the number of unique student views, number of pageviews and number of posts. The assessment table includes the name of the assessment, the assessment type, the number of unique student views, number of attempts and average score.

FIGURE 14: Top accessed content table

Top Accessed Content

Page	Type	Student Visits	Pageviews
Week 1 Lecture Notes	resource/x-bb-folder	406	7529
Neural Integration Online Modules (Lectures 6 - 10)	resource/x-bb-folder	404	4535
Diffusion, Osmolarity & Tonicity Onine Modules (Lecture 6 part)	resource/x-bb-folder	404	4451
Skeletal Muscle Online Modules (Lectures 11, 13, 14)	resource/x-bb-folder	402	3679
--TOP--	resource/x-bb-folder	409	3620
Lecture 1: Introduction, Homeostasis and Control Systems-1	resource/x-bb-document	400	2071
Lecture 5: Embryological origins of anatomical structures 2	resource/x-bb-document	397	2045
Lecture 2: Nervous system & nerves 1	resource/x-bb-document	401	2044
Lecture 4: Embryological origins of anatomical structures 1	resource/x-bb-document	399	2034

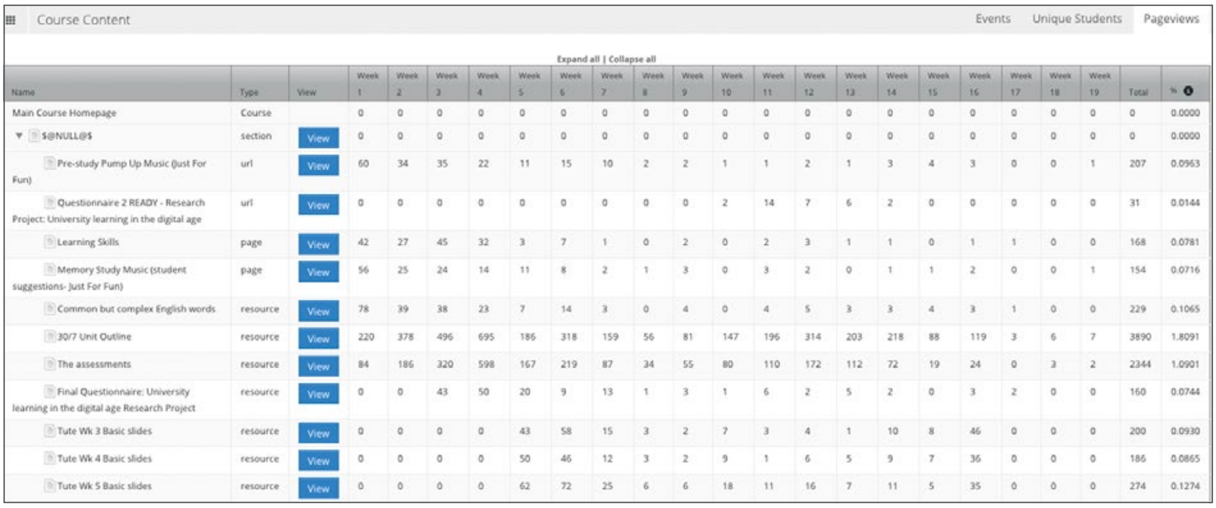
Course Access

The course access section is composed of three subsections: content, communication and assessment. The tables in this section are presented using the LMS course structure. This means that all content, communication (i.e., discussion boards) and assessments created in the LMS are automatically displayed in the Loop Tool. This includes all resources even if not visible to students (i.e., hidden items). To avoid the tables being too busy it is recommended that teachers delete any unnecessary resources in the LMS course before integrating it with the Loop Tool. This will minimise any difficulty in finding and visualising relevant information.

Content

In the content section, users can examine the frequency that resources have been accessed during the course. This section opens automatically to the Pageviews table (Figure 15) which presents a cumulative count of access to each page. The last column includes the percentage the resources represents of the total pageviews for the course. This helps to identify which resources have been accessed most frequently.

FIGURE 15: Pageviews table in the Course access > Content section



Course Content | Events | Unique Students | Pageviews

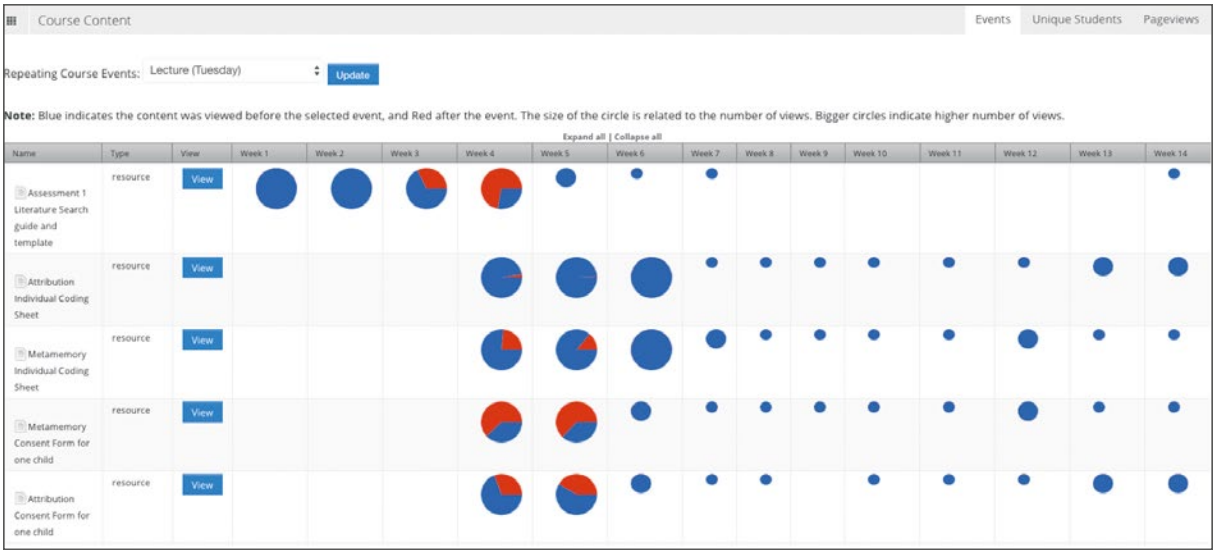
Expand all | Collapse all

Name	Type	View	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Total	%
Main Course Homepage	Course		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
▼ $@NULL@$	section	View	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
Pre-study Pump Up Music (Just For Fun)	url	View	60	34	35	22	11	15	10	2	2	1	1	2	1	3	4	3	0	0	1	207	0.0963
Questionnaire 2 READY - Research Project: University learning in the digital age	url	View	0	0	0	0	0	0	0	0	0	2	14	7	6	2	0	0	0	0	0	31	0.0144
Learning Skills	page	View	42	27	45	32	3	7	1	0	2	0	2	3	1	1	0	1	1	0	0	168	0.0781
Memory Study Music (student suggestions- Just For Fun)	page	View	56	25	24	14	11	8	2	1	3	0	3	2	0	1	1	2	0	0	1	154	0.0716
Common but complex English words	resource	View	78	39	38	23	7	14	3	0	4	0	4	5	3	3	4	3	1	0	0	229	0.1065
30/7 Unit Outline	resource	View	220	378	496	695	186	318	159	56	81	147	196	314	203	218	88	119	3	6	7	3890	1.8091
The assessments	resource	View	84	186	320	598	167	219	87	34	55	80	110	172	112	72	19	24	0	3	2	2344	1.0901
Final Questionnaire: University learning in the digital age Research Project	resource	View	0	0	43	50	20	9	13	1	3	1	6	2	5	2	0	3	2	0	0	160	0.0744
Tute Wk 3 Basic slides	resource	View	0	0	0	0	43	58	15	3	2	7	3	4	1	10	8	46	0	0	0	200	0.0930
Tute Wk 4 Basic slides	resource	View	0	0	0	0	50	46	12	3	2	9	1	6	5	9	7	36	0	0	0	186	0.0865
Tute Wk 5 Basic slides	resource	View	0	0	0	0	62	72	25	6	6	18	11	16	7	11	5	35	0	0	0	274	0.1274

There are two other views available for this table and these are accessible from the top right-hand corner of the table. The unique students tab provides a table that displays a total for each resource representing the number of unique students who have accessed that resource. This gives the teacher a quick way to see how many students in relation to the total number of enrolled students who have been accessing resources in particular weeks.

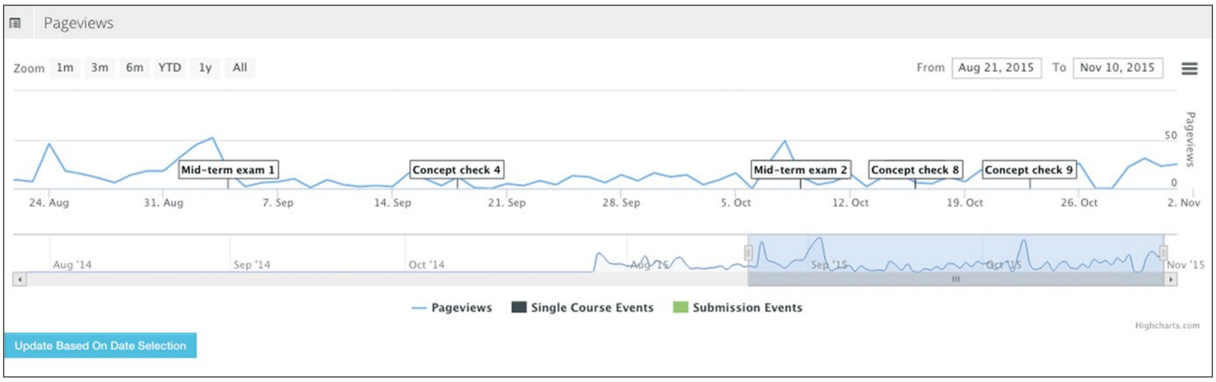
The events tab provides a visualisation of students' access to each resource relative to a specific event in the course. Once the specific event has been selected from the dropdown menu at the top of the screen, the events tab presents a circle for each week indicating the percentage of students who accessed the resource before and after the event (Figure 16). The blue part of the circle indicates the percentage of students who accessed the resource before the selected event, and the red part of the circle represents the percentage who accessed the resource after the event. The size of the circle is relative to the number of views. Larger circles indicate a higher number of views. The percentage and total number of students' access before and after the event can be viewed by hovering the mouse over the circle.

FIGURE 16: Events tab in the Course access > Content section



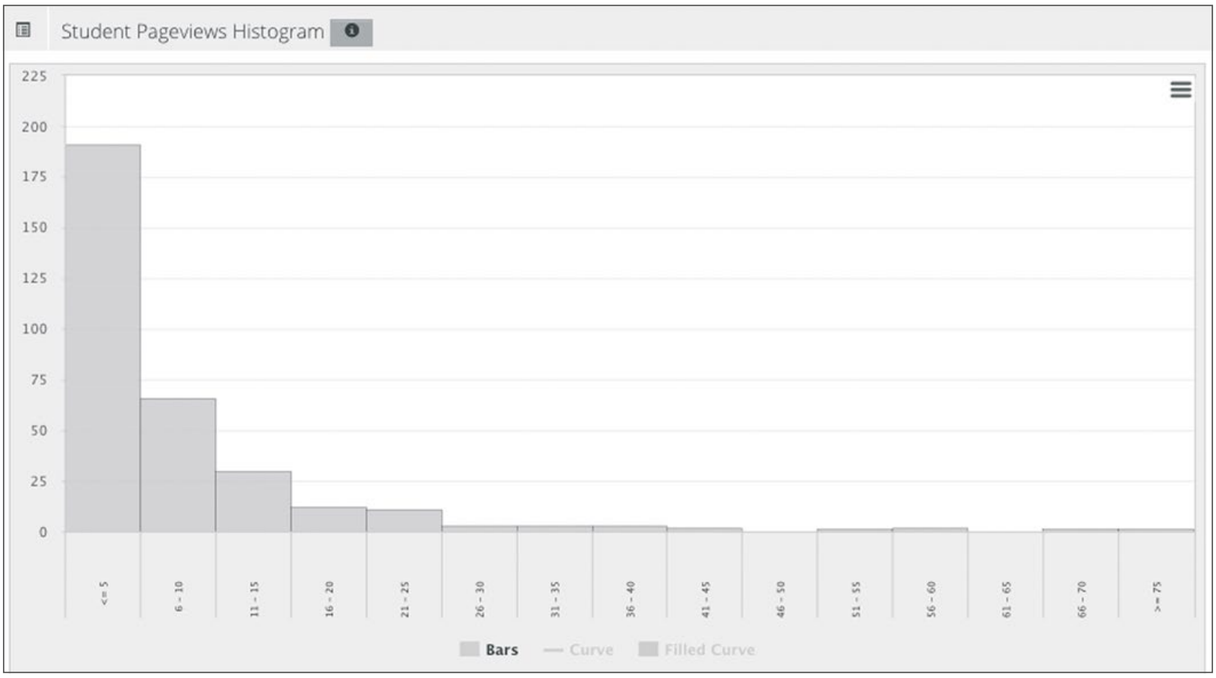
From each of the tables in the content section there is an option to view more detailed information about the resource by clicking on the "View" button next to the relevant resource. These resource pages contain a pageviews graph, a histogram graph and a table listing students who have not yet accessed the resource. The pageviews graph shows the trend of student access to the selected resource across the course (Figure 17) as well as in relation to critical events across the course timeline.

FIGURE 17: Pageviews graph of students' access to a specific resource across the course



The student pageviews histogram presents the number of unique students who have viewed the selected resource within a certain range of times during the course (Figure 18). This graph allows teachers to identify the distribution of students' patterns of access to this specific resource.

FIGURE 18: Student pageviews histogram with number of unique students on the vertical axes and range of number of access to the selected page on the horizontal axes



The students with no views table at the bottom of the page lists all students who have not accessed the specific resource so far. The table includes students' names and email addresses. Teachers can use this information to contact students if engagement with the resource is critical to the learning design of the course.

Communication

The communication section of the Loop Tool presents information relating to students' interactions with discussion forums within the LMS. This section opens automatically on the access table which shows the page access totals for each discussion forum in the course (Figure 19). These figures relate to the number of times the discussion forum has been viewed. The last column presents the percentage of views for the discussion forum in relation to the total pageviews for the course.

FIGURE 19: Access table in the Course access > Communication section

Course Communication — Events | Unique Students | Posts | Access

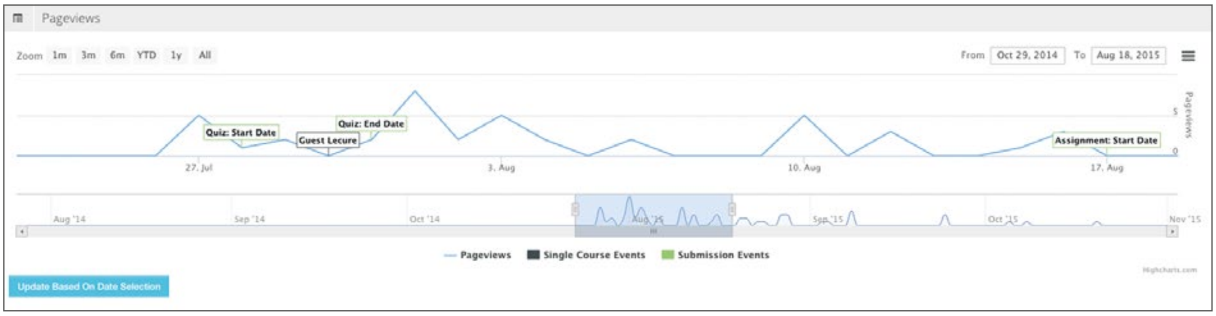
Pageviews

Name	Type	View	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Total	%
All Forums	Forum		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
Financial Accounting 1 - Course Content Forum	forum	View	0	0	0	23	261	201	423	983	43	29	68	120	337	517	178	205	402	337	0	4127	2.2637
Financial Accounting 1 - Off-Campus Student Forum	forum	View	0	0	0	1	144	45	89	395	16	54	59	82	292	131	15	8	21	58	0	1410	0.7734
Financial Accounting 1 - Administrative Queries Forum	forum	View	0	0	0	3	69	70	64	111	5	10	28	25	52	44	31	25	53	54	0	644	0.3532
News forum	forum	View	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0.0016
Total			0	0	0	27	476	316	576	1489	65	93	155	227	681	692	224	238	476	449	0		

Similar to the content section, the course communication table has a number of tabs accessible from the top right-hand corner. The posts tab presents the total number of posts students have made to each discussion forum per week and in total. The unique students tab shows the number of unique students who have viewed each discussion forum across the weeks of the course and in total. The events tab provides a visualisation of students' access to each discussion forum relative to a specific event in the course. Once the specific event has been selected from the dropdown menu at the top of the screen, the events tab presents a circle for each week indicating the percentage of views before and after the event. The blue part of the circle indicates the percentage of views before the selected event, and the red part of the circle represents the percentage of views after the event. The size of the circle is relative to the number of views. Larger circles indicate a higher number of views. The percentage and total number of students' access before and after the event can be viewed by hovering the mouse over the circle.

From each discussion board there is an option to view more detailed information by clicking on the "View" button. This detailed discussion forum page contains a pageviews graph, a histogram graph and a table listing students who have not yet accessed the discussion forum. The pageviews graph shows the trend of student access to the selected discussion forum across the course (Figure 20) as well as in relation to critical events across the course timeline.

FIGURE 20: Students' access to a specific discussion board across the course



The student pageviews histogram presents the number of unique students who have viewed the selected discussion forum within a certain range of times during the course. This graph allows teachers to identify the distribution of students' patterns of access to this specific discussion forum. The students with no views table at the bottom of the page lists all students who have not accessed the specific discussion forum so far. The table includes students' names and email addresses. Teachers can use this information to contact students if engagement with the discussion forum is critical to the learning design of the course.

Assessment

The assessment section presents students' interactions with the online quizzes and other assessment items within the LMS. This section opens automatically on the access table that shows the page access totals for each assessment item in the course (Figure 21). These figures relate to the number of times the assessment item has been viewed. The last column presents the percentage of views for the assessment item in relation to the total pageviews for the course.

FIGURE 21: Access table in the Course access > Assessment section

Course Assessment — Events | Unique Students | Grades | Access

Pageviews

Name	Type	View	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Total	%
Induction Declaration questions	assessment/x-bb-qti-test	View	1454	803	1185	1257	57	172	31	33	88	34	35	44	475	45	47	13	6	0	3	5782	0.4946
Concept Check 1: Membrane Potential	assessment/x-bb-qti-test	View	0	3843	1603	729	569	1545	76	113	160	377	1352	206	392	276	1935	1797	24	28	7	15032	1.2859
Concept Check 3: Nerve/Muscle Integration	assessment/x-bb-qti-test	View	0	0	1	2104	629	1662	78	121	178	367	1359	214	366	268	1778	1924	24	27	5	11105	0.9499
Concept Check 3: ANS and Endocrine Systems	assessment/x-bb-qti-test	View	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
Concept Check 9: Reproduction	assessment/x-bb-qti-test	View	0	0	0	0	0	0	0	0	0	0	1	0	423	304	1830	2165	12	36	5	4776	0.4085
Concept Check 4: Digestion	assessment/x-bb-qti-test	View	0	0	0	0	0	0	158	306	290	675	2841	224	343	243	1755	2008	18	15	11	8887	0.7602

Similar to the content and communication sections, the course assessment table has a number of tabs accessible from the top right-hand corner. The grades tab presents each student's score for each assessment across the course. The unique students tab shows the number of unique students who have viewed each assessment item across the weeks of the course and in total. The events tab provides a visualisation of students' access to each assessment item relative to a specific event in the course. Once the specific event has been selected from the dropdown menu at the top of the screen, the events tab presents a circle for each week indicating the percentage of views before and after the event. The blue part of the circle indicates the percentage of students who viewed the assessment item before the selected event, and the red part of the circle represents the percentage of views after the event. The size of the circle is relative to the number of views. Larger circles indicate a higher number of views. The percentage and total number of students' access before and after the event can be viewed by hovering the mouse over the circle.

Students' interaction with specific assessments can be examined in more detail by clicking on the "View" button next to the assessment item. This view includes a pageviews graph, a pageviews histogram, and a table that lists students with no views of the selected assessment. The pageviews graph shows the trend of student access to the selected assessment item across the course as well as in relation to critical events across the course timeline.

The student pageviews histogram presents the number of unique students who have viewed the selected assessment item within a certain range of times during the course. This graph allows teachers to identify the distribution of students' patterns of access to this specific assessment item. The students with no views table at the bottom of the page lists all students who have not accessed the specific assessment item so far. The table includes students' names and email addresses. Teachers can use this information to contact students if engagement with the assessment item is critical to the learning design of the course.

Students

The students section of the Learning Analytics Tool allows examination of each student's interaction with the LMS. The pageviews table (Figure 22) presents a cumulative count of views of pages in the course by week and in total. This includes views of content, communication and assessment pages. Shading is used to highlight high number of views (dark blue) as well as no views (white).

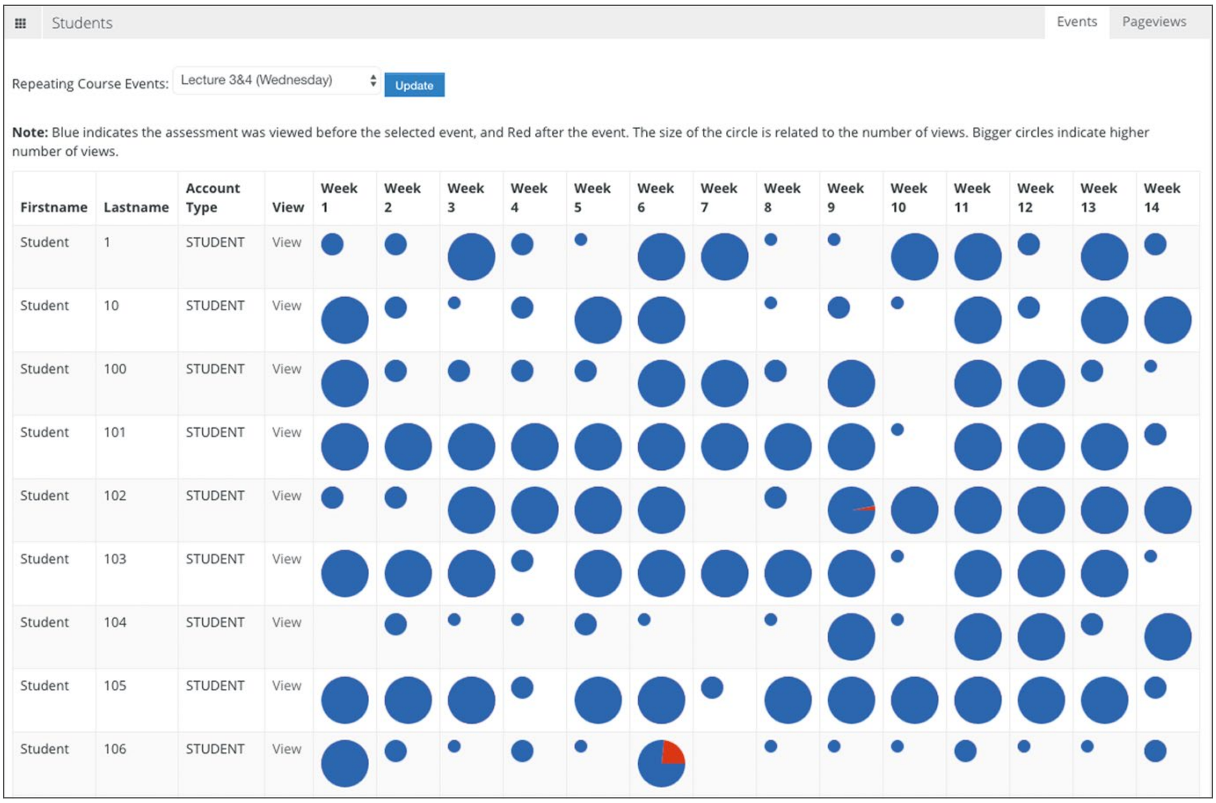
FIGURE 22: Pageviews table with shading relative to each students' number of access

Students | Events | Pageviews

Firstname	Lastname	Account Type	View	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16
Student	1	STUDENT	View	71	34	165	29	8	172	108	5	12	79	82	62	89	60	29	19
Student	10	STUDENT	View	99	54	14	36	128	413	0	1	34	7	259	49	488	405	720	120
Student	100	STUDENT	View	104	40	45	73	54	97	136	26	218	0	210	96	57	6	44	1
Student	101	STUDENT	View	174	157	81	161	246	138	155	105	146	25	359	128	93	34	16	3
Student	102	STUDENT	View	33	32	145	81	190	85	0	32	414	177	165	120	192	79	124	112
Student	103	STUDENT	View	170	156	152	46	120	102	123	118	166	6	111	120	145	18	48	163
Student	104	STUDENT	View	0	58	21	24	65	11	0	8	179	10	255	718	59	367	556	505
Student	105	STUDENT	View	234	145	265	65	155	262	70	229	386	144	325	180	574	47	292	116
Student	106	STUDENT	View	76	27	13	60	17	141	0	5	23	4	40	15	6	49	0	5
Student	107	STUDENT	View	300	223	63	252	87	80	13	201	84	213	152	138	303	34	199	105
Student	108	STUDENT	View	444	177	190	186	170	214	172	408	276	251	74	182	176	37	72	63
Student	109	STUDENT	View	77	150	97	63	150	31	484	51	193	181	161	216	214	14	44	18
Student	11	STUDENT	View	168	60	81	69	244	134	56	207	194	66	451	175	110	67	17	124
Student	110	STUDENT	View	176	250	216	247	196	230	131	103	167	266	130	229	223	55	80	18

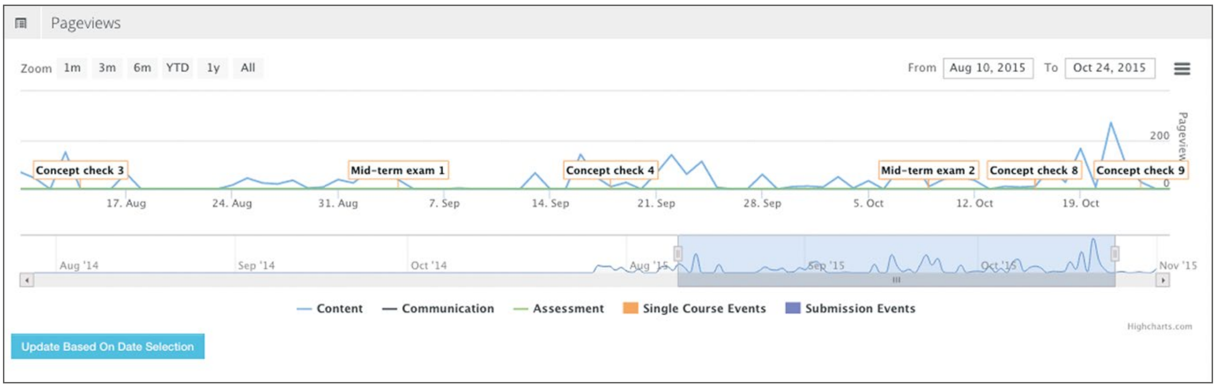
The events tab provides a visualisation of students' overall access to the LMS relative to a specific event in the course (Figure 23). Once the specific event has been selected, the events graph presents a circle indicating the percentage of access to the LMS before and after the event. The blue part of the circle indicates the percentage of students who accessed the LMS before the selected event, and the red part of the circle represents the percentage who accessed the LMS after the event. The size of the circle is relative to the number of views. Larger circles indicate a higher number of views. The percentage and total number of students' access before and after the event can be viewed by hovering the mouse over the circle.

FIGURE 23: Events tab in the students section



Similar to the course access section, the interaction of a specific student with the LMS can be examined by clicking on the "View" button. The pageviews graph (Figure 24) presents the selected student access to content (blue line), communication (black line), and assessment items (green line).

FIGURE 24: An individual student's access to the LMS



The two tables below the pageviews graph list all communication and assessment items the selected student has interacted with across the course. The communication table includes the details of the discussion forums with which the student has interacted, including name, number of views and number of posts. The assessment table includes details of the assessment items with which the student has interacted, including the number of views, attempts and average student score.

5: PILOT CASE STUDIES

Phase 3 of the project involved piloting the Loop Tool with three courses (one from each of the participating institutions). The teachers of each course were interviewed at the beginning of the semester to get a sense of how frequently, and in what way they expected to use the Loop Tool. Throughout the semester the teachers were asked to keep a record of when they used the tool, why they used it, and any actions that resulted from using the tool. At the end of the semester the teachers were interviewed again to get feedback on their overall impressions of the tool, specific issues around usability and the identification of any technical errors.

Each of the case studies are profiled below.

CASE STUDY 1: FLIPPED CLASSROOM IN BIOMEDICINE

Brief Overview

In the subject Human Structure and Function, content is structured around the anatomy, pharmacology and physiology of different human body systems (e.g., digestive system, respiratory system). For the anatomy and pharmacology content the teaching delivery method is fairly traditional with didactic lectures accompanied by lecture notes. By contrast, physiology content is delivered in a flipped classroom style, with required pre-readings/online interactive modules and the use of clickers to facilitate active learning during class time. In addition, each week students are asked to complete a computer-aided learning (CAL) task related to the body system. Students are also required to attend six anatomy (dissection) labs and one physiology lab (which is assessed) across the semester.

Institutional Context

Institution: The University of Melbourne

Participating Teacher: Professor David Williams (Course coordinator)

Discipline: Physiology Department, Faculty of Medicine, Dentistry and Health Sciences

Description of the Course

Course: Human Structure and Function

Credit Points: 25 (equivalent to two standard courses)

Level of study: 2nd year undergraduate

Number of students: Approximately 490 students

Course length: 12 weeks

Contact hours: 6 x 1-hour lectures per week, 1 x 2-hour online computer-aided learning workshops (for 12 weeks) plus 4 x 2-hour Anatomy (dissection) practicals and 1 x 2-hour Physiology practical at relevant stages of the semester.

Intended learning outcomes: Upon completion of this course, students should have an understanding of normal structure and function of the human body, the general principles of anatomy, the concept of homeostasis and the operation of the key organ systems that maintain it, and basic principles of pharmacology and drug action.

Summative assessments

Written laboratory report (1000 words, 10% total);

2 x mid-term tests during semester (10% each - 20% total); and

2 x 2-hour end of semester exams (35% each - 70% total).

Formative assessments

Online computer-aided learning materials every week.

Technologies used

Learning management system: Blackboard.

Clickers: Clickers are used during class to promote engagement and provide immediate feedback to students on their knowledge.

Discussion board: An open discussion board on the learning management system is used to answer general questions.

Computer-aided learning tasks: These tasks are designed and delivered using the SmartSparrow platform and are to be completed before lectures as support material for the flipped-classroom.

Digital resources: Readings, presentations and videos are available to students via the learning management system.

Lecture capture: Screen and audio recordings of lectures.

Expectations for the Loop Tool

Two main needs were identified for this course for the use of the Loop Tool:

- **Identify students' patterns of usage of materials during the course:** The physiology component of the course uses the flipped classroom approach, in which students are required to do some preparation before the lectures. The preparation involves accessing reading lists (for textbook pre-reading) and/or digital resources as well as the completion of computer-aided learning tasks. The teacher wanted the Loop Tool to help gauge whether students' patterns of usage of these resources matched the intended design of the course. Also, he wanted the Loop Tool to reveal if there were different patterns of usage, such as re-visits to resources at critical times. This was to check whether appropriate materials were being provided. As the course involves resources relating to anatomy, pharmacology and physiology, the teacher was interested in learning whether students engage differently with materials from these content areas.
- **Identify students who are falling behind:** The teacher also wanted the Loop Tool to help identify students who were not using or accessing the resources. He acknowledged that although this may sometimes be misleading (e.g., this might be related to their own style of learning), he would rather contact a student about their lack of engagement than ignore it.

Prior to the Loop Tool trial, the teacher indicated that he expected to access the tool daily to support his teaching. In order to prepare for the use of the tool, he was required to turn on the statistics tracking function within Blackboard for all content items. He also expressed an intention to "clean up" his Blackboard course site by deleting old resources that were hidden from students.

Institutional Data Integration Process

At the University of Melbourne, data feeds were generated every weekday in the morning containing data from the previous day and uploaded to a share folder. On Mondays, data feeds included data from Friday, Saturday and Sunday. The University IT team dedicated approximately 30 minutes per day to this task. The Loop Tool would then automatically import data from the shared folder each night. Therefore, there was a delay of approximately 48 hours on data available in the Loop Tool during this pilot period. Further details of the data integration process for Blackboard can be found in Appendix A.

Usage of the Loop Tool

During semester, the teacher accessed the Loop Tool at least weekly, increasing to several times per week towards the end of semester. He indicated that the time commitment required to use the Loop Tool was around five to ten minutes per visit. However, the teacher admitted that he would often spend more time accessing the Loop Tool as "it is addictive". The addictive nature of the tool was further explained as a process whereby he explored the nuances of particular resource data as well as downloading data to perform further correlation analyses. However, he did indicate that he did not always have the time he would have liked, or any teaching time allocated, to engage with this information. At times, the 24-48 hour delay in access to updates of the data hindered effective use of the tool. The teacher noted that he often wished to look at something that was happening on a particular day, but due to the data update lag, had often moved on to other things by the time these data became available.

Primarily, the teacher used the tool to check whether students had accessed the CAL tasks in preparation for the flipped classroom sessions. He found that generally the students were accessing the CAL tasks in a timely manner. Unexpectedly, he also found that students continued to re-visit the CAL tasks throughout the semester. The other main way that the teacher used the Loop Tool was to retrospectively correlate data on performance and access to resources in order to identify "successful" patterns of engagement. He did this in order to plan future interventions. While the teacher said that he did not take any specific actions during the semester of the pilot, his aim was to observe the behaviour of the cohort as a baseline for interventions in future cohorts. He also mentioned that he referred to the tool during individual face-to-face consultations with six students as a basis for the discussion of study habits.

A challenge the teacher identified was the need to trawl through old resources that still existed in the LMS because each semester LMS sites are copied from the previous semester. This resulted in the tables in the Loop Tool being "overpopulated".

Overall, the teacher was satisfied with the Loop Tool. In terms of usability, the teacher said that use of the tool did not represent a steep learning curve. He also indicated that he would be interested in using the tool in future semesters, as well as in other courses. He would like to further explore students' patterns of engagement with particular resources, especially those resources that are set to have a timed release, to see if adjustments should be made to these availabilities.

CASE STUDY 2:
SUPPORT SITE FOR ASSESSMENT IN EDUCATION

Brief Overview

The course, Educational Assessment, focuses on how to design effective assessments and research-informed processes of evaluation. The major assessment piece for the course is a research report on the evaluation of an assessment task. To support the teaching and learning in the course, students have access to a companion website – the Research Ed site. While also hosted via the learning management system, the Research Ed site is separate to the main course LMS site. It provides activities and materials specifically related to the research report assessment. Students can access content in the form of text and videos or post in a discussion forum. The site also contains online quizzes that check students' knowledge of statistics and other content related to assessment evaluation, and provide real-time feedback.

Institutional Context

Institution: Macquarie University

Participating Teacher: Dr Rod Lane

Discipline: Department of Educational Studies, Faculty of Human Sciences

Description of the Course

Course: Educational Assessment

Credit points: 3

Level of study: 3rd year undergraduate

Number of students: Approx. 100 students

Course length: 12 weeks

Contact hours: 2 x 1-hour lectures per week, 1 x 1-hour tutorial per week (for 12 weeks)

Intended learning outcomes: This unit provides students with an understanding of how to use assessment information to make informed decisions about curriculum design, the process of teaching and learning, and student progress.

Summative assessments

Written research report (2200 words, 35%);

One 2-hr end of semester exam (35% total);

Weekly generation and evaluation of multiple choice items using Peerwise (10% total); and

Two online quizzes (10% each).

Technologies used

Learning management system: Moodle.

Discussion board: An open discussion board on the learning management system is used to answer general questions.

Digital resources: Texts, presentations and videos are available to students via the learning management system.

Online quizzes: Online quizzes available via the learning management system and the Research Ed site provide immediate feedback to students on different topics.

Expectations for the Loop Tool

The teacher identified three main ways in which he expected to use the Loop Tool:

- **Identify resource access:** He wanted to be able to check whether students were able to find resources, specifically the support resources for assessment.
- **Identify students' patterns of access to resources:** He also wanted to explore the patterns of access to these resources to see if these access patterns match the course design. In particular, he wanted to look at whether students were accessing the support resources throughout the semester, or if they were only accessing them at the last minute before the major assessment piece was due.
- **Identify ways to enhance the LMS site:** He hoped that the Loop Tool would give him an insight into how the site was being used by students that could help inform enhancements to the site for future cohorts.

The teacher felt somewhat confident about his ability to use the tool when introduced to it at the start of the pilot (rating himself 6 out of 10 in confidence). He stated that he expected to access the tool each week after the lecture. He identified the period from Week 2 (when the major assessment was introduced to the class), until the assessment was due as the key time period for usage of the Loop Tool. In preparation for the pilot he did not make any changes to the Research Ed LMS site.

Institutional Data Integration Process

At Macquarie University, the data feeds were generated and uploaded to a share folder twice a week, on Mondays and Wednesdays. The preparation of the data took approximately 3.5 hours each time and involved backing up the LMS sites, extracting the data logs for each site from the database dump using SQL, and then sending all files to Google Drive. The Loop Tool would then automatically import data from the shared Google Drive folder overnight. Therefore, there was a delay of up to five days on data available in the Loop Tool during the pilot period. Further details of data integration for Moodle can be found in Appendix A.

Usage of the Loop Tool

The teacher used the Loop Tool at three main points across the semester. At the beginning of the semester he used it to become familiar with the functionality. However, due to the limited amount of data in relation to the assessment at that stage in the semester, he stopped using the tool for a few weeks. He then waited until the students had completed the major assessment before logging in again to study student engagement with the support resources for the assessment. At the end of semester he returned to the tool to do more extensive analyses of the data. He exported student access statistics and performed a regression analysis to see if students' use of resources (as measured by the number of pages they viewed in the site) influenced their performance in the major assessments. The correlation was positive and significant, but only when the highest performing students were removed.

The teacher found the shading of cells in the students table useful to quickly gauge who had engaged with the site prior to the assessment. The shading allowed the teacher to visually identify performance statistics of interest 'at a glance' without having to digest large volumes of numbers in the table. He also liked the ability to see the ranking of resources by access, as this allowed him to see what resources the students valued and used most. This also informed the guidance he could give to students about what to look at on the site.

Early in the semester he emailed non-engaging students (who had not yet accessed instructions for the major assignment in the main LMS website or the support website) to remind them about the online resources available. For those students who had accessed the assessment information on the main course LMS site, the teacher then monitored their engagement and contacted students to highlight the support resources available. He also used the data when considering appeals to the assessment grade to see if students had engaged with the assessment resources over time or only at the last minute (if at all).

Overall the teacher found the tool very useful, giving it a nine out of ten. He said that using the tool was not time consuming, but there was a slight learning curve in understanding what particular data meant. He suggested that the dashboard should open on the whole course view by default, rather than on Week One, as his focus was on the entire course. How the course design was represented in the LMS was identified as something that needed to be considered more closely in terms of the statistics generated. For example, putting resources together on a single page only allows a single view to be counted, but not more detailed information about which resources on the page the students had interacted with. He also would have liked more detailed information on the specific pages that students had accessed. One other suggestion the teacher made related to the ability to easily export the raw data from the tables in order to use it in other statistical packages to run more sophisticated analyses.

CASE STUDY 3: BLENDED LEARNING IN A FINANCIAL ACCOUNTING COURSE

Brief Overview

This Financial Accounting I course is designed to expand students' knowledge of the complete accounting cycle with an emphasis on double entry accounting systems in manual and computerised formats. Students are exposed to various accounting standards used in financial accounting with particular reference to the acquisition, depreciation and disposal of Non-Current Assets, Inventories, Accounts Receivable, Cash and some of the issues related to Partnerships. The learning activities are designed to allow students to develop knowledge and skills through readings, lectures, and podcasts and then apply this in a variety of formats, through quizzes, tutorial presentations, workshop activities/tests and examinations.

Institutional Context

Institution: University of South Australia

Participating Teacher: Mr Scott Copeland

Discipline: Accounting Department, Business School

Description of the Course

Course: Financial Accounting 1

Unit value: 4.5

Level of study: 1st year undergraduate

Number of students: Approx. 365 internal and 50 external students

Contact hours: 1 x 2½-hour workshop per week (for 12 weeks)

Intended learning outcomes: This course had four main learning outcomes:

- Discuss from an introductory perspective the theoretical, conceptual and ethical environments in the practice of financial accounting;
- Outline the content of a number of Accounting Standards and their application to the basic practice of corporate financial accounting;
- Demonstrate an integrated knowledge of the financial accounting process and recognise the procedures required for designing and implementing accounting systems, both manual and computer based; and
- Display a grounding in fundamental financial accounting practice as applied to a variety of basic issues confronted by accountants.

Summative assessments

Weekly tutorial work (10%);

Mid-term test with short answer calculations (10%);

Discussion of a presented scenario via presentation (15%);

Data entry and calculations (15%); and

Final exam (50%).

Technology used

Learning management system: Moodle.

Discussion board: An open discussion board on the learning management system is used to answer general questions.

Wiki: Used by external students to collaborate on weekly tutorial case studies and present answers in an assigned week.

Lecture capture: ”Lectures” are delivered in 5-10 concept videos recorded using iSpring Pro, with approximately 4-6 videos per topic.

Expectations for the Loop Tool

The teacher identified two main ways in which he expected to use the Loop Tool:

- Identify patterns of resource use: The teacher wanted to see what LMS resources students were using and when students were accessing them. In particular, he was interested in which resources were used frequently, and which were used infrequently. He was also interested in identifying resources with a high level of repeat visits.
- Identify resource use in relation to assessment: He was interested in seeing when students were accessing resources in relation to specific assessment items to identify successful access patterns.

The teacher was fairly confident about his ability to use the tool (rating himself 7 out of 10). He expected to use the tool on a weekly basis to get an overview of student interaction with a more in depth look before and after the assessment items to see which resources students were utilising and when they were accessing these to complete assessment requirements. He did not specifically make any changes to his LMS site in the lead up to using the Loop Tool, but he had done some organisation of materials prior to the start of semester.

Institutional Data Integration Process

At the University of South Australia, data feeds were generated every weekday in the morning containing data from the previous day and uploaded to a share folder. On Mondays, data feeds included data from Friday, Saturday and Sunday. The University IT team dedicated approximately 30 minutes per day to this task. The Loop Tool would then automatically import data from the shared folder each night. Therefore, there was a delay of approximately 48 hours on data available in the Loop Tool during this pilot period.

Usage of the Loop Tool

The teacher accessed the tool each week for the first two weeks of semester, but then more sporadically after that. This was usually prompted by an assessment or by the desire to give other forms of feedback. For example, if the teacher sensed that students were struggling with a concept he would use the Loop Tool to confirm his impressions and try to understand what was happening. His main focus was on looking at patterns of usage of particular resources, especially the timing of access in relation to learning activities throughout semester. He wanted to get a sense of which resources students were and were not accessing for the purpose of reviewing the content made available to students online throughout the course.

The teacher was able to give general feedback to students based on his use of the Loop Tool. For example, he was able to provide guidance to students about resources that were important but that not many students had accessed. He indicated that he wanted to incorporate more of this type of feedback in future offerings of the course to promote the most important resources in a timely manner.

One additional function that this teacher said would be very helpful was allowing the grouping of resources or students. Being able to group resources would allow him to look at sets of resources that related to a particular topic or assessment. He mentioned that as the lecture recordings were broken into 5 to 10 individual videos, it would be good to be able to see the access statistics for this group of resources. Similarly, he wanted to be able to group students together to look for other patterns of engagement or to be able to give specific feedback to a particular group. For example, he suggested that being able to group students by tutorial group could be very useful.

The teacher found the Loop Tool "pretty easy to use". Having been involved in the Loop Tool development, it did not take him too long to familiarise himself with the functions of the tool. However, he did suggest that support resources may be needed for users who were new to using the Loop Tool. One thing that he felt made the tool slightly harder to use was the fact that his LMS design included a large number of resources which resulted in the need to scroll through long tables of data. He mentioned that initially it took a bit of consideration to assess how things in the LMS corresponded to what he was seeing in the tables in the Loop Tool. He also requested the ability to be able to easily add additional instructional events, like an extension to an assessment deadline. Overall, he said that the Loop Tool provided him with a greater insight into students' interaction with the course and supported his ability to provide feedback to students to support their approaches to study.

6: DISCUSSION

A Fundamental Tension

The original ambition of the Completing the Loop project was to discover how learning analytics could be used to help teachers effectively address the teaching and learning challenges they face.

Two key principles underpinned both the study and also contributed to the development of a practical learning analytics tool. The first principle was the notion that productive learning is predicated on learning "conversations" between teachers and students (Laurillard, 2002). By using analytics to "look at" online conversations and interactions between and among teachers and students, deeper understanding of the learning process can be achieved. Moreover, given that generative, productive learning is often underpinned by rich conversations and interactions, learning analytics needs to recognise and build on this. This involves a deliberate move away from simple frequency counts and access analytics (Lockyer, Heathcote & Dawson, 2013). A second and related principle was that in order to create meaning from any data gathered through learning analytics, it is necessary to first appreciate the pedagogical or learning design intent.

With these principles in place, the project team sought input from teachers about how they were designing online learning activities for their students, how they were using technology to support these activities, what pedagogical challenges they encountered, and how learning analytics data could potentially help them address these challenges. We were fortunate enough to interview dedicated educators who were creating thoughtful and engaging learning environments for their students. However, our interviews with university teachers revealed a number of findings, which created a fundamental tension for the project.

First, while teachers were creating engaging learning activities for students in their courses, in the main, most of the deeply engaging, interactive elements of these designs were not delivered, captured or reflected through the LMS course sites because they were offline. Activities that students were asked to complete online were generally routine and transactional. Teachers made extensive use of the management and transactional features of their institutional LMSs (e.g., resource delivery, announcements, scheduling, assessment delivery), but made less extensive use of more "interactive" technology-based tools available within the LMS (e.g., wikis, blogs). Therefore, even though there is a potential for learning analytics to capture students' engagement with interactive learning tasks, this potential was largely unrealised due to the nature of the learning tasks presented to students online.

The second tension arose when we asked teachers about what challenges they encountered and how analytics could help. We discovered that the challenges and issues that teachers saw as important did not align well with the challenges envisaged by the project team. The intention of the project was to investigate how analytics could help teachers delve deeply into learning interactions online, and to develop a tool to support them to identify, diagnose and resolve issues with learning. However, teachers were more interested in using learning analytics for more fundamental purposes: to determine overall engagement profiles, find out whether clusters of students differed in their access to learning resources, and to understand how patterns of engagement related to other offline learning activities or performance. While these were clearly valuable challenges to address and well suited to the reporting capabilities of learning analytics, they were not the teaching and learning challenges the project team anticipated the project would address.

The first phase of the project, therefore, revealed that the design of online activities articulated by teachers, the ways in which they used the technology-based tools provided in their LMS, and the educational challenges that they were interested in exploring, aligned poorly with those anticipated by the project team. While the project team had the somewhat ambitious goal of creating a useful learning analytics tool that university teachers could use to understand the minutiae of students' online learning processes, teachers were, quite reasonably, designing and using online learning technologies in ways with their students that made this goal difficult to achieve. Moreover, the important challenges teachers wanted to resolve concerned fundamental issues like attendance and whether students accessed an essential reading, rather than the more specific concern of, for example, whether their students were genuinely engaged in a bilateral exchange on a wiki.

This tension represents a central finding of this project. While there is some risk of over-extrapolating from the 12 interviews conducted in this study to the entire higher education sector, there is clearly a potential disconnect between how the majority of teachers in the higher education sector are routinely using LMS-based learning technologies, and how learning analytics can most effectively be applied in these contexts, and for what purposes.

Dealing with the Tension

The tension identified was not simply an intellectual one. As described in Chapter 3, this project sought to base the development of an analytics tool both on interviews with university teachers and on a conceptual framework (Laurillard's conversational framework). Thus, it became clear that this tool would need to steer a course between the original ambition of the project, and what could be practically developed and be useful for a wide range of teachers. The Loop Tool described in Chapter 4 represents the outcome of our work to date, and the Case Studies presented in Chapter 5 provide a clear overview of the usability, limitations and benefits of the Loop Tool in some local contexts. The remainder of this Chapter will draw on these cases and the broader findings of the project, to discuss more general findings and implications of the project in terms of the purpose and interpretation of analytics, data quality, actionability, awareness, and the scholarship of teaching and learning (SOTL).

Analytics Interpretation

We started with strong view that the teacher's learning design should drive the analytics-based inquiries they make with the Loop Tool. The pedagogical helper component of the Loop Tool was designed to encourage this explicit connection. As discussed in Chapter 2, an active area in current educational technology research and development is integrating the fields of learning design and learning analytics so that valid, robust interpretations of student activity can be made. We still consider that it is extremely important for the pedagogical intent of teaching and learning tasks and activities to drive the interpretation data gleaned through learning analytics. Certainly, all teachers involved in the pilot test of the Loop Tool were motivated by the desire to understand whether students were using or "covering" the material designed for them in the way the teacher had envisaged.

However, it also became clear that many other legitimate intentions and motivations drive teachers' inquiries. Teachers in the three case studies also pursued administrative questions, and used analytics in an exploratory sense, to simply understand what students were doing and "what was going on" in their course site. For example, the teacher in the second case was interested in how students were accessing support resources, and when during semester they were doing this. While not fundamental to the learning design of the course, these are nonetheless important questions that teachers could investigate using analytics, which could lead to insights that might suggest improvements to the design, format or timing of the delivery of resources.

There is evident value in having a clear research, evaluation, or investigative question in mind when delving into learning analytics. Educators, practitioners and administrators in higher education should always be mindful of the quip: “If big data and learning analytics is the answer, what is the question?” While we maintain that the pedagogical intent of the learning tasks and activities provided to students should be central among these questions, we acknowledge that other questions can be very usefully investigated using analytics.

In Chapter 2, we highlighted another important issue in the area of analytics interpretation, namely the need to exercise caution in extrapolating from analytics data to make inferences about students’ learning processes. While some student interactions within online environments may explicitly capture their thoughts, learning strategies and learning processes (e.g. freeform text), other data (logins, downloads, etc.) are more difficult to interpret: we can infer that students have accessed resources, but not necessarily that they have engaged with them in a meaningful way (i.e. read, understood or reflected on the material).

Analytics Data Quality

The technical development of the Loop Tool and its use in the pilot studies exposed a range of factors that impact on the quality of the analytics data that is displayed. How teachers structure their courses, at both ‘macro’ and ‘micro’ levels, can dramatically affect the data that is returned by the Loop Tool. For instance, if in the Blackboard LMS a teacher chooses to structure their courses with resources grouped by week, then the Loop Tool will return quite different data than if they group the same learning activity resources by resource type. Different learning management systems also have idiosyncrasies in how they measure and count student interactions with learning materials and resources, which may lead to different types of data for ostensibly the same activity. It may not be the case that one type of data is inherently better or worse than another, but the different measures used and activities counted can lead to different representations.

The choice of technological tool to support a given learning activity can also influence the interpretation of learning behaviour. An online learning activity with a particular learning design could be supported by a variety of technology-based tools, each of which could have a different structure and functionality. Given this variation, the technology-based tool employed is a key determinant of what learning analytics data is actually available for any particular learning design and also impacts upon the form and granularity of that data.

These issues in turn raise questions about the reliability and validity of learning analytics data, particularly when comparisons are made across courses or systems. For instance, if two courses or two LMSs collect and present data to the Loop Tool in different ways for the same activity, it may be difficult to make valid and reliable comparisons between these activities on the basis of the analytics. A key challenge for the educational technology and learning analytics community - perhaps locally within institutions and more broadly across the international landscape - is to derive common frames of reference or standards in these areas.

Actionable Analytics

A central ambition of this project was to develop a learning analytics tool for teachers that would allow them to interrogate students’ interaction with their online courses in real time, so that any insights were immediately ‘actionable’. This aim was somewhat hamstrung by technical issues associated with real-time data feeds. For the three pilot case studies, data from the LMS course sites were delivered to the analytics tool with a time lag of between one and five days; there was no capacity to create automated data feeds and ‘real-time’ analytics. A consequence was that the data feeds into the tool were not able to support “real-time” analytics, in the sense that the data being reviewed by teachers was not “live” or up-to-the-minute.

Nevertheless, the project was able to provide analytics data in a sufficiently timely manner to enable teachers to review student engagement with material, and examine changes to this engagement on a daily or weekly basis. Teachers in the pilot test used the timely analytic reports to reflect on how their class was running, and intervene with students during the session. An advantage of the Loop Tool was that teachers were able to easily review and evaluate student access to their LMS subject site as it was running. This allowed them to potentially adapt their course (technologically or non-technologically) during the current session or for a future session. This would seem preferable to making a request for data at the conclusion of the session which would limit course renewals to the next session.

A second issue associated with actionable analytics that emerged for the project team in their observations of the pilot studies was the question: what is a legitimate action, and for whom, based on the analytics provided by the Loop Tool? Many would see it as uncontroversial that a teacher is responsible for acting on information revealed by analytics in their subject, however, it is less clear what thresholds of student interactions with learning materials should prompt intervention actions (e.g. making contact with an individual student, making a change to the course structure, or posting an announcement to students). Furthermore, once the decision has been made to intervene, what form should that intervention take? What is an appropriate educational and institutional response and what responsibilities come with this action? These issues are not new for the learning analytics community (Sclater, Peasgood & Mullan, 2016) and they were not prominent in our pilot studies, but they warrant careful consideration. If, as we hope, the Loop Tool becomes more widely used in higher education settings, and facilitates access and response to learning analytics data, individuals and institutions need to have in place clear ideas (and guidelines) about appropriate actions which are based on learning analytics data. There is an emerging literature base on the ethics of learning analytics and their use, which will become an important resource for individuals and institutions alike.

Analytics Awareness

An observation from this project is that while there has been a rise in awareness of learning and academic analytics within universities, there is still a relatively limited understanding of how data in institutional systems can be used and for what purposes. The findings from a recent Australian, sector-wide, commissioned project found that on the whole, institutional learning analytics projects were “immature and small in scale” (Colvin et al., 2015, p. 6). The report found evidence of two clusters of institutional approaches to the conceptualisation and deployment of learning analytics. Some institutions saw learning analytics predominantly as a mechanism to address issues associated with student retention, and sought to develop technical solutions to enable better prediction or identification of students at risk, to enable swift intervention. Others took a more holistic approach to learning analytics and saw them as a way of understanding student learning and as a mechanism to improve the quality of teaching, learning and assessment, and the student experience. Even in this second cluster, it is apparent that while there is emerging awareness of, and interest in learning analytics, understanding of what kinds of teaching, learning and assessment challenges and questions that learning analytics can help solve remains limited.

It is perhaps useful to articulate more clearly the possibilities of learning analytics in supporting and enhancing teaching, learning and assessment. While experts in learning analytics and educational technology may understand the potential benefits of learning analytics to support different types of adaptive learning environments and forms of personalised student learning, these need to be translated into concrete, understandable and actionable proposals about how learning analytics can be used by university teachers everyday. This represents a grand challenge for the emerging field of learning analytics. We need on the one hand, to find ways to describe common, generalised teaching, learning and assessment structures (learning designs) that resonate with teachers, and on the other, to show in concrete terms how learning analytics can shed meaningful and actionable light on these structures in order to improve teaching, learning, and assessment processes.

Analytics, Quality and the Scholarship of Teaching and Learning

Learning analytics have the potential to serve as an important tool to stimulate interest in the scholarship of teaching and learning (SOTL). For instance, the Loop Tool allows teachers to interrogate their teaching practice and how students respond to it, to make evidence-based decisions. The pilot cases studies suggest that while the Loop Tool and its integration require further development, it has the potential to be a useful support for SOTL. Used appropriately and thoughtfully, learning analytics platforms could become powerful and widespread tools to support SOTL. This would hopefully have multiple advantages: increasing our understanding of how digital learning environments work and are working for teachers and students, supporting teachers to reflect on and improve their professional practice, and providing evidence that can help to improve students' learning process and outcomes.

In addition to the scholarship of teaching and learning, the quality of teaching and learning in universities has become a topic of increased scrutiny in recent times, both nationally and internationally (https://www.qilt.edu.au/), UK Department for Business Innovations & Skills, 2016; Fabrice, 2010). It seems unlikely that the policy landscape will drastically change in the short term, and indeed, there is every indication that higher education institutions and their staff will increasingly be asked to be accountable for the quality of the teaching and learning experiences they provide to students. Learning analytics can play an important role in this. But it is important to see learning analytics as only one part of a suite of indicators that can be used to evaluate quality, given their current limitations.

7: RECOMMENDATIONS AND FUTURE DIRECTIONS

This project has covered a great deal of terrain on the conceptual and practical use of learning analytics in higher education settings, teachers' and students' use of technology in teaching andlearning, learning analytics tool design, development and implementation, and the evaluation of teaching and learning. This final chapter of the handbook aims to draw together some of the findings of this project and use them as the underpinnings for general recommendations about the practical use of learning analytics in higher education, as well as more specific recommendations about the Loop Tool developed as part of this project. These recommendations are not comprehensive, nor will they apply to everyone in all circumstances. They are presented to simply guide individual and institutional reflections and considerations about the practical implementation and effective use of learning analytics in higher education settings.

Educational Recommendations

1. When using analytics, it is critical that teachers clearly identify the teaching and learning goals for their course and how they are using resources and technology-based tools (in the LMS for example) to support them. The value of any learning analytics data returned will be greatly enhanced by a clear understanding of the pedagogical goals and intent, and learning design, of the course.

2. Before starting to use learning analytics, teachers need to think through the research, evaluation or investigative question they seek to answer. While there is some value in exploring data generated from digital learning environments, this can quickly become overwhelming. Having clearly defined questions to guide investigations will greatly assist teachers. These questions will hopefully be related to the pedagogical intent and learning design of the course and its activities, but equally might be about the expectations the teacher has of students' access to learning resources or the quality of the administration or support provided to students in the course.

3. Educators should think critically, exercise scepticism and not leap to conclusions about what learning analytics data reveal about both individuals and groups of students in their courses. Considering alternative explanations of students' engagement behaviour will allow for a wider range of appropriate responses to be considered.

4. Learning analytics can be used by teaching staff as the basis for interventions in the teaching and learning process. However, teaching staff should be mindful that a range of interventions may be appropriate in response to a single learning analytics 'finding'. As with all educational interventions, teaching staff should consider the potential impacts of any change on both students and other teaching staff.

5. Teachers should remember that learning analytics will capture only a fraction of student learning behavior. Students study in different ways and much of their engagement with learning might happen offline or outside university-sanctioned digital learning systems. It is therefore useful to consider what activities students are engaging in which are not online, and how information about such activities could be gathered.

6 Just as learning analytics can effectively be used as the basis for individual reflection and educational intervention, they can contribute to more academic activity in the scholarship of teaching and learning (SOTL). Learning analytics data can be a powerful resource for practitioners researching and evaluating the effectiveness of their teaching and learning. There are myriad ways in which learning analytics could inform educational research and evaluation questions associated with the learning design of digital resources, curriculum and instructional models, student engagement, and student motivation, study habits and self-direction, to name but a few.

Administrative and Technical Recommendations

7 The Loop Tool was designed to make learning analytics data more easily accessible to teachers, but reviewing these data can still be time-consuming. It is important to make allowances for this and not presume that the investigative work will somehow be "done by the tool". Having a clear idea about what specific questions will be addressed using the Loop Tool, and scheduling time to review Loop data tables and visualisations will provide maximum return on time investment. It will also maximise the opportunity to respond to learning analytics data in a timely way, during a teaching session. There is a real danger that if the time and administrative burden of learning analytics-based investigations becomes too high, teaching staff may abandon them. Having a team based approach (where more than one person is responsible for interrogating analytics from a single class) and established routines (where specific, discrete data sets are reviewed a set number of times over the session) are practical suggestions to alleviate this concern.

8 It is helpful to anticipate what form of learning analytics data will be generated beforehand, since decisions about how an LMS site is set up can impact on the type and quality of learning analytics that are generated. We do not advocate setting up LMS sites for the express purpose of generating learning analytics data; digital learning environments should be designed primarily to achieve educational objectives of teachers and students. However, it is worth being mindful that decisions about how you set up a LMS site might impact on the type and quality of learning analytics available.

9 Consistent with the recommendations above, a key administrative consideration is the quality of the data that is returned by the Loop Tool. As it is clear that the ways in which LMS course sites are built and implemented fundamentally impacts on how learning behaviours of students are recorded and counted (i.e. the quality of the data), we recommend that a small-scale validity test of the data returned by the Loop Tool be undertaken before formal interpretations and responses are made from learning analytics data. It may be useful, for example, to interrogate a subset of data from a previous semester's instance of a subject to evaluate whether the Loop Tool is summarising learners' activities as expected. This could clarify how different folder, files, and embedded objects in the LMS are presented in the Loop Tool. Such a test would both aid subsequent interpretation and guide potential changes in the LMS site's structure to improve data quality.

10 To realise the potential benefits of learning analytics, and the potential benefits of the Loop Tool, more support and professional development of staff is required. As interest in, and use of learning analytics becomes more widespread, and software such as the Loop Tool or vendor-based products become more widely available, there is an imperative for higher education institutions to provide their staff with more coordinated and comprehensive professional development. These professional development opportunities need to be tailored to individual teaching and support staff, program coordinators, and staff in university leadership positions. Inevitably, growth in the use of learning analytics will raise questions about the collection, analysis, interpretation, reporting and ethics of using learning analytics in higher education.

11 While the Loop Tool was originally intended to provide real-time learning analytics data to university staff, this was not possible in the pilot study implementation. More regular data feeds provide better options and opportunities for staff to modify or update their courses and course material, but until data feeds into the Loop Tool are automated, delays and significant administrative overheads will remain. We recommend that those interested in using the tool discuss with local system administrators the optimal timing of data feeds from their learning and content management systems. Decisions in this area could be usefully informed by the specific questions posed to by staff. For example, if a teacher wishes to provide feedback to students about specific resources or events, this would suggest a particular timing of data feeds. Staff interested in more exploratory or reflective uses of learning analytics might be able to request data feeds at longer intervals.

Conclusion and Future Directions

This project has explored how the educationally informed practical use of learning analytics in Australian higher education can be advanced, and hopefully its findings and outputs will prove to be of benefit to the sector. Certainly the interdisciplinary nature of the project, the multi-institutional representation of its participants, and the scope of its ambition have generated new opportunities for future exploration, technology development, and dissemination.

Ultimately, any practical and beneficial implementations of learning analytics in the future will be determined by the interest, dedication and commitment of individual teaching and support staff. The project team has endeavoured to provide a conceptual framework, a foundational technical tool and some practical advice about how individuals can use learning analytics in pedagogically informed ways. Through the project website, the GitHub repository from which the Loop Tool will be available, and outcomes such as this handbook, workshops and academic publications, we hope to create a critical, practitioner-focussed learning analytics community that links to existing communities such as SoLAR and the ASCILITE SIG.

We have made the Loop Tool source code freely available via GitHub in the hope that this will encourage others to use the tool, suggest improvements and contribute to an emerging community around it. We expect that ongoing efforts by the team, coupled with input from the open-source community, will improve the stability and quality of the Loop Tool. We will seek funding to further improve the tool and potentially integrate it with other similar initiatives nationally and internationally.

In the future it would be highly desirable to develop a technical mechanism to automate the data feeds from institutional repositories into the Loop Tool. The project team will monitor conversations associated with GitHub and the Loop project website to learn about any individual or institutional advances in this area. We believe automation of data feeds is critical for encouraging more widespread adoption of the Loop Tool. Within the tool, a high priority will be finding ways to improve the Pedagogical Helper Tool, so that it potentially generates automated reports based on the learning design mapped by individuals, and creating satellite ‘helper’ applications to support end users of the tool.

Learning analytics is a rapidly growing area in higher education research and practice. Like others, the project team recognises the immense potential value of learning analytics in developing our understanding of effective teaching and learning, and improving the quality of students learning processes, outcomes and experiences. We hope that this project has both contributed to an understanding of how learning analytics can practically be used by teaching staff, and provided the foundation for a technological solution that teachers anywhere can use to refine, improve and support teaching and learning.

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APPENDIX A:
LOOP TOOL TECHNICAL MANUAL

Overview

The learning analytics tool was developed as an outcome of the Closing the Loop project. The Loop Tool provides new opportunities for teaching staff to connect their course design with a set of available analytics visualisations. The Loop Tool is built using Python, Django, Pandas and MySQL and supports both Moodle and Blackboard Learning Management Systems. The information in this appendix relates to the first release of the Loop Tool. For more up-to-date technical information please refer to https://github.com/looptool/download.

Loop Tool Architecture

A key requirement of the Loop Tool was to provide easy visualisations for teaching staff to view course access by content item and LMS tool use. The Loop Tool therefore requires the log files and an export of the course structure from either Blackboard or Moodle LMS. IMS-CP Export files are required from Blackboard and the course export format is required for a Moodle course.

The Loop Tool is made up of the following two components:

- **Data Warehouse:** The Loop Tool creates a data warehouse in MySQL. Log and course export zip files are processed and both Moodle and Blackboard data is stored in a single schema. Quiz and forum data is also extracted from the course export zip files. Content and tool items are categorised into Content, Communication and Assessment. The data warehouse implements a star schema design to allow queries by week and day to be easily made. The schema also contains tables that cache all major data components of the dashboards.
- **Dashboard:** The Dashboard is built with the Django web application framework. The dashboard retrieves cached data from the MySQL database and displays the weekly, overall and content, communication, assessment and overall student dashboards. There are also individual student and content item/tool dashboards.

Course Exports

This section describes the process to export the files required for processing and visualising the respective analytics available through the Loop Tool. The tool requires the LMS access logs and a full course export (including the course structure, forum posts and quiz submissions). Note that the process to export the required files differs across the LMS supported platforms and versions.

Moodle

A course export is required and contains both the access logs and the course structure.

To export from Moodle:

1. Select Backup from the Administration block
2. Select the required information to be included in the backup. Include "grade history" and "Include course logs" must be selected
3. Continue through the wizard. This will result in the generation of a "mbz file" (moodle version of a zip file).

Moodle Hosted

The export may contain some anomalies depending on the version and institutional configuration of the Moodle install. It is recommended that data integrity be reviewed and validated. In the case of any identified errors you may refer to your IT institutional support and export a csv file directly from the Moodle database.

Blackboard

The IMS-CP course archive file is required and a csv export from the Activity_Accumulator table in the Blackboard database.

The SQL query to obtain the dates in the correct format is below:

```
select PK1
from BB_BB60.COURSE_MAIN
where COURSE_ID = 'coursecode';

--Check the count
select count(*)
from BB_BB60.ACTIVITY_ACCUMULATOR aa
where aa.COURSE_PK1 = 'insertpk';

--Query for the data export
--Change date range as required

select aa.PK1, aa.EVENT_TYPE, aa.USER_PK1, aa.COURSE_PK1, aa.GROUP_PK1,
aa.FORUM_PK1, aa.INTERNAL_HANDLE, aa.CONTENT_PK1, aa.DATA,
       to_char(aa.TIMESTAMP, 'DD-MON-YY HH24:MI:SS') TIMESTAMP,
       aa.STATUS, aa.SESSION_ID, aa.MESSAGES
from BB_BB60.ACTIVITY_ACCUMULATOR aa
where aa.COURSE_PK1 = 'insertpk'

      and aa.TIMESTAMP
      between to_date('11-12-2015 00:00:01', 'DD-MM-YYYY HH24:MI:SS')
      and   to_date('13-12-2015 23:59:59', 'DD-MM-YYYY HH24:MI:SS')
      ;
```

Loop Installation and Configuration

The source code is available as open source via the Github repository at:
https://github.com/looptool/download

1 Clone the repository

```
$ git clone https://github.com/looptool/download.git
$ cd download
```

2 Install the project requirements

```
$ pip install -r requirements.txt
```

A Virtual environment can be created for this project.

A Virtual Environment is a tool to keep the dependencies required by different projects in separate places, by creating virtual Python environments for them.

3 Setup a MySQL database using the datawarehouse/cloop_olap.sql script. This is the OLAP database.

4 Enter the database settings in cloop_project/settings.py. A secret key also needs to be entered. There is a local database for the Dashboard (this can be in any database supported by Django) and the OLAP database (currently in MySQL).

5 Setup the local django database

```
$ python manage.py makemigrations
$ python manage.py migrate
```

6 Create an admin user

```
$ python manage.py createsuperuser
```

7 Integrate Django with a Webserver. Apache or Nginx can be used. Instructions for Apache are included.

Create a Virtual Host:

```
$ mkdir  -p ~/public_html/loop
$ sudo chmod -R 755 /home/ubuntu/public_html
$ cd ~/public_html/loop
```

Edit the default virtual host file

```
$ sudo nano /etc/apache2/sites-available/000-default.conf
```

The main things to change are:

- comment out the document root
- add the WSGIScriptAlias to point to the location of the wsgi file
- Include the <Directory> directive otherwise there will be apache access errors. Without <Directory> you will get an `H01630: client denied by server` error.
- Includes a mapping for a static folder for the django project (i.e. for serving static files for images, js or css)

```
<VirtualHost *:80>
# The ServerName directive sets the request scheme, hostname and port that
# the server uses to identify itself. This is used when creating
# redirection URLs. In the context of virtual hosts, the ServerName
# specifies what hostname must appear in the request's Host: header to
# match this virtual host. For the default virtual host (this file) this
# value is not decisive as it is used as a last resort host regardless.
# However, you must set it for any further virtual host explicitly.
#ServerName www.example.com
ServerAdmin webmaster@localhost
#DocumentRoot /var/www/html
WSGIScriptAlias / /home/ubuntu/public_html/loop/loop_project.wsgi
Alias /static/ /home/ubuntu/public_html/loop/loop_project/static/
<Location "/static/">
Options -Indexes
</Location>
<Directory /home/ubuntu/public_html/loop>
Options Indexes FollowSymLinks
AllowOverride None
Require all granted
</Directory>
# Available loglevels: trace8, ..., trace1, debug, info, notice, warn,
# error, crit, alert, emerg.
# It is also possible to configure the loglevel for particular
# modules, e.g.
#LogLevel info ssl:warn
ErrorLog ${APACHE_LOG_DIR}/error.log
CustomLog ${APACHE_LOG_DIR}/access.log combined
</VirtualHost>
```

Creating a WSGI File

The Web Server Gateway Interface (WSGI) is an interface that maps requests from a Webserver (e.g. Apache) to a web application in python.

A WSGI configuration file `/var/www/loop_wsgi.py` must be setup. In the file a virtual environment can be specified along with the django project settings:

Create the .wsgi file mentioned in `/etc/apache2/sites-available/000-default.conf:`

```
$ sudo nano ~/public_html/loop/loop_project.wsgi
```

Enter the following:

```
import os
import sys
```

```
sys.path.append('/home/ubuntu/public_html/loop/loop_project')
os.environ['DJANGO_SETTINGS_MODULE'] = 'loop_project.settings'
import django.core.handlers.wsgi
from django.core.wsgi import get_wsgi_application
application = get_wsgi_application()
Reload Apache VirtualHost and Server
$ sudo a2ensite
$ sudo /etc/init.d/apache2 reload
```

Note: Use a2dissite to remove a loaded virtualhost

8 Go to the /admin in a Web browser and add users and courses (adding a course repeating event is mandatory). You will need to login using the admin username and password that was created in step 6. You must also set up the dates for key course events. Users are added and assigned to courses using the admin interface.

9 Setup the data warehouse config file (datawarehouse/config.json). The course_id must match the course_id from the Django dashboard database (the one automatically generated by Django, not the ID defined by the user of the system). The format for the json file is below:

```
[
{"course_id": 5, "start_date":"27/JUL/15", "end_date":"06/NOV/15",
    "course_type": "Blackboard"},
{"course_id": 6, "start_date":"27/JUL/15", "end_date":"06/NOV/15",
    "course_type": "Moodle"}
```

Note: Semester start and end dates must be included.

In datawarehouse/build_olap.py enter the database access credentials.

10 Create a /data directory. Each course must have a folder with the course_id as the name. The course export file must be unzipped and placed in the folder. The log file must also be placed in the folder and named log.csv.

11 Run datawarehouse/build_olap.py to create the data warehouse and cache the display results for the dashboard.

12 All users will now be able to login to the dashboard.

13 The OLAP DB can be started.

14 The server can be started

```
$ python manager.py runserver
```


Mid-term exam 1
Concept check 4
Mid-term exam 2
Pageviews
Single Course Events
Submission Events

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