Innovative Research Universities

The Use of Learning Analytics to Support Improvements in Teaching Practice

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Table of Contents

Executive Summary

The Use of Learning Analytics to Support Improvements in Teaching Practice is a joint Innovative Research Universities (IRU) and Malaysian Research Universities (MRUN) project. The project's overall aim was to explore the use of learning analytics by teaching staff to enhance improvements in teaching practice. The project's specific goals were to:

- identify the range of learning analytics functions related to teaching practice available in partner institutions
- identify ways in which learning analytics can be used to improve teaching practice
- develop a set of metrics based on learning analytics to improve teaching practice
- test this set of metrics' effectiveness for improving teaching, based on students' retention, engagement and motivation.

These goals were achieved in three stages:

1. duplicating surveys previously conducted in Australia in Malaysia to provide a comparison of development in the two countries
2. conducting focus groups to explore teacher requirements and views of visualisations
3. developing case studies to demonstrate how learning analytics is being used by teachers in partner institutions.

Each of these project stages includes a methodology, findings and implications for the next stage. The first two stages also included a literature review.

Stage 1 of the project used surveys with teaching staff to explore and compare the learning analytics environments in Australia and Malaysia. The survey instrument had been trialled and tested in Australia in 2014 as part of the Australian Government funded project, Learning Analytics: Assisting Universities with Student Retention (West et al. 2015); a modified version of the same survey was subsequently used in Malaysia in 2016. (As the survey was modified, Australian project members provided advice and guidance to Malaysian colleagues to ensure comparability would be maintained.) Numerous similarities and differences were observed across the two countries.

In Stage 2, the focus groups, the project focused on the development of teacher metrics in an effort to determine ways to use learning analytics to improve teaching and learning. Two critical questions arose out of Stage 1:

- Is the community of inquiry model (CoI) appropriate as a conceptual framework within which to situate the development of teacher metrics to support the use of learning analytics to improve learning and teaching outcomes?
- Can learning analytics impact on learning and teaching outcomes across a variety of teaching settings?

Focus groups were conducted with teaching staff in Australia to explore their perspectives on learning analytics and how they could see it being used in their teaching practice. Participants in the focus groups were asked to note key questions they wanted answered in relation to learning and teaching and to reflect on what data they would find useful. (The focus groups in Malaysia are, however, still to be undertaken, so data from those could not be included in the project findings).

Seven report visualisations from across the institutions were also presented to focus group participants; each included a title and brief explanation. Participants were asked to rate reports in relation to their potential usefulness.

Stage 3, the final stage of the project, was originally designed to develop and test teacher metrics. Due to issues with timelines, institutional readiness and infrastructure, this stage was modified. Instead eight institutional case studies were developed, describing how teachers are using the data available to them.

Overall, the project produced several significant results:

- Learning analytics development must be considered in context at multiple levels.
- There is considerable variation in terms of stages of development and readiness which operates at various levels.
- The questions that most teaching staff currently seek to answer are at the level of descriptive.
- The usefulness of any learning analytics report/ visualisation will be connected to the purpose of the report in relation to the role of the university teacher, their discipline and pedagogical approach as well as the learning and teaching lifecycle.
- Teaching staff are most interested in reports that can help improve student success (beyond retention) and classroom analytics (data within the teaching context) which can assist in understanding student success.
- There was great variation in the knowledge and skills of teaching staff in relation to their appreciation of learning analytics reports and applications; however, teachers are more likely to invest in learning about and using the reports if there is a clear appreciation of the value offered by the report.

These findings support the following actions and considerations regarding the use of learning analytics to support staff in improving their teaching practice.

- It is important to determine institutional readiness to gather, process and apply data from a broad range of sources and ensure teaching staff are included in discussions and decision making.
- A clear plan for learning analytics, focusing on teaching and learning and taking into account institutional readiness and context, needs to be developed and articulated to staff in a timely manner.
- In order to improve the take up and the use of reports by teaching staff, the reports' value will need to be made clear; they will also need to be easy to access and use, and professional development will need to be provided.

Introduction

The Use of Learning Analytics to Support Improvements in Teaching Practice is a joint Innovative Research Universities (IRU) and Malaysian Research Universities (MRUN) project. The overall project aim was to explore the use of learning analytics to support improvements in teaching practice; its specific goals were to:

- identify the range of learning analytics functions available in partner institutions which are related to teaching practice
- identify the ways in which learning analytics can be used to improve teaching
- develop a set of metrics based on learning analytics to improve teaching practice
- test the set of metrics for improving teaching based on students' retention, engagement and motivation.

In order to achieve these goals, the project was undertaken in three stages:

1. Duplicating surveys previously conducted in Australia in Malaysia to provide a comparison of development in the two countries
2. Conducting focus groups to explore teacher requirements and views of visualisations
3. Developing case studies to demonstrate how learning analytics is being used by teachers in partner institutions.

This report begins with a brief literature review to set the scene and then presents the methodology, findings and a discussion relevant to each stage of the project. It concludes with a general discussion which returns to the key goals and overall findings.

Background Literature

Learning analytics is defined as the 'measurement, collection, analysis and reporting of data about learners and their contexts, for the purposes of understanding and optimising learning and the environments in which it occurs' (Siemens & Long 2011, p. 34). Learning analytics can take a variety of forms including dashboards, recommender systems, predictive analytics, and alerts/warnings/interventions. Papamitsiou and Economides (2014) conducted a review of literature on learning analytics and educational data mining, identifying 40 key studies conducted between 2008 and 2013. These studies explored various areas of use for learning analytics and data mining with most investigating, 'student/student behaviour modelling and prediction of performance, followed by increase of students' and teachers' reflection and awareness and improvement of provided feedback and assessment services' and recommendation of resources (p. 53). These issues have not changed since 2013.

Learning analytics provides scope to address concerns related to a broad range of teaching and learning areas. These areas include: retention and student success (Arnold & Pistilli 2012; de Freitas et al. 2015; Gašević et al. 2016); improvement of learning design, units, courses and teaching practice (Dyckhoff et al. 2012; Haya et al. 2015; McKenney & Mor 2015; Persico & Pozzi 2015; Toetenel & Rienties 2016); the development of personalised learning pathways; and student support (Liu et al. 2017). However, the realisation of using learning analytics to their full potential in addressing these various teaching and learning areas has yet to be fully achieved.

Much of the work in the sector to date has been focused on addressing student retention and, to a lesser extent, student success, with a clear emphasis on 'at risk' students (Lawson et al. 2016; Marbouti et al. 2016; Joksimović et al. 2015; Zacharis 2015). This focus is probably the result of government drivers in the countries leading learning analytics development. Australia, the United States and the United Kingdom are all seen as leaders in this field (Sclater et al. 2016), and all these countries have clear government agendas regarding student retention. It is therefore unsurprising that learning analytics development has been motivated to determine how to identify and retain 'at-risk' students. While retention is an important application of learning analytics, it shifts the focus to an issue prioritised most often by the institution rather than areas of teaching that teaching staff might consider a focus. Several studies have explored the level of interest by teaching staff in the field of learning analytics (e.g. Corrin et al. 2016; West et al. 2015).

These studies found that while teaching staff are interested in the use of learning analytics, they often have little understanding of how it can be utilised or of what is available in their context (Corrin et al. 2016; West et al. 2015). Additionally, while retention is of some interest, teaching staff tend to be more concerned with the broader issue of student success and how learning analytics can be used to improve learning and teaching within the 'classroom' environment.

As the use of information technology has expanded in education, the traditional classroom environment has evolved to include a range of modalities, from the traditional face-to-face approach to the use of information technology to 'blend' face to face and online learning, through to fully online courses/ programs. This increased use of information technology in higher education provides the foundation for the use of learning analytics, and teaching staff have begun using them to measure students' engagement in online contexts (Beer et al. 2010). However, the use of learning analytics to determine what students do as they learn (and indeed all aspects of the use of learning analytics) is variable across the sector (Atherton et al. 2017; Liu et al. 2015).

By definition, learning analytics relies on the use of digital data relating to students' learning journeys. It is therefore heavily dependent on the use of information technology to collect the data in a useful format, and preparedness for this varies considerably across institutions and countries (Sclater et al. 2016). This state of preparedness, often referred to as 'institutional readiness', is dependent in the first instance on technological infrastructure and use, but is also connected to the culture of the institution, including its strategy, policy frameworks and understanding regarding learning analytics (JISC 2017; Colvin et al. 2016; West et al. 2015; Greller & Drachsler 2012). Institutions which regularly utilise a range of educational technologies (learning management systems, online classrooms etc.) are therefore better placed to harness the affordances of learning analytics than those who do not. Additionally, institutional readiness is related to the idea that the more reliant an institution is on information technology the more digital data it is likely to have, and consequently the more relevant and of greater value the processing and delivery of this data to stakeholders will be.

In addition, learning analytics data and development can be seen to operate on several continua. First is the idea that data can be accessed and utilised from one system (e.g. from either the student information system (SIS) or the learning management system (LMS), independently of each other) to provide some insights, or it can integrate data from two systems (such as the SIS and the LMS together), or it can be federated, drawing in data from multiple systems. The capacity to extrapolate more and greater insights is generally enhanced as the number of relevant data sources being integrated is increased.

The levels of complexity and sophistication in the data processing, and the application involved, also have a significant effect on learning analytics outcomes. As noted earlier, learning analytics can take a variety of

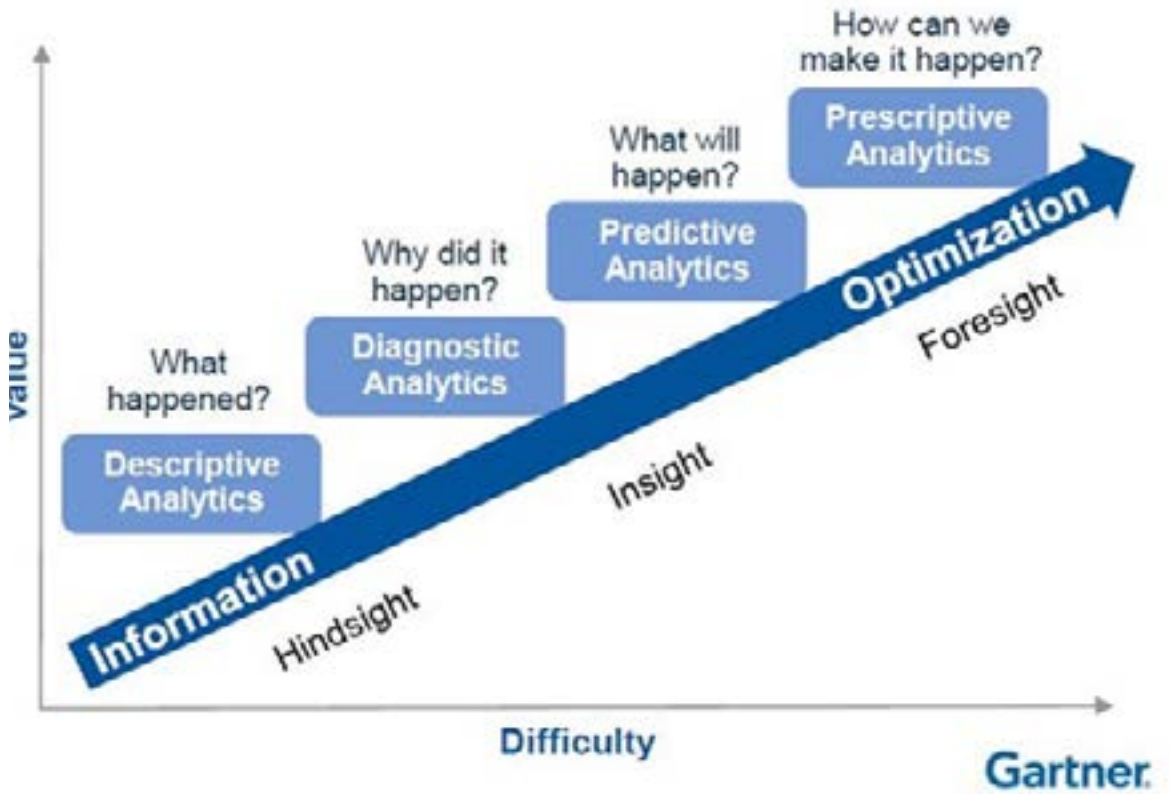

Figure 1: Analytics maturity curve (from Morgan & Duncan 2016)

forms including dashboards, recommender systems, predictive analytics, and alerts/warnings/interventions. All of these have a purpose but some are able to achieve their purpose with smaller data sets, while others require larger data sets in order to build sophisticated, predictive models.

Figure 1, produced by Gartner (Morgan & Duncan 2016), shows a maturity curve for the field of data analytics.

The diagram should not be interpreted as suggesting that descriptive analytics, positioned as the lower, beginning point of the diagram, are not as useful as predictive analytics (positioned at the top of the diagram), as the use and value of each type of analytics will depend on its overall purpose and context. In relation to learning and teaching in higher education, each type of analytics indicated on the diagram will have a value and will speak to a different stage of learning analytics development and will be relevant to different institutional audiences.

However, while work continues in the broader learning analytics field, research and development in the area of learning and teaching interactions has remained somewhat limited. Calls for research to focus on what can be termed 'classroom analytics' have been increasing (Siemens et al. 2013), though few studies report on the specific types of data and reports teachers would find useful. West et al. (2015) highlight that the majority of questions teaching staff want answered could be provided through the integration of SIS and LMS data.

The work by Corrin et al. (2016) also draws attention to the key role of pedagogy in the design of learning analytics reports. Also, as online learning using 'Web 2.0' technologies has gained momentum, interest has grown in considering pedagogical practices specifically related to supporting online teaching and learning.

Acknowledging the importance of learning as a social activity (i.e. not something that occurs in isolation), the learning theory known as connectivism (Siemens 2004) was put forward as one that could support online learning. However, as critiqued by Clarà and Barberà (2013), connectivism was developed to support Massive Online Open Courses (MOOCs) and 'has mainly been disseminated in a large number of blog posts and articles on Internet sites (without peer-review processes)' (p. 198). Research into the networks and interactions developed by students with their peers has also progressed, with tools such as Social Network Analysis and Pedagogical Practice (SNAPP) (Dawson 2010).

Alongside these advances, Garrison, with various colleagues and over a number of years (Garrison et al. 2001; Garrison & Anderson 2003; Garrison & Arbaugh 2007; Garrison et al. 2012), developed the CoI model for teaching in online contexts. The advantage of the CoI model is its acknowledgement of the significance of the social aspects of learning while also recognising the importance of the particular roles played by both teachers and students.

As recognised by the work of Garrison, his colleagues and others (e.g. Corrin et al. 2016; Siemens et al. 2013; West et al. 2015), it is imperative to advance learning analytics in ways useful to teachers such that they will actually engage in using them. As discussed by Keppell et al. (2015) the alignment of 'pedagogical, technical and administrative issues remains a necessary condition of success in creating an engaging learning environment' (p. 6).

Data science work and progress in learning analytics, which is also important, must, therefore, be grounded in, and connected to, good pedagogical practice and educational theory; otherwise, either group runs the risk of moving forward in isolation. Additionally, all practitioners need to be mindful that all work in learning analytics may be either enhanced or limited by its developmental context, including organisational culture and infrastructure.

The literature review, overall, provided evidence for the need to determine how learning analytics could best be used to further support teaching staff in 'classroom' contexts. This project was established to identify a means to determine the current 'state of play' of learning analytics in IRU and MRN institutions and to determine how it might be better used to support and enhance teaching practice.

Overview of the Project

As noted above, the overall project aim was to explore the use of learning analytics to support improvements in teaching practice, with the specific goals of:

- identifying the range of learning analytics functions available in partner institutions which are related to teaching practice
- identifying the ways in which learning analytics can be used to improve teaching
- developing a set of metrics, based on learning analytics, to improve teaching practice
- testing the set of metrics, based on student retention, engagement and motivation.

In order to achieve these goals, the project was undertaken in three stages each with its own methodology, findings and implications for the next stage. The following section outlines each stage separately and the summary integrates data from the previous stages.

Stage 1: Finding the baseline: Malaysian/Australian comparison

The first stage of the project involved exploring and comparing the learning analytics landscape in Australia and Malaysia. This stage was essential for gaining understanding of the two countries readiness for learning analytics in terms of both infrastructure and academic perspectives.

Methodology

In order to undertake a comparison between the two countries, two surveys (one academic, one institutional), initially developed for the Australian Government funded project Learning Analytics: Assisting Universities with Student Retention (West et al. 2015), were used to gather a range of information. Data collection in Australia had taken place in late 2014 as part of this previous project, with 353 responses to the academic survey. Initial discussions with the Malaysian researchers indicated that these surveys could potentially be used to gather the same data in Malaysia and support a comparison of results across the two countries. The IRU institutions provided practical support to their MRUN colleagues by checking for consistency across the two surveys and offering advice and guidance as required.

The surveys were reviewed and amended by the project team to clarify language, meaning and appropriateness for the Malaysian context. They were then piloted in Malaysia and further reviewed by a Malaysian expert panel. Reliability testing of the survey was undertaken using a Rasch Model technique returning a Cronbach Alpha (KR-20) value of 1.0, indicating that the survey had a high level of reliability. The academic survey in Malaysia yielded 224 responses.

Findings

Conducting the survey across two countries and cultural contexts illustrated a number of similarities and differences. These include:

- a great deal of interest in learning analytics across both countries
- the two countries being at different stages of learning analytics development
- considerable differences between the two countries in the use of LMS
- differences in the ways in which institutional context and infrastructure influence the expectations and understandings of staff and their capacity to use learning analytics
- variations in institutional capacity in meeting the needs, expectations and understandings of staff and their capacity to use learning analytics
- differences in ethical concerns, which were evident across both countries, which may be a reflection of institutional policies, understandings or cultural differences.

These similarities and differences are explored in more detail below. It should be noted that a more in-depth article on this comparison has been submitted for publication and that the figures presented below are duplicated in that article.

Interest in Learning Analytics

Although the surveys were distributed at different times, with the Australian survey conducted in 2014 and the Malaysian survey in 2016, a great deal of interest in learning analytics is evident across both countries. Teaching staff were asked to indicate their level of involvement in particular learning analytics related activities: Figure 2 illustrates the varied activities in which they were involved.

In both countries the highest percentage of responses concerned using learning analytics to help with analysis and decision making and reading about learning analytics for personal professional development.

The greatest differences were around conducting formal research and/or publishing work on the topic of learning analytics, advocating the use of learning analytics to colleagues and none of the listed choices (i.e. other activities around learning analytics). Malaysian teaching staff indicated that they are conducting formal research and/or publishing in learning analytics more than their Australian colleagues, while Australian teaching staff are more often advocating the use of learning analytics and were involved in more unlisted activities.

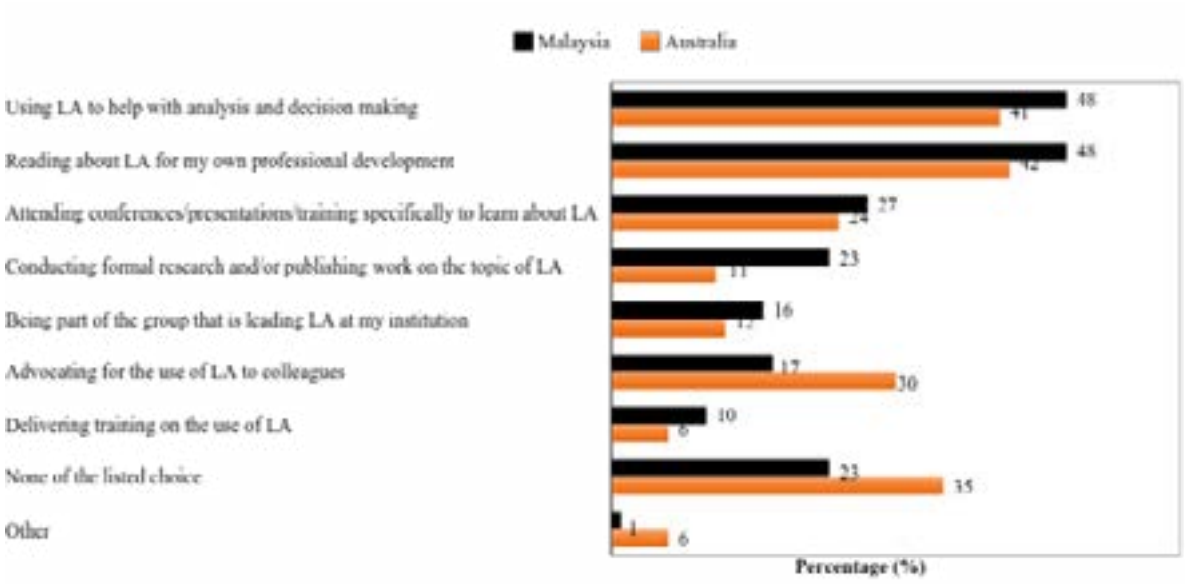

Figure 2: Types of learning analytics related activities in which Australian and Malaysian teaching staff indicated involvement

Discussions regarding learning analytics are also an indicator of interest in the topic. Figures 3a and 3b illustrate the frequency of discussions and with whom they are held. It is evident that conversations in relation to learning analytics occur at all levels, although they occur less with institutional management than with staff in other areas. The discussions are relatively infrequent (with most occurring less than monthly) across institutions in both countries, though teaching staff in Malaysia report having conversations more frequently.

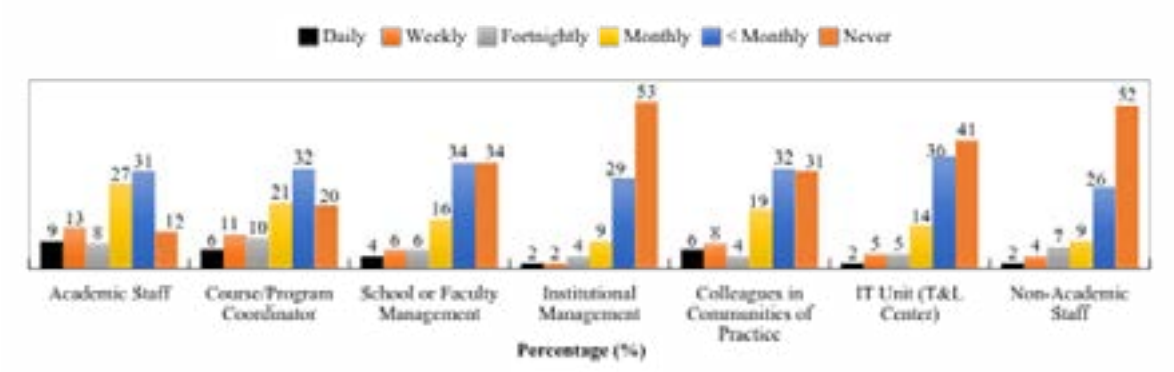

Figure 3a: Frequency and staff members with whom learning analytics is discussed (Malaysia)

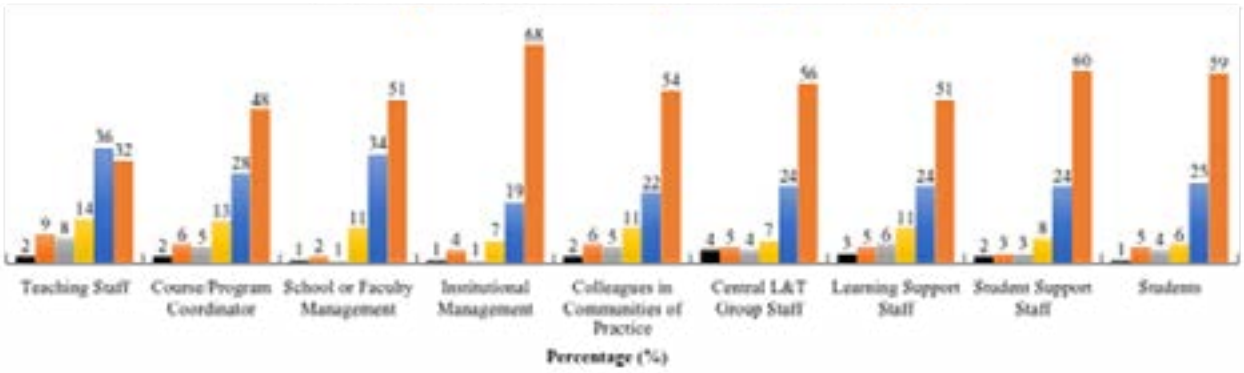

Figure3b: Frequency and staff members with whom learning analytics is discussed (Malaysia) (cont.)

Each country is at a different stage of learning analytics development

As understanding and interest in the use of learning analytics have developed, the way it is applied within teaching and learning contexts has also grown and changed.

For example, as shown in Figure 4 below, Malaysian teaching staff tended to show more interest in areas of learning analytics relating to student retention and success, while in Australia there was more variation in interest regarding the topic.

The differences in interest may be related to a longer and more sustained focus on at-risk students and retention in Australian institutions as a result of government policies linked to widening participation.

The differences in interest may also be linked to perceptions regarding responsibilities, culture, academic autonomy, perceptions of academic freedom and ethical considerations.

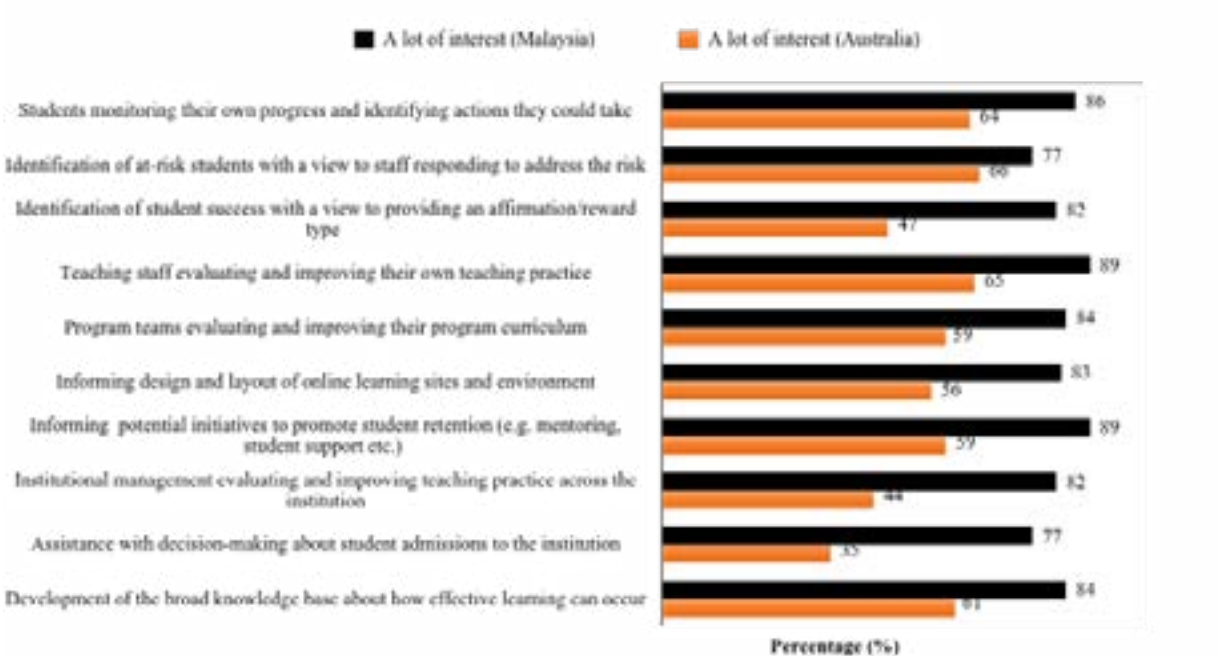

Figure 4: Percentage distribution of Malaysian and Australian teaching staff interest in learning analytics applications that can be linked to student retention and success (n varies)

Differences in the use of LMS between Malaysia and Australia

Figure 5 (below) illustrates survey responses regarding access to sources of data relating to the students' learning journey. In Australia teaching staff have more access to data from the LMS than Malaysian colleagues, who have more access to SIS data. Access to data from the library, learning support services and student support services is low in both countries. These results influence the survey findings in terms of the usage and relevance of learning analytics and may be indicative of the stage of the learning analytics journey that each country is at, as well as of a greater focus on online learning, reflected by the use of LMS in teaching and learning contexts in Australia.

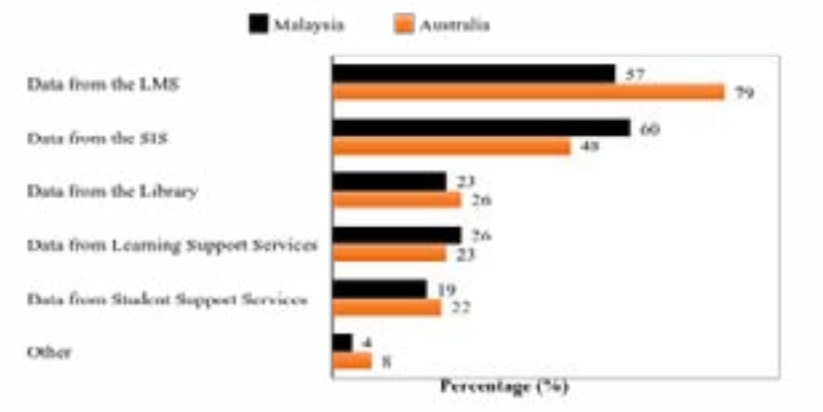

Figure 5: Access to sources of data relating to the student journey

Influence of institutional context and infrastructure

When adopting learning analytics, stakeholders require appropriate infrastructure that allows relevant data to be suitably captured, integrated and presented. It also requires staff to have opportunities and access to professional development so they may acquire the skills and abilities to become competent in accessing, understanding and using learning analytics data.

The capacity for institutions to provide the support that adequately underpins learning analytics demonstrates the different stages of the learning analytics journey experienced in each country reflected in questions related to access to student data from the LMS or Student Information System (SIS) (discussed above and reflected in Figure 5); institutional capacity to meet staff needs and expectations and understandings of staff and their capacity to use learning analytics; and, institutional infrastructure and questions related to ethics (all discussed below).

Variations in institutional capacity

Ways in which institutions can meet the needs and expectations of teaching staff as well as support their capacity to use learning analytics, include providing access to data and systems that allow staff to identify how their intended outcomes for students are being met and how students are using the resources provided to them. In addition, institutions can provide access and support to training and professional develop opportunities that develop staff understanding, aptitude and confidence. Figures 6 and 7 indicate the differences across Australia and Malaysia in staff perceptions' of institutional capacity to meet their needs.

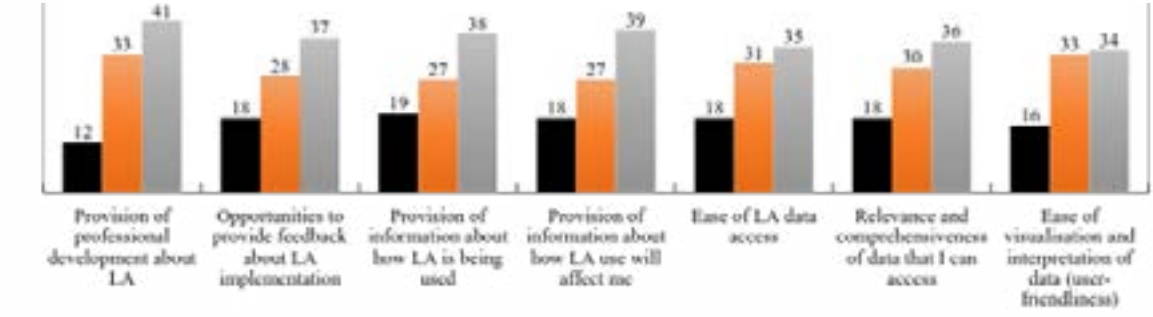

Figure 6: Staff perceptions of institutional capacity to meet their needs (Malaysia)

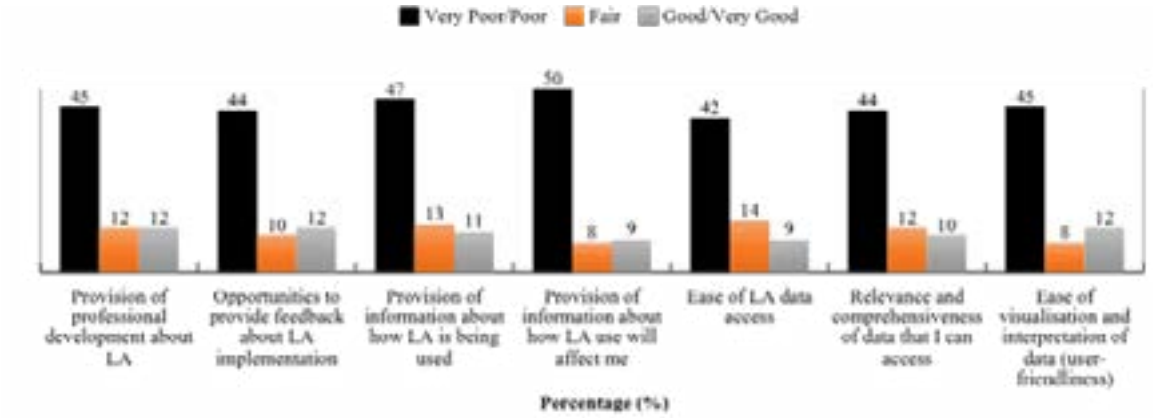

Figure 7: Staff perceptions of institutional capacity to meet their needs (Australia)

It is evident from these results that staff in Malaysia and Australia have differing perceptions and expectations regarding their institutions' capacity to meet their needs regarding learning analytics. In Malaysia, teaching staff rated the components of institutional capacity more highly (giving all seven a good/very good score) while their Australian counterparts rated the same categories as poor/very poor.

These findings may be an indicator that Australian teaching staff are at a different part of the learning analytics journey and therefore have different expectations of their needs and the institutional capacity to meet those needs. Ethical considerations may also be linked institutional capacity as they are linked to policies, understandings and cultural differences.

Differences regarding ethical concerns

The literature on ethics in learning analytics indicates that teachers' views on this need exploration. Teaching staff were asked a number of questions regarding their ethical concerns and how they felt these might influence their adoption and acceptability of learning analytics, specifically where it related to their teaching practice. The responses indicate that ethical concerns in Australia and Malaysia differ, as shown in Figures 8 and 9, below.

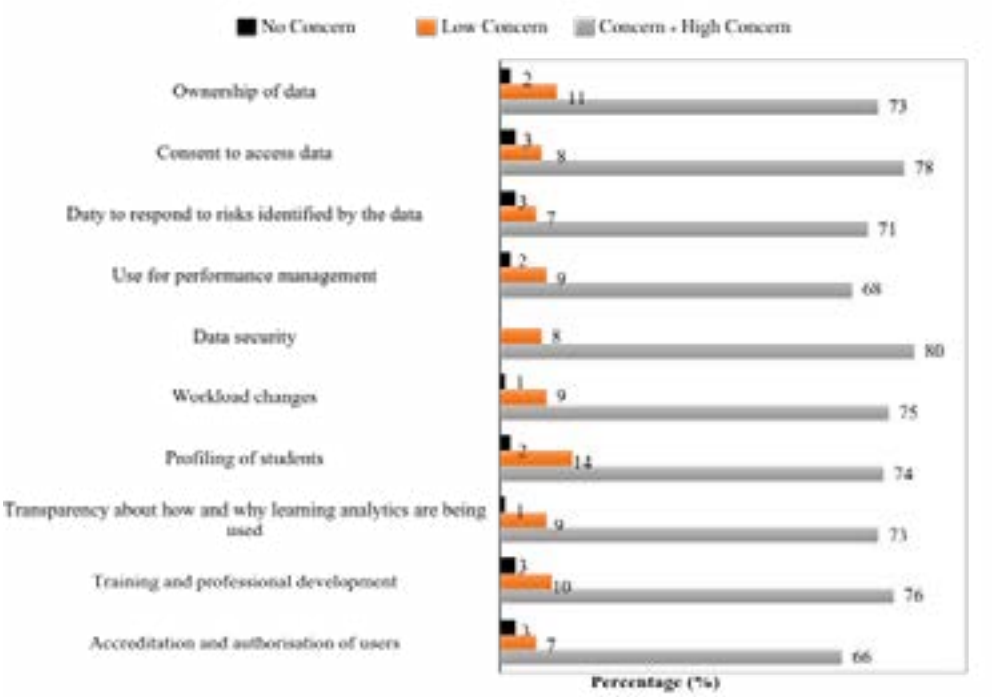

Figure 8: Concerns regarding ethics and learning analytics (Malaysia)

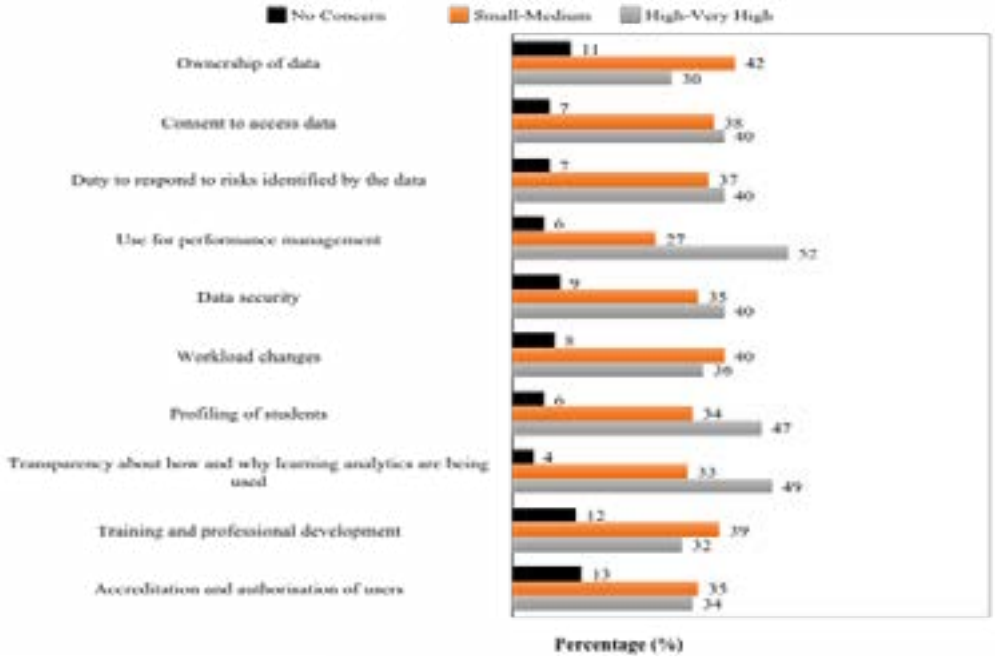

Figure 9: Concerns regarding ethics and learning analytics (Australia)

Teaching staff in Malaysia indicate a high level of concern about ethical issues across all areas, while in Australia the responses varied more, depending on the aspect of ethics broached.

Discussion

The results of these surveys make contributions to the understanding of what is currently available in data systems, and the types of data and business questions that teaching staff feel would be useful. However, the results also highlight several tensions in the development of learning analytics capacity and usage. These include balancing business needs and priorities with academic priorities and capacities to provide the information being requested. They also highlight a tension regarding institutional capacity to build the kind of more advanced predictive models which rely on bigger data sets.

For many institutions the focus is on the development of learning analytics to address problems of student retention, which may or may not be related to the types of questions teaching staff would like to pursue (such as curriculum improvement). While it is acknowledged that issues like curriculum design do contribute to retention, this is not necessarily the main contributor to attrition. In recent times institutions have generally been looking for the 'quick wins' around retention, including investigating the demographics and behaviour patterns of students who are most likely to attrite and developing programs to support these students.

Whilst some improvements in retention have been realised through these programs, they have often not yielded the rates of return (i.e. reduced attrition) that were originally hoped. Consequently, institutions are beginning to embrace a whole-of-institution approach to retention that involves looking at the results of institution-wide predictive models in conjunction with the analysis of data at the unit/classroom level for each of a student's enrolled units, in order to gain a more holistic view of a student's risk profile.

Essentially, respondents indicated that they would like key teaching and learning data integrated with other relevant data (such as demographic data or library access) to be available to them to incorporate within their analyses. However, this is often not available, or when it is, it is not in a form that can be readily utilised.

This unavailability of data is mainly due to two factors: the collection of various data in digital form, and the competing priorities institutions face when making decisions regarding the choice of data sets to incorporate into data warehouses. The provision of teaching data involves several issues, including the level of use of educational technology which can collect the relevant interactions between students, teachers and systems. Much of the teaching taking place occurs in a face-to-face or 'blended' mode which limits the use of learning analytics, as some important data is simply not captured or not seen as a priority to capture. For some programs, primarily in the arts and humanities, the use of the LMS may be seen to be restricted to administrative and communication purposes, again further limiting the opportunities for data collection.

The findings of this study suggest that educational technology is more widely used in Australian institutions, which tend to have a greater focus on blended and fully online educational approaches. Other data such as library access or access to support services is challenging as many institutions do not have systems in place to capture this in an electronic format which can be subsequently integrated with other data sets.

The second factor regarding data collection concerns institutional priorities on the integration of data. Building data warehouses and ingesting data sets (even where they are available) presents significant challenges regarding the preparation of data, integration systems, and building the appropriate analysis and visualisation elements. Preparing, integrating and presenting data is costly and time consuming, and therefore requires institutions to prioritise its development. At this stage institutions have prioritised data integration relating to broader concerns such as finance, human resources, teaching load and retention.

Despite these challenges the survey respondents expressed a need for a broad range of descriptive statistics, with some respondents also expressing interest in some metrics such as student grades, unit readiness given prior learning, tasks/assessments which best predict final grade, and patterns of resource usage.

However, the ability to build predictive models requires 'big' data, but many institutions do not have enough data available/collected for it to fit into this category. Currently, the main application of big data analytics within the higher education sector is the use of whole-of-institution predictive models regarding student retention rates. These models are typically developed using machine learning approaches (such as decision trees, neural networks or support vector machines) trained on several years of admissions, demographic, grade, LMS activity and wireless logins data, for often in the order of 100,000 students.

In contrast to this collection and manipulation of big data, classroom analytics, which operate at the individual unit of study level, are unlikely to have the required volume of data to build such models. Whilst in a relatively small number of units it is possible for there to be several hundred students enrolled per offering, for many institutions the average number of students enrolled in a unit is typically much less.

Even assuming little change occurs to the curriculum and learning design over a five-year period, this only yields a small number of training examples, which is insufficient to build a reliable predictive model. Consequently, whilst not impossible, modellers need to develop greater capacity for using smaller data sets when building predictive models for classroom analytics applications. However, most teaching staff suggest there is great value in being able to utilise descriptive forms of data which do not require large data sets. The type of questions teaching staff would like to be able to answer is explored further in Stage 2.

In summary, Stage 1 found that teaching staff in both Malaysia and Australia had strong interests in exploring learning analytics and determining how it could be used to improve teaching and learning. However, the findings also highlighted the different levels of understanding and development in thinking as well as institutional capability and readiness. These results reinforce the stand-alone findings of the Australian study (West et al. 2015), which drew attention to the critical role of context in learning analytics development.

Stage 2: Exploring teacher metrics

The second stage of the project focused on the development of teacher metrics.

The work undertaken in Stage 1 raised two critical questions related to the broad development of teacher metrics in this context. The first question concerns the conceptual framework within which the development of classroom analytics can take place, and the second to the potential impact of learning analytics. More specifically:

- Is the CoI model appropriate as a conceptual framework within which to situate the development of teacher metrics to support the use of learning analytics to improve learning and teaching outcomes?
- Can learning analytics impact on learning and teaching outcomes across a variety of teaching settings?

The first question arises from the need to draw on educational theory regarding learning analytics development as outlined above in the Background literature section. The CoI (discussed at length below in The CoI model section) is a conceptual framework based on three core elements: teacher presence, cognitive presence and social presence. These elements are seen as interrelated and, of relevance to this project, together provide a framework that can be used to understand 'the process of the complexities of online learning' (see Garrison & Archer 2000; Anderson et al. 2001; Garrison & Anderson 2003; Garrison & Arbaugh 2007; Garrison et al. 2010).

The second research question uses the CoI model to explore the metrics that could be used by teaching staff to better understand learning and teaching processes, activities and course design. This is complicated by the wide variety of settings where contemporary teaching takes place, including: face-to-face, blended, online, external or distance education, most of which use some form of learning management system or learning information technology to enable the achievement of learning outcomes. Investigation into the CoI model allowed a clearer focus on how metrics could be useful to teachers.

Methodology

To answer the questions outlined above, Stage 2 of the project first conducted a focused literature review to explore theoretical educational frameworks, drew on insights from key questions in the academic surveys and conducted a series of focus groups. These processes also provided scope for further verification and exploration of the findings from Stage 1 (as discussed above) in relation to the Stage 2 questions.

As noted above, and highlighted in Stage 1, the teaching approach taken will have a critical influence on learning analytics. The literature was revisited in an attempt to explicitly identify specific teaching models which operationalise learning analytics in the classroom. The literature review was undertaken prior to the focus groups and the summary of this work is presented in the Findings of the focused literature review section below. It is situated in this part of the report to illustrate the developmental nature of thinking regarding learning analytics, and to provide a specific theoretical framework for the analysis of particular data from the focus groups.

Issues identified in the academic survey that were further explored in Stage 2 were concerned with what aspects of learning analytics teaching staff saw as being potentially useful to them in improving learning and teaching outcomes; in particular, the questions they would like to be able to answer, the reports, and the data from which those reports were generated.

Focus groups were then conducted with teaching staff in three Australian (IRU) universities to explore their perspectives on learning analytics, and how they could see it being used in their teaching practice. (The focus groups that were planned for Malaysian universities are yet to be undertaken, so results from them are not included in the findings.) Ethics approval to conduct the focus groups was received via Charles Darwin University's Human Ethics committee, and the focus groups were conducted during March and April 2017.

Participants were recruited via an email which was sent to all teaching staff in each institution inviting them to attend a focus group to explore teachers' views and requirements regarding learning analytics.

A total of nine focus groups with 48 participants were held across the three institutions, as shown in Table 1.

Table 1: Focus group participation

Institution	Number of focus groups	Total participants	Disciplines represented
Charles Darwin University	4	20	10
Murdoch University	3	16	8
Flinders University	2	10	7

Participants came from a wide range of disciplines including creative arts, business, education, health sciences, physical sciences, and IT, thus providing a good mix of views and insights into academic challenges and teaching approaches.

The focus groups were conducted over 1.5 hours and were facilitated by the project team members in their own institutions. In order to provide some level of consistency the focus groups were structured with a set of questions and activities and followed the same process in each institution:

1. An exercise where participants were asked to write down individually, on 'sticky notes', questions that they would like to be able to answer or have insight to in relation to teaching/learning in their classes.
2. A discussion where participants shared with each other the questions they had written down to explore ideas and the types of data that might be required to answer those questions.
3. An exercise where seven learning analytics reports/ visualisations were presented to participants, who were then asked to grade the reports' usefulness on a scale of 1 to 5, and to describe what enhancements to those reports might be useful. An ongoing discussion was held during this exercise to explore each report, its applications and the reasons for giving the specific score to each report.
4. A discussion regarding what other reports teaching staff might see as useful.

All the focus groups were audio-recorded and then transcribed. All participants were de-identified in the process and the focus group findings are presented at an aggregate level both overall and by institution. Further methodological elements are incorporated in the Findings sections below as the data set was analysed in a variety of ways; it is best read within the context of the Findings of the focus groups, which is presented as a follow-on to the Findings of the focused literature review.

Findings of the focused literature review

A further review of literature was undertaken to ascertain where practitioners and researchers were developing links between learning analytics and classroom practice. As the focus on online learning increased in the late 1990s, the need to identify a suitable pedagogical practice that supported online learning and teaching increased. Numerous practitioners and researchers worked to develop a suitable pedagogy to support online practice (Garrison & Anderson 2004; Laurillard 2002; Siemens 2005; Stephenson 2001). Garrison and Anderson (2004) recognised that online learning complicated the role of teaching staff who became responsible for supporting students to find ways of navigating 'through this chaos, provide order and create the conditions to encourage a deep approach to learning' (p. 17).

Other early practitioners identified the missing elements in learning theories in an attempt to determine how a new paradigm of learning might allow the capture and use of potentially unknown data to be associated with the development of new knowledge. Siemens (2005), for example, argued that conventional learning theories (such as behaviourism, cognitivism, and constructivism) were limited because they focused on the individual learner, rather than what was being learned. He suggested that connectivism provides an answer as it is 'driven by the understanding that decisions are based on rapidly altering foundations' (p. 5) and therefore offers a paradigm for learning in a digital age.

The focus on connectivism became particularly significant as interest in learning analytics developed alongside the increasing reliance on teaching in online contexts. Online teaching and learning provides the opportunity to capture the interactions between students and their learning, as it provides an environment for capturing data on what students actually do as they learn. However, to date the missing elements for creating an effective environment where data may be used to inform teaching and pedagogy remain elusive, as staff researching learning analytics are often either not those at the 'coal face', engaged in teaching, or are teaching in contexts which easily lend themselves to the collection of data.

In the second review of literature we deliberately sought to identify material which specifically discussed the collection of data in classroom settings, as this literature better responded to our goals of identifying the ways learning analytics may be used to improve teaching, and to develop a set of metrics based on learning analytics to improve teaching practice. Studies which discuss pedagogical designs aligned with the use of learning analytics were identified (Corrin et al. 2016; Koh et al. 2016; Martin & Whitmer 2016; Toetenel & Rienties 2016; Rodriquez-Tirana et al. 2015) but few of these discuss ways of capturing the complex elements that address both teaching and learning activities.

The CoI Model

In attempting to discuss the complexity related to capturing data related to both teaching and learning activities, Stage 2 of this project works at the intersection of teaching and learning pedagogy/theory and data science. The CoI model, which is based on a social constructivist approach to learning and teaching, was found to offer an effective and appropriate starting point.

The CoI model for online learning has been developed over a number of years and is theoretically grounded in social constructivist models of learning and teaching and learning community theory (see Garrison & Archer 1999; Anderson et al. 2001; Garrison & Anderson 2003; Garrison & Arbaugh 2007; Garrison et al. 2010). The model, as delineated in Table 2, is based on three core elements, teacher presence, cognitive presence and social presence, that are seen as interrelated and which 'can provide order and parsimony to the complexities of online learning' (Garrison & Arburgh 2007, p. 158).

Anderson et al. (2001 in Garrison et al. 2010) define teacher presence as 'the design, facilitation and direction of cognitive and social processes for the purpose of realising personally meaningful and educationally worthwhile learning outcomes' (p. 32). In essence, this summarises the role of the teacher in online learning from the curriculum design aspects through to teaching activities and assessment.

Cognitive presence is related to the student's learning process and incorporates four key stages: 'definition of a problem or task; exploration for relevant information/ knowledge; making sense of and integrating ideas; and finally, testing plausible solutions' (Garrison et al. 2010, p32). Social presence is defined as 'the ability of participants to identify with the community (e.g. course of study), communicate purposefully in a trusting environment, and develop inter-personal relationships by way of projecting their individual personalities' (Garrison 2009 in Garrison et al. 2012, p. 32).

Self-regulated learning is the conceptual framework for the fourth area of the model referred to as learning presence (Shea et al. 2012). However, this has not yet been articulated in the factor framework presented below. Open Universities UK have also added a separate fourth element of emotional presence (Cleveland-Innes & Campbell 2012).

In the model, social presence is seen as a 'mediating variable' between teaching presence and cognitive presence and as such is 'a responsibility of teaching presence and a condition for cognitive presence' (Garrison et al. 2012, p. 32). In other words, the teacher needs to provide the conditions for, and facilitate social presence, in order to increase cognitive presence in students. Testing of this hypothesis has been borne out by studies undertaken by Shea and Bidjerano (2012) and Garrison et al. (2012). In addition, a high level of both teaching presence and social presence was found to be necessarily associated with higher cognitive presence, despite variations in self-regulated learning (Shea & Bidjerano 2012).

The collaborative research team (e.g. Arbaugh et al. 2008; Shea & Bidjerano 2008; Swan et al. 2008 in Shea & Bidjerano 2012) developed three CoI presences and outlined a range of factors associated with each presence. This has allowed for operationalisation and empirical testing of the model. Table 2, below, outlines each presence and their associated factors.

Table 2: Community of inquiry (CoI) domains and factors (Garrison et al. 2012)

Teacher presence	Cognitive presence	Social presence
The instructor:	Problems posed increased interest in course	Getting to know others gave students a sense of belonging in the course
– communicated course topics	Course activities piqued curiosity	Students formed distinct impressions of course participants
– communicated course goals	Students felt motivated to explore content related topics	Students found online or web-based communication an excellent medium for social interaction
– provided clear instructions	Students utilised a variety of resources during the course	Students felt comfortable conversing online
– communicated due dates	Students brainstormed and found relevant information to aid them in resolving questions	Students felt comfortable participating in course discussions
– helped students learn	Online discussions helped student appreciate different perspectives	Students felt comfortable interacting with course participants
– helped students clarify their thinking	Learning activities helped students create solutions	Students felt comfortable disagreeing with others
– kept students engaged and participating	Reflection on course content and discussions helped student understand fundamental concepts	Students felt their points of view were acknowledged by others

Table 2 Cont. : Community of inquiry (CoI) domains and factors (Garrison et al. 2012)

Teacher presence	Cognitive presence	Social presence
– kept students on task	Students can describe ways to test and apply their new knowledge	Online discussions helped students develop a sense of collaboration
– encouraged students to explore new ideas	Students developed solutions to course problems that can be applied in practice	
– established a sense of course community	Students can apply knowledge created in their courses to work on other non-class related activities	
– helped focus discussion on issues that aided student learning		
– gave feedback and that helped students		
– provided feedback in a timely manner		

The CoI provides a useful starting point for considering data points in relation to metrics which can be aligned with improving learning outcomes.

Findings of survey mapping to CoI

As noted in the Methodology section above, several questions from the institutional and academic surveys were seen as relevant to addressing the main research questions in Stage 2. While the institutional survey is likely to yield insightful data from the Malaysian context it is currently incomplete due to a limited number (three) of institutional responses. However, the academic survey provides insights in relation to the identifying what teaching staff want. The relevant questions in the academic survey are:

- Given that learning analytics is about using data to help improve learning, what data are you most interested in accessing and exploring?
- How interested are you in the following (listed) applications of learning analytics that can be linked with student retention and success?

Given the review of the CoI and the sense that it would provide a valuable framework, the data points identified in the two survey questions listed above were mapped to the CoI. This mapping exercise was based on a CoI mapping template developed by Garrison et al. (2000). Of the total of 114 (not mutually exclusive) data points across the two countries the overwhelming majority fell into the cognitive presence (94) domain followed by social presence (35) and then teacher presence (12). However, there were more data points identified by Australian respondents (77) compared to their Malaysian counterparts (37). While this difference may be partially accounted for based on the total survey responses in the two countries (353 in Australia compared to 224 in Malaysia) it could also be related to several other factors.

These might include differences in the predominant teaching mode, the data available in the systems that teaching staff are aware of, and overall development of thinking around learning analytics. The additional data points identified in the Australian survey all fell into the cognitive domain. There were no data points across the two countries that could not be mapped into the CoI.

Looking at the data points in more depth across the two countries draws out interesting differences in emphasis. Malaysian respondents tended to focus predominantly on information related to social interactions on discussion forums and the correlation of these to cognitive presence and demographics. Australian respondents did not have the same emphasis; however they tended to include the use of a much broader range of educational technology ((e.g. online classroom,

lecture capture, use of social media, ePortfolios) which were not mentioned at all by Malaysian respondents. These emphases in the survey results are arguably a reflection of the technological infrastructure and development of blended and online modes of teaching in Australia, which are less available in Malaysia.

Findings of the focus groups

The next set of data captured in Stage 2 came from the focus groups held in Australia. It is at this point that the project diverges and the two countries can no longer be points of comparison, as focus groups have not yet been conducted in Malaysia, so there is no data available. This section unpacks the methodology further while presenting the findings in this context. The section is structured around the two key components of the focus groups which comprised an exploration of the questions teaching staff wanted answered and their responses to seven visualisations.

What learning and teaching questions do teaching staff want answered?

Focus group participants were given five to ten minutes to note down key questions they want answered in relation to learning and teaching and to reflect on the data they would see as useful in answering those questions. They were asked to do this individually before sharing their answers as a group. The questions and data traits were collected at the end of the focus groups and analysed according to key areas of interest. The questions teaching staff sought to answer fell within what would be defined as classroom analytics (within the teaching and learning context) and student success (beyond retention).

A sample of the questions participants sought to have answered and their categories include:

Access metrics

- What is the date of first access and last access to the LMS?
- Who has not accessed the LMS?
- What is the frequency of access?
- What are the access patterns and trends?
- What learning materials are accessed?
- What learning materials are not accessed?
- Who has/has not submitted work?
- How long does it take to find and log on to the LMS?

Time measurements

- What is the time spent on a task?
- How much time does a student spend on the LMS?
- What is the time spent on specific materials/ objects?
- How long are students engaged?
- What is the relationship between time and quiz results?
- How long are students spending on individual test/ quiz questions?

It should be noted that the nature of questions teaching staff asked has a relationship to the understanding and context of learning analytics at each institution and a dependency on the teaching approach in use (e.g. blended, fully online). This conversely explains the degree of complexity in the questions teaching staff want answered. Higher order thinking in terms of the complexity of questions is a development that can be expected as understanding of learning analytics matures.

Each institution also emphasised questions concerning student preparedness for higher education study, (e.g. background, how prepared are they for this subject, what kind of experience do they have in relation to this discipline) and particularly what is the level of English and Maths proficiency. Very few questions were raised regarding the teachers' own learning and teaching practice or curriculum.

The CoI framework was then used to map the questions to elements in the framework; cognitive presence; social presence and teaching presence to further test the applicability of the model with this data set. Most questions asked by teaching staff in the focus groups related to the cognitive presence element and reflected the idea that the domains of classroom analytics and student success to offer insight into cognitive presence. These results reinforced what was found when mapping the data from the surveys to the CoI.

Educational technology is a major enabler of cognitive presence and the 'digital footprint' of students is a means to measure and report this presence through learning analytics. It is therefore unsurprising that key questions teaching staff want answered concern cognitive presence. Further analysis and work on the application of the CoI is currently being developed and will be presented in a journal article.

Review of report visualisations scores and comments

The next part of the focus groups explored a set of seven visualisations and reports. The project team each selected visualisations/reports from their institution. Each represents an explicit facet of learning analytics in the context of the institution and has a focus on classroom analytics.

The seven reports incorporated visualisations of unit/course/topic access patterns, views and counts of items/objects/tools, time measurements, grade performance and engagement metrics, login patterns and access trends, student demographics, unit and course attributes, class and school metrics and retention and intervention rules and alerts.

Each report was 'titled' and included a 'layman's' explanation to help focus group participants' understanding. The following reports were selected for discussion (see Appendix 1 for descriptions):

1. Flinders University
    - Early Intervention Clustering Tool
    - Personalised Learning Designer
    - Active User Block
2. Charles Darwin University
    - Unit at a Glance
    - Student at a Glance
3. Murdoch University
    - Heat Map
    - Progress Bar

Participants were presented with each report individually and asked how useful it seemed to be, rating them on a scale from 1 (indicating 'not useful') to 5 (indicating 'very useful'). Analysis of these scores indicated that all of the visualisations/reports were seen to be useful but that visualisations showing student engagement metrics and activities were given higher ratings.

Context is an important consideration in looking at this data, as each institution has a different approach to their implementation of learning analytics and is at different stages and levels of maturity in learning analytics development. Additionally, institutional knowledge and understanding of each report probably influenced the discussion. It is assumed that while background information was provided when introducing the reports, each institution has a better understanding of their own individual reports. For example, at the Charles Darwin University focus groups participants did not score the Active User Block as it was assumed that this report was an element of the Personalised Learning Designer. In other focus groups the terminology used to describe reports may have also contributed to the scoring of reports, for example the terms 'unit', 'course' and 'topic' mean different things to different institutions.

Following the scoring process, participants were asked to provide comments about the scores to stimulate general discussion about each report's usefulness, design, utility, purpose, impact on learning and teaching and professional development. This discussion drew attention to several key findings.

Perception of usefulness is variable according to several factors, including the role of the university teacher in relation to the purpose of the report and the relationship between the underlying data in the report and the pedagogical approach the teacher uses. Essentially, different reports have different purposes which can be useful to some teaching staff at particular points in the learning and teaching lifecycle. For example, some reports are designed for early intervention at the beginning of a semester (e.g. to ensure students have accessed materials) while others are designed to provide insight across a semester so are more useful towards the end of semester, and in ongoing curriculum design and improvement.

The relationship between pedagogy and the report/visualisation is critical, and impacts on the teachers' perceptions of usefulness. For example, the 'early intervention clustering tool' is reliant on the use of weekly quizzes to gauge student engagement and understanding of concepts in the early part of the semester. This is seen as very useful where the discipline and pedagogy are appropriate for quizzes, but is seen as not useful at all to others who teach in a different way or where the quizzes are not appropriate for the discipline.

Discussion of the design of the visualisations included comments on the layout, presentation and general look and feel. This discussion included considerations regarding whether it was seen as being easy or hard to read and interpret. Simple visualisations tended to gain positive comments from those who were less experienced in the use and interpretation of learning analytics. Several of the reports which were seen as more complex were described as useful to 'power users' (i.e. those who are comfortable with quantitative data and/or regularly engage with such reports). Again, these comments often also related to disciplinary background and role. In the context of experience there was discussion around the need to include more or less data in a report. The amount of data included often varied according to the purpose and usability of the report and the role and experience of the teacher viewing or interpreting it.

The perceived complexity of the reports led to discussion around the need for professional development for many staff in order for them to be able to engage effectively with the reports. This ranged from knowing how to access the reports through to how to use and interpret the data. The range of discussion suggests the need to provide professional development in a variety of ways including taking account of role, discipline and pedagogical approaches. The provision of 'use cases' was also suggested.

The issue of time pressures came through quite consistently in terms of both the time needed to learn about the reports and their uses and the time to actually engage with the data. Concerns about time suggest two key points – the reports need to be as simple to use as possible, and they need to be easily accessible. Many teachers suggested that a 'push' notification to remind teaching staff at key points in the semester would be very useful for two purposes: to remind teaching staff to look at data at key points in the semester and to automate actions to the students. The reports must also be seen to have a clear value proposition for the teacher (e.g. to save time).

Review of transcripts from focus groups

All focus group discussion was recorded and transcribed using professional services. Each transcript was read by each institution with key points captured in a spreadsheet and grouped by Data Point Comments, Visualisation Comments and Insight Summary.

A review was undertaken to understand commonalities across the institutions. In looking at the comments associated with data points it was clear that teaching staff at each institution sought to gain more information about the student profile, data from other sources (e.g. systems beyond the LMS), time spent on task, and performance and engagement across units/topics/courses.

While the student profile was a focus in the transcripts, it was only emphasised in the sticky notes exercise and not identified as being of most interest in the visualisations. The transcripts, however, identify that all institutions sought to gain greater awareness of the student profile and wanted to understand how prepared the student is for higher education. The main considerations were the understanding of digital literacy, pathways, educational background, admission to university and prior studies.

Each institution also recognised that data from sources other than the LMS is an integral element in understanding the student learning journey, and while learning analytics offers opportunities regarding classroom analytics, it was evident that data from other sources such as library access and student support services would enhance this understanding.

The investigation of the visualisation comments recorded in the transcripts highlighted several common elements across the three institutions. All recognised that learning analytics visualisations enable and support the student conversation and consultation and provide a basis for opening discussion. It was also found that, when visualisations are used to report data, flexibility and customisation to context are important considerations.

In analysing the transcripts each institution identified key insights. Unsurprisingly, these insights align with the broader findings from the focus groups but highlighted engagement, time, level of analysis and the student profile as key facets. Conceivably, identifying these facets as key reflects the circular nature of discussions over the duration of the focus groups, as the first activity participants engaged with was to seek out key questions that teaching staff want answered. However, in the review of the transcripts it is apparent that as the discussion became more robust, higher order thinking and understanding developed. This was reflected in the ways understanding of the context of learning analytics came into greater focus as the discussion between participants matured.

Regarding student engagement, there was an identified need for clarity around how student engagement is measured and what it means. The current measurements and data 'footprint' do not tell a teacher if the content was of any value to students' learning; furthermore, it is difficult to utilise learning analytics to represent what is not working. Time was a central issue identified by teaching staff across all focus groups regarding their use of learning analytics, as they indicated that it takes time to understand, time to learn and time to act on any data that is available to them.

The level of analysis was a common issue across all the institutions. One question raised, for example, was: what is the focus of analysis (unit/topic/subject level vs course/program/degree level)? It was agreed that there is a need to provide a bigger picture of student learning analytics at the course/program/degree level and over time, to allow longitudinal representation.

As is evident in the comments associated with data points, each institution sought to gain more information about the student profile. While this key insight is largely relevant for student cohorts that study at a distance or never attend on campus, it is of some use regardless of teaching modality or learning methods.

Discussion

As noted above, this stage of the project sought to answer two key questions:

- Can learning analytics impact on learning and teaching outcomes across a variety of teaching settings?
- Is the CoI model appropriate as a conceptual framework within which to situate the development of teacher metrics to support the use of learning analytics to improve learning and teaching outcomes?

In response to the first question, the evidence suggests that while the potential is there for learning analytics to impact on learning and teaching outcomes across a variety of teaching settings there are a number of caveats. Considering the nature of the teaching interaction, there are obvious limitations to the collection and use of data in settings where teaching takes place in a largely face to face mode. Learning analytics clearly offers more to those teaching in a blended mode and more again for those who teach in a fully online mode. Therefore the greater the use of educational technology, the more data will be collected and available. However, this also relates to the way the curriculum and teaching are structure, the educational theory used and the pedagogical approach employed.

Regarding pedagogy, teaching staff responded to the different sample reports according to how they went about their teaching (irrespective of mode). For example, teachers who typically use quizzes on a regular basis tended to like the report which was predicated on that approach, whereas others felt that report would be completely inappropriate in their teaching contexts. This kind of response tended often to be connected to discipline association, and was flagged with comments such as 'I teach in x discipline and that just wouldn't work in our discipline'. Other comments linked to pedagogical approaches were underpinned by a social constructivist or problem-based approach which highlighted the need to understand the interactions taking place in groups of students.

In terms of learning analytics visualisations, there was no clear preference for one type of visualisation over another. It was very clear however, that different types of reports would be of value to different pedagogical roles and for different purposes. This can be viewed in a variety of ways which includes the role of teaching staff in relation to the purpose of the report. An academic teaching a subject may find one set of reports useful but not others, while a course/program coordinator would utilise a different set of reports for a different set of purposes. Awareness of the range of potential applications came through in the questions that teaching staff identified, as well as in discussion of the visualisations.

The issue of variations in the appropriateness of reports also relates to the learning and teaching lifecycle: some reports are useful at the beginning of the semester (e.g. to understand who is in the class; or to assist in targeting 'at risk' students early in the learning process); some in the middle of semester (e.g. to understand the patterns of engagement and provide assistance where appropriate); and some at the end of semester (e.g. to assist in the grading or appeals process). Reports may also be used in the ongoing improvement cycle for subjects/units or course/programs, which may be after the completion of the teaching period and in preparation for the next teaching cycle.

There were however several factors that may have impacted on the responses received. The focus groups were run at three different institutions by the project team members at that institution. Despite the inclusion of an explanation about each report, it seems likely that they were explained in different ways, which may have impacted on the way they were viewed in terms of their potential application. Due to these variations in the perceived usefulness of the report by discipline and role, the responses received were also probably affected by who was in the room and their role or roles. Also, those who were familiar with the reports in their institution or had greater knowledge of learning analytics were likely to have had more understanding of how those reports could potentially be used.

In summary, the participants in the focus groups did see potential for learning analytics to impact on learning and teaching in a variety of ways. The perception did however vary according to role and discipline as well as with the participant's understanding of, and experience in, using learning analytics to provide insights. At this point the ability to impact on learning and teaching relies on a teacher actually looking at, interpreting and taking some action in relation to a report, particularly as none of the universities included in this study were at the point of having automated recommender systems.

In order to understand the potential impact of learning analytics, the data needs to be collected, processed and integrated. Exploring the questions that teaching staff wanted answered highlighted a focus on data which could show teaching interactions in relation to a range of other data points. In the first instance, these were predominantly demographic as well as student progression and success data. The project undertook an exercise of mapping the questions to the available data points and the infrastructure available to support a response to these questions.

This highlighted that none of the participating institutions were currently in a position to respond to all of the questions asked by teaching staff and only one institution could respond to the majority of questions. The integration of additional data sources such as library access and student support access was seen as desirable but is currently not available in any of the institutions in a way that is integrated with any other data. Predictive analytics was less of a focus for participants in the focus groups although it was connected to the progression of thinking but again, none of the institutions can currently provide these reports.

The second question addressed in this stage addressed the CoI model's relevance as a conceptual framework within which to situate the development of teacher metrics to support the use of learning analytics to improve learning and teaching outcomes. The mapping of the data points gathered from the academic survey in Stage 1 and the academic questions in Stage 2 of the project to the CoI did prove useful to gain further insights into what teaching staff were really trying to understand. As noted above the majority of the data points related to the cognitive presence domain with social presence being less prevalent, with and teacher presence last. There were very few data points that arose in the course of the study that could not be mapped to the CoI. Further work in this area is being undertaken by the IRU project team to explore the applicability of the model and will be forthcoming in a journal article.

Stage 3: Testing the metrics and case studies

The final stage of the project was intended to develop and test teacher metrics. However, it became increasingly evident that what had been originally envisaged would not be possible for several separate but related reasons. First, the scope of such work was not possible within the timeline, but this was partially related to the second and more substantive reason around readiness and infrastructure. It became apparent in the earlier stages that the participating institutions did not have the necessary capacity, or in some cases the infrastructure, to develop teacher metrics, particularly the MRUN universities.

The IRU universities did, to varying extents, have some of the necessary infrastructure, and they also had a range of reports either available or in development. Additionally, earlier stages of the project had reinforced and further highlighted the impact of context (readiness of institution, teaching staff, discipline) on any learning analytics development.

However, the data collected in Stage 2 was seen as a strong basis for the development of metrics which could be used according to specific teaching contexts. It was therefore decided that the development of a set of use cases in a case study format would be both useful and achievable. Completing these case studies also responded to a suggestion from the focus groups.

Case Study Methodology

Given the importance of context in the development and use of learning analytics, it was decided that each participating institution should outline their learning analytics development in a case study. The institutional case studies set the scene for the other case studies which outline how teachers are using the data available to them. This approach, therefore, translates the broader infrastructure into actual use of teacher metrics.

Teachers in each institution were identified via the focus groups and/or as being known to the project team as people who were effectively using learning analytics to support teaching practice. The team sought to include a variety of applications to demonstrate the breadth of application.

A template was developed based on the IRU case study template used as part of the work of the IRU Vice Chancellor's Fellow, Associate Professor Jessica Vanderlelie, with the intention that these case studies could also be included in the broader IRU suite.

However, the template was revised to provide an explicit focus that allowed key considerations and elements relevant to and identified through the learning

analytics project to be drawn out. These included the following:

- The context of the work in relation to the unit/course/school/faculty overview depending on the activity being highlighted. If appropriate to context, the discipline, number of students and mode of delivery.
- The rationale for innovation: Why was this important to develop in their context?
- A description of the innovation in terms of what they are doing and how they are doing it, as well as the value proposition. This also sought detail about their stage of development, the reports they were using, and how often and when.
- The impact of innovation – who it might be impacting on and if it is achieving the expected outcome.
- Any lessons learned in relation to the tool, innovation and/or process.
- A highlight statement to succinctly draw attention to the most exciting aspect of this innovation.
- Any dissemination activity either internally or external to the institution.

Findings

A total of eight case studies were developed across the three IRU institutions. The full case studies can be found on the IRU Case Study website (iru.knack.com/national-innovation-case-study-collection); however, a brief summary of each is given below.

Flinders Case Study 1: The Learning Analytics Community of Practice

Since its inception three years ago, the Learning Analytics Community of Practice (LA CoP) has played a major role in bringing together key people across the university who have an interest in the field. As Flinders University has declared learning analytics a key strategic direction and as such is starting to invest more heavily in the area, it is envisaged that the LA CoP will continue to play an important ongoing role in helping to shape future developments for learning analytics at Flinders.

Flinders Case Study 2: Use of Learning Analytics in a Flipped Classroom – Genetics, Evolution and Biodiversity (Dr Masha Smallhorn)

Since the unit commencement in 2008, live lectures were delivered each week to a steadily declining audience. In 2016 the teaching team decided to flip the delivery of the topic to improve overall student engagement with the unit and to provide students with the opportunity to tackle challenging problems in class when teaching staff were present. The traditional lectures were therefore replaced by a 'flipped class'. The teaching team measured student LMS engagement with the topic video resources by analysing the learning analytics and comparing them to final topic grades. As hoped, an increase in unit grade was observed as video access increased. Student engagement was also measured via frequency of physical attendance and compared to final topic grades and similarly an increase in final grade was also observed as physical attendance increased. Unfortunately, however, no overall increase was seen in final topic grades or exam scores when compared against the previous year following the implementation of the flipped classroom.

Flinders Case Study 3: Learning Analytics for a First Year Psychology Research Methods Topic (Associate Professor Nathan Weber)

In this unit the lecturer carefully structures formative assessments and via the use of learning analytics identifies concepts that students appear to be struggling with. A review workshop at the end of each semester is then used to revisit these areas as well as the recommendation of extra revision and practice exercises to specifically address these problematic issues. Furthermore, as this process has evolved from year to year the teacher has been able to adopt different approaches for the teaching of the identified problem areas and then used learning analytics to compare the relative merits of these different approaches.

Murdoch Case Study 1: Development of Learning Analytics at Murdoch University

Murdoch University is at a relatively early stage of its development and adoption of learning analytics. To date, the main focus has been investigation of student attrition, but more recently a Student Analytics Committee has been formed that has been tasked with investigating learning analytics more broadly. It has so far identified and instigated several initiatives that involve utilisation of existing tools and functions within the LMS. It is also developing a longer-term plan around learning analytics within the educational technologies environment that considers the initiatives that other universities are undertaking within the same environments, as well as the emerging learning analytics technologies in the educational technologies landscape. Aspects of this longer-term plan are to:

- drive uptake of existing learning analytics tools and associated 'know-how' within the schools ('quick wins')

- provide relevant data and insights to inform the work of the broader Student Analytics and Student Success initiative
- investigate and/or contribute to the development of the learning analytics capabilities within the LMS and associated educational technologies.

Murdoch Case Study 2: Learning Analytics in a Multi-Mode IT Unit (Danny Toohey)

This unit is offered to students who are on-campus, off-campus (external/distance/online), and at international campuses in Singapore and Dubai. It was designed from the ground up to be offered in blended mode. Students have preparatory materials that include readings, lecture materials provided to all students as a series of short videos, and a pre-workshop quiz. On-campus students and those at international campuses then have workshops that consist of a computer lab session followed by a group discussion/tutorial session. Off-campus students complete the same computer lab session and participate in an online discussion forum. Students then have post-workshop activities to complete. Because of the variety of delivery modes, it was decided that it was important to understand which of the learning objects and activities were being used, when they were being used (in the timeline of the unit offering), and which types were being used more (e.g., videos, online quizzes).

Charles Darwin University Case Study 1: Institutional Development

Charles Darwin University is a dual sector institution which harnesses the power of educational technology to provide and support learning opportunities for students throughout the Northern Territory and beyond. The combination of the educational technology suite together with a large external student cohort means that much of the teaching activity is captured digitally in its systems. This provides a strong case for the use of learning analytics for a variety of purposes including improving learning and teaching and retention.

Charles Darwin University has done substantial work in relation to learning analytics development and deployment across the institution. The main focus of the work has been on the integration of the LMS and SIS data. These two systems contain much of the data related to learning and teaching practice and to the types of questions that teaching staff would like to be able to answer. This has resulted in the customisation of a broad suite of reports for both vocational education and training and higher education teachers, as well as a variety of reports at course, school/faculty and university level which can be used for a variety of purposes.

Charles Darwin University Case Study 2: Tertiary Enabling Program (Dr James Valentine)

Given the high rate of attrition in the Tertiary Enabling Program (TEP), and enabling programs across Australia in general, this project is being undertaken to identify potential factors that contribute to the attrition rate and the key points in time when attrition may occur. The intention is that this information can be used to better support students when they need it so that they can successfully complete their program.

This initiative draws on reports which provide data on the relationship between LMS access frequencies and timelines and academic performance to identify critical points in time. This provides key information to assist teaching staff to effectively intervene and better support students. Additionally, this information is being fed into ongoing program reviews and to inform the ongoing development of curriculum and teaching practice. While this initiative started with work in one TEP unit, it has now been expanded to other units in the program.

Charles Darwin University Case Study 3: Using analytics for decision making on grade boundaries (Dr Brian Phillips)

This case study explores the use of learning analytics to support students during the semester and to inform and support academic decisions around grading in situations where a student is sitting on a grade boundary.

This nursing unit, delivered fully externally through the LMS, has a consistent sequential structure including weekly self-assessment quizzes as well as adaptive release, meaning that many data points are available that can be readily interpreted as an historical record of student progression and performance. The Performance Dashboard (shows different types of user activity) and Retention Centre (helps to discover students considered 'at risk' based on a series of configurable rules) are utilised to provide early warning emails to students and to direct students to informative sources of assistance to help them get 'back on track' (or help for life issues). A combination of the Student Snapshot report, grade centre spreadsheet download, and a record of early 'progression warnings', provides an idiosyncratic, reliable body of evidence to support consistent and fair grade decisions.

Summary and conclusion

Returning to the overall aims of the project, the data collected in all three of the stages contributes in various ways to achieving to the following goals.

Identify the range of learning analytics functions available in partner institutions which are related to teaching practice

As would be expected, the functions available in the partner institutions vary. Development of infrastructure and thinking about learning analytics is related to the modes of teaching undertaken in the institution (face to face, blended, fully online) and, perhaps more importantly, strategic priorities. In general, the Australian partners are better placed than their Malaysian counterparts regarding learning analytics development due to a higher level of use of educational technologies which enable the collection of data. Classroom analytics is also further advanced in institutions which teach more online courses and is probably connected to the priority placed on such development due to the workload involved.

Identify the ways in which learning analytics can be used to improve teaching

This study considered academic views on how learning analytics could be used, which highlighted a range of purposes connected to the role of teaching staff and the learning and teaching lifecycle. Different uses were identified at the beginning, middle and end of a semester as well as in the review or lead-up to a teaching period. However, such uses were related to whether the teacher had responsibility for a topic/unit, or if they were one of several teachers but not the unit coordinator. Additionally, those who were coordinating courses/programs identified other ways that learning analytics could be used to support student success, for example, by being able to see the student in the context of their course/program and identify patterns, or to look across course/program curricula to identify areas in need of improvement.

Develop a set of metrics based on learning analytics to improve teaching practice

This project took the approach that the development of metrics is related to the identification of data points which provide the underpinning framework for understanding teaching practice in order to improve it. Teaching staff identified a range of questions and data points they saw as useful to understand and improve teaching practice. The CoI is the framework that is used in this study to connect the collection of data to educational theory and pedagogy, particularly for blended and online teaching. Teaching staff were particularly focused on understanding the cognitive presence of students, and mapping their responses to the CoI provided insight into the data points which could be used to explore this focus. Malaysian teaching staff had a much stronger focus on social presence and interactions than their Australian counterparts. Interestingly, teaching staff in both Australia and Malaysia displayed much less interest in metrics relating to their role in the teaching/learning interaction (i.e. the teaching presence) and how that influenced student success.

Test the set of metrics for improving teaching based on students' retention, engagement and motivation

While the project did not build or test a set of metrics, the current level of analytics development in the Australian institutions allowed for exploration of how it was being used based on existing reports. Providing evidence of how learning analytics has developed and is being used was seen as useful, because the focus groups had identified a need for 'use cases' or examples which can be used for professional development, as well as promotion of work within the IRU. Eight case studies which outline the progress of each institution in learning analytics, as well as how it is being applied by teaching staff, were developed.

In terms of the overall project aim, several headline findings emerge:

- Learning analytics development must be considered in context at multiple levels. This context relates to the institutional infrastructure, strategic positioning of learning analytics, the nature of the teaching profile in terms of mode, and then in relation to the actual teaching. In the teaching space, learning analytics must be considered in the context of the mode of delivery and pedagogical approach.
- There is considerable variation in terms of stages of development and readiness which operates at various levels. While development and readiness is inherently connected to context, it is important to also emphasise that thinking about learning analytics evolves over time, with use, both for those directing learning analytics initiatives and for end users. To utilise learning analytics at an institutional level, changes will need to be made to the way in which teaching is carried out, including enhanced use of educational technology to capture data and increased sophistication in reports. From an end user perspective, the ways in which teaching staff thought about the use of learning analytics evolved even during a short focus group. The sharing of innovative practice and application between teaching staff is therefore essential.
- The nature of the questions that most teaching staff currently seek to answer falls into the descriptive category. There are many issues around the development and use of predictive analytics in

relation to classroom analytics which need to be further explored and resolved. Institutions can, meanwhile, benefit and achieve 'buy-in' from teaching staff by developing descriptive analytics for academic use.

- The usefulness of any learning analytics report/visualisation will depend on the purpose of the report in relation to the role of the university teacher, their discipline and the pedagogical approach, as well as the learning and teaching lifecycle. As such, a suite of reports is required to meet the needs of teaching staff across the diversity of roles and pedagogical approaches. This suite of reports needs to range from the institutional executive level, to head of school, course/program coordinator to the unit/topic coordinator, those responsible for teaching, and those responsible for curriculum design and development.
- Teaching staff are most interested in reports that can help improve student success (beyond retention) and classroom analytics (data within the teaching context) which can assist in understanding student success. The focus on supporting student success was evident in the types of data points teaching staff identified and the questions they wanted to be able to answer.
- There was great variation in the knowledge and skills of teaching staff in relation to learning analytics reports and applications; however teaching staff are more likely to invest in learning about and using the reports if there is a clear value proposition. Examples of how others are using reports will help to build use cases and share practice.

These high level findings suggest a range of actions and considerations regarding learning analytics to support teaching staff in improving learning and teaching:

- It is important to determine institutional readiness to gather, process and apply data from a broad range of sources and ensure teaching staff are included in discussions and decision making.
- A clear plan for learning analytics focusing on teaching and learning and taking into account institutional readiness and context must be developed and articulated to staff in a timely manner.
- In order to improve the take up of the use of reports, the value proposition for the users will need to be made clear, the reports will need to be easy to access and use, and professional development will need to be provided.

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Appendix 1: Report visualisations

Definitions

There is variation in language across the three IRU universities related to learning and teaching. For the purpose of this document the following applies:

Unit/topic/subject refers to the for credit discrete building blocks of a course/program. For example a student enrols in four units/topics/subjects per semester.

Course/program is the degree that a student is enrolled into (e.g. Bachelor of Arts)

Personalised learning designer

The Personalised Learning Designer report allows the setup of 'rules' based on a series of trigger points to customise the student experience as they move through the Learning Management System. Some use cases include sending the student an email welcoming to the topic once they've posted to the 'Introduce Yourself' forum or providing a student who does not do well in a certain quiz / assessment with additional reading.

The benefit is that 'rules' can all be setup before a unit begins and it allows for some automated monitoring. Staff

can then monitor which students have met the criteria for each 'rule' and intervene if appropriate. The rules can be chained together and allow for very complex scenarios to trigger a rule (e.g. accessing a unit resource, achieving a specified grade in an assessment, completing an activity, and or posting to a forum etc).

Active user block

Allows for monitoring of students that haven't accessed the unit (login) or an activity based on set parameters and send a message accordingly. You can view a report of the students who've been contacted by this monitoring.

Unit at a glance

Provides summary information about a unit in the LMS, and comparative information against a group of other units in the same School with the same delivery method.

This report can help analyse how a unit is designed, how the unit compares to the average of other units in the same School, and how the students in the unit are using and performing in the unit compared to the average of all students enrolled in the unit.

Student at a glance

Provides comparative information about a student against a cohort of other students. This report can help staff get a detailed sense of how a student is performing compared to other students in the same unit or to find students within a unit. It also includes detailed information about the materials that a student has accessed from the unit.

Early intervention clustering tool

The purpose of the tool is to automatically identify students who may benefit from an early intervention strategy. The tool calculates a performance metric for each student which is the average of the results attained from three quizzes performed in the first three weeks of the year. An engagement metric is formed using the total number of LMS clicks made in the unit over the same three-week period. The tool places students in to one of four clusters depending on their levels of performance and engagement. A list of students together with their engagement and performance metrics can be obtained by clicking on the cluster.

Heat map

The Heat map tool provides the teaching staff with a quick overview of which objects/activities are being viewed/completed by the students; the darker the colour, the more times the object has been accessed. For each object, the number of views and the number of unique users is shown.

Progress bar

The Progress bar tool can be used to view when a student last logged in, and which objects/activities have been viewed/completed. Each row represents one student's progress, and each of the coloured boxes an object or activity they have completed.

Appendix 2: Data points from the Australian Academic Survey

The following table shows the data points that Australian academics identified as useful in the Academic Survey (n=353) mapped to the community of inquiry (CoI) framework.

Data Point	Cognitive Presence	Social Presence
Student 'classroom' participation		
LMS clickstream – accessing content items (rate and duration)	✓	
LMS clickstream – accessing assessment items (rate and duration)	✓	
Time that a student takes to respond to a prompt (call to action) in the system	✓	✓
Submission of assessment	✓	
Submission of activities	✓	
Qualitative data on discussions/comments	✓	✓

Data Point	Cognitive Presence	Social Presence
Online live classroom participation (interaction)		✓
Online live classroom attendance		✓
Online live classroom – time spent		✓
Time spent on activities	✓	
Interpersonal interaction		✓
Lecture attendance	✓	
Accessing recorded lectures	✓	
Recorded lectures time spent	✓	
Recorded lectures – which specific points of video accessed; time spent on that	✓	
Data from social media that is used in classes (e.g. YouTube, Facebook)		✓
Data from associated technologies such as e-Portfolios where outside of LMS	✓	
Attendance at tutorials and workshops	✓	
Participation in tutorials and workshops	✓	
Participation in additional learning experience (e.g. field visits, work experience)	✓	
Online quiz results broken down to be able to see key concepts/questions response patterns	✓	
Access to set readings	✓	
Indicator of emotional 'vibe'/feeling for different concept learning/content	✓	
Indicator of how students rate their own learning of a concept	✓	
Number and frequency of emails to teacher	✓	
Access to feedback on assessment	✓	
Teacher participation		
Clickstream data on teacher actions		
Curriculum		
Type of assessment task	✓	
Student evaluations of units/subjects		✓
Student evaluations/feedback on course/program		✓
Staffing changes in a unit	✓	
Success indicators		
Unit/subject grade		
Progress in unit/subject		
Assessment item results		
Completion		
Grade trends in a unit/subject across various years		
Student reflections on learning post unit completion (e.g. a year later to reflect)		✓
Requests for special consideration		
Academic integrity reported issues		
Enrolment		
Course/program enrolment		
Class size		
Campus affiliation		

Data Point	Cognitive Presence	Social Presence
Faculty/school affiliation		
Withdrawal from units/subjects		
Withdrawal from course/program		
Reason for withdrawal from unit/subject		
Reason for withdrawal from course/program		
Course transfer reasons		
Enrolment load (with full-time/part-time indicators)		
Demographic		
Age		
Gender		
Domestic		
International		
ATSI		
Basis of entry		
First in family		
Scores for basis of entry (e.g. TER)		
Primary language		
Disability		
Hours worked		
Postcode		
High school subjects completed (including mark)		
Scores on IELTS		
Student internet connection (including capacity/speed)		✓
Admission data from first point of contact		✓
Follow up of departed students (those who complete)		✓
Follow up of departed students (those who attrite)		✓
Support service		
Awareness of support services at start of enrolment		✓
Access to services		✓
Services provided		✓
Participation in co-curricular activities		✓
Library access including item access		
Access to learning support services		
Access to counselling service		
Access to equity services		
Accessing different parts of website		
Attendance at orientation/induction programs		

Appendix 3: Data points from the Malaysian Academic Survey

The following table shows the data points that Malaysian academics identified as useful in the Academic Survey (n=242) mapped to the CoI framework.

Data Point	Teacher Presence	Cognitive Presence	Social Presence
Student 'classroom' participation			
How many times a student accessing LMS? (e.g. login)		✓	
How long students spend in various areas of LMS? (e.g. time spent)		✓	
What are number of hits that a student clicks on resources/forum/ quiz etc. in LMS?		✓	
Does student with high commitment in campus participate more in a discussion forum?		✓	✓
How high/low is the usage of certain learning materials inside or outside LMS?		✓	
How fast students access new learning materials posted?		✓	
How students with different learning style navigate through LMS?		✓	✓
How does teaching styles impact online learning behaviour?	✓	✓	
Which teaching activities increase learning activities (e.g. discussion forum, access LMS)?	✓	✓	✓
How often does a student with high/low learning performance utilize discussion forum?		✓	✓
What is indegree and outdegree pattern of a student in a discussion forum?		✓	✓
How does a student with high/low socio-economic background per-formed in a discussion forum?		✓	✓
What are the affective states being captured in reflection activity?		✓	✓
What competency skills can be identified in a discussion forum?		✓	✓
What learning materials being accessed by students outside LMS?		✓	
How effective the use of learning materials in correlation to learning styles?		✓	
Do mature-age students have higher LMS usage?		✓	
Does time spend and quantity of interaction types has an effect on course grades?		✓	
What are number of students replied by the instructor in a discussion forum?	✓	✓	✓
What is the average of student post length?		✓	✓
What are number of reviews of own posts?		✓	✓
What are number of reviews of others' posts?		✓	✓
How did the students like the learning activity?		✓	✓
Are students accessing LMS at school or home?		✓	

Data Point	Teacher Presence	Cognitive Presence	Social Presence
Do native speakers have less problems in discussion forum than non-native speakers?		✓	✓
Is the performance in task somehow related to exam grades?		✓	
What is the correlation of learning performance with program of study, the duration of study, the mother language of students?		✓	
Is there correlation between how long students remain on an LMS and the degree to which they participate in online discussion?		✓	✓
Who provides high/low value messages in online discussion?		✓	✓
Who is progressing ahead of the class or in comparison to their peers?		✓	
What learning activities are difficult to learn?		✓	
What are clusters of students who made specific mistakes?		✓	
What are the mistakes that often come together (a-priori)?		✓	
What is the average cognitive load per lesson/topic/learning design?		✓	
Teacher participation			
How many times an instructor accessing LMS?	✓		
How many times an instructor posts course notification?	✓		
To what degree students follow up on instructors' recommendations to utilize LMS?	✓		✓

About IRU

Innovative Research Universities (IRU) is a network of seven comprehensive universities committed to inclusive excellence in teaching and research in Australia.

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