"What in me is Dark, Illumine": developing a semantic URL learning analytics solution for Moodle

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With the growing prevalence of "Big Data," a significant challenge facing New Zealand's tertiary sector is the transition to becoming data-driven organisations. Learning Analytics is an emerging trend that provides a means to leverage "Big Data" in an educational context. However, despite the rhetoric surrounding learning analytics, the reality is that for many organisations existing Learning Analytics solutions present a number of challenges that impede adoption. Existing solutions are expensive, overly complex, or require specialist/external skillsets and infrastructure to implement and maintain. This paper sets out the Eastern Institute of Technology's development of a macro-level learning analytics solution for its Moodle Learning Management System using free, web-based analytical tools. The Institute's goal is to share its solution and development experience, thus furthering the conversation around learning analytics, data governance, and the application of data to enrich decision-making.

Keywords: learning analytics, self assessment, ITP, Moodle, Big Data, blended learning

The promise of "Big Data" and analytics

Ours is a "Big-Data" world. As digital technologies become increasingly ubiquitous across our societies and economies so too comes the ability to generate, collate and analyse data sets of staggering size and complexity. Proponents of analytics are quick to explain that for those organisations who are able to use Big Data successfully, the rewards will be transformative (Siemens & Long, 2011, p. 40). As the authors of the Mckinsey Global Institute Report into Big Data state:

> ...the impact of developing a superior capacity to take advantage of big data will confer enhanced competitive advantage over the long term and is therefore well worth the investment to create this capability. But the converse is also true. In a big data world, a competitor that fails to sufficiently develop its capabilities will be left behind…. Early movers that secure access to the data necessary to create value are likely to reap the most benefit. From the standpoint of competitiveness and the potential capture of value, all companies need to take big data seriously. (Manyika et al., 2011, p. 6)

This view of the primacy of Big Data and analytical capability is supported throughout the literature. MIT Sloan Management Review's survey of over 3000 executives, managers and analysts revealed that analytical capability was a differentiator between top-performing and low performing organisations (LaValle, Lesser, Shockley, Hopkins, & Kruschwitz, 2013, p. 3). Top performing organisations were twice as likely to use analytics to inform day-to-day operations and future strategies than lower performers. Over half of the respondents stated that "improvement of information and analytics was a top priority in their organisation" (2013, p. 4).

The Education sector is by no means exempt from the prevalence of digital technologies and Big Data. While the use of analytics in education is a relatively new phenomena (Gasevic, Mirriahi, Long, & Dawson, 2014; van Barneveld, Arnold, & Campbell, 2012), there is a growing sense of urgency for educational organisations to understand Big Data and to develop and deploy analytical capabilities. Mirroring similar findings, the Society for Learning Analytics Research (SoLAR) predicts that those educational organisations "that do make the transition towards data-informed planning, decision-making, and teaching and learning will hold significant competitive advantages over those that do not" (Siemens, Dawson, & Lynch, 2013, p. 2). Indeed, the literature is persuasive and compelling. Much has been made of the promise and potential Big Data and analytics affords education to improve, refine and innovate (Manyika et al., 2011; Norris & Baer, 2013; Oblinger, 2012). As Norris explains:

> Analytics and big data offer the potential to identify promising practices, effective and efficient models, and powerful innovations, sustaining higher education for the future. They promise to pose and answer questions we could not even frame without big data (2013, p. 13).

Authors on the topic have begun to unpack that promise and potential and address the value analytics may deliver. For Grajek, the use of analytics and "data expands the capacity and ability of organizations to make sense of complex environments" (2011, p. 15). Long and Siemens have documented a number of value areas where the use of analytics may lead to improvements, efficiencies and innovation (2011, p. 36). These value areas span the gamut of analytic capability, "affecting administration, research, teaching and learning, and support resources" (2011, p. 36). Given these incentives and the breadth of possibilities presented by the literature, a key challenge facing educational organisations is where do we even begin to realise this potential?

Unsurprisingly, a number of key terms and definitions are evolving, each attempting to frame the application of analytics within an educational context (Siemens & d Baker, 2012; van Barneveld et al., 2012) These definitions are important as they help clarify what is meant when we speak of analytics--our intentions, our data focus, and our required technology and systems. The most familiar term, Learning Analytics, provides one such defining frame by which educational organisations can begin to orientate, understand and apply Big Data. SoLAR defines Learning Analytics as being: "the measurement, collection, analysis and reporting of data about learners and their contexts for purposes of understanding and optimizing learning and the environments in which learning occurs" (2014).

SoLAR's definition is typical in that focuses upon the learner and learner-generated data. This specificity differentiates Learning Analytics from other emergent terms such as Academic Analytics: "the application of business intelligence in education at institutional, regional and international levels" (Siemens & Long, 2011, p. 34), and Predictive Analytics: the application of analytical technologies in order to uncover patterns and relationships and to predict behaviour and events" (van Barneveld et al., 2012, p. 8).

Yet despite the rhetoric surrounding big data and analytics, despite the continuing rise of blended and online learning and the integration of educational/digital technologies into teaching practice, education as a sector remains slow to realise the opportunities afforded by data generated by these technological advances (Grajek, 2011; Natsu, 2010). These barriers to adoption appear substantial:

> Research shows that we are on the cusp of a tremendous wave of innovation, productivity, and growth as well as new modes of competition and value capture—all driven by big data. While sectors will have to overcome barriers to capture value from the use of big data, barriers are structurally higher for some than for others. For example, the public sector, including education, faces higher hurdles because of a lack of a data-driven mind-set and available data. (Manyika et al., 2011, p. 9)

Mind-set and data availability are not the only barriers. From her ECAR survey findings, Bichsel observes amongst educational organisations a "perceived need for expensive tools or data collection methods" (2012, p. 3). ECAR survey respondents rated affordability the biggest concern, followed by data misuse and regulation (Bichsel, 2012, p. 10). Lack of affordably stifles adoption, and when the tools you are looking to invest in are poorly understood by most, establishing institutional buy-in is near-impossible. Norris describes a bleaker picture: "Put simply, a significant analytics capacity gap exists in higher education, encompassing all of the elements of analytics capacity—technology, processes/practices, skilled people, culture/behaviors, and leadership" (2013, p. 43).

For many in education, this evolving discipline of analytics is a dark science--unfamiliar, overwhelming, and expensive. Knowing where to start is unclear, let alone beginning to make sense of what data is useful and developing the capabilities to use it. While the potential value of analytics is compelling, it is difficult to know where to begin. How can medium-sized educational organisations in New Zealand even begin to realise some of these benefits? Some hope is offered by Lavelle et al. who note "Value creation can be achieved early in an organisation's progress to analytics sophistication. Contrary to common assumptions, it doesn't require the presence of perfect data or full-scale transformation to be complete" (2013, p. 7). Is the key simply to start somewhere, anywhere?

This paper outlines the Eastern Institute of Technology's (EIT) foray into developing an affordable analytics solution for the Moodle Learning Manage System (LMS). It provides the context in which the development occurred, and it explains the semantic URL mechanism that allows for data capture and analysis. The intention of this paper is to show that, despite acknowledged barriers to adoption, it is possible to design and develop affordable analytic solutions for the Moodle LMS.

Context for development

Norris observes that amongst "For-profit universities and not-for-profit, primarily online universities are among the most advanced in their embedding of predictive analytics into academic and administrative processes" (2013, p. 15). This correlation between online development and analytic capability is comparable to EIT's experience with analytics. EIT undertook significant Blended programme development over a period from April 2011 to Jan 2014. This development was identified as a critical success factor for the institute's merger with Tairāwhiti Polytechnic in 2011. Five Bachelor degrees, involving a total of 82 courses, were developed across 18 months using Agile and phased development methodologies. Importantly, each degree was able to decide its approach to blended learning and employed a range of educational technologies and strategies (including mobile tablet devices). Amongst the five degrees the major point of technological consistency was the use of the institute's Learning Management System (LMS): Moodle. The institute's LMS provided the online environment and was the conduit through which learning and teaching resources were accessed. This blended development provided the catalyst and incentive for the EIT's Educational Development Centre to scope and develop a macro-level analytics solution that would allow the organisation to investigate the transition to, and continuing refinement of, blended learning and the behaviours of its online communities.

Critically, the Educational Development Centre also identified Learning Analytics as a potential "evidence engine" for the institute's self assessment activities, in that it provides a mechanism to review, monitor and extrapolate on the online user experience in a way that was previously inaccessible. The goal was to develop a solution that could capture data the EIT's LMS use and turn that data into actionable intelligence for the organisation. In doing so, the solution would also contribute to the institute's capability in self assessment. This aligns with observations in the literature that "Higher education's adoption of analytics is growing in response to demands for accountability and the need for greater efficiency and continuous improvement" (Oblinger, 2012, p. 45). For New Zealand tertiary education organisations (TEOs), self assessment is a key element in the New Zealand Quality Framework (NZQF) and is described as "a systematic process of data-driven self-reflection. It is directed towards coherent and clearly articulated goals to inform decision-making and operational practices" (NZQA, 2014). The development of academic and learning analytic capability is inherently synergistic with self assessment practices. As NZQA asserts:

> TEOs generate and gather a large amount of data. Analysing and making sense of this data enables better decision-making. Good self-assessment is only possible when a range of people in the organisation are involved, e.g. teachers, non-teaching staff, students and other stakeholders such as employers. (2014)

TEOs looking to strengthen their self assessment practices would do well to consider developing analytic capabilities. Conversely, champions of analytics would do well to position investment in analytics alongside self assessment strategies and capability. Those organisations already using online and blended delivery are at an advantage in that an institute's LMS is a recognizable, obvious source of data.

Development approach

At the time of writing, Moodle does not provide accessible macro-level analytical tools. Within the Moodle community some tools exist that provide access to Moodle user data but these are often limited in functionality, aimed at the individual course level, and poorly maintained. A solution had to be developed that circumvented these limitations while integrating with Moodle with little to no impact on EIT's existing systems and their operation. The following requirements were put forward:

- Utilises in-house skill sets wherever possible.
- The solution is affordable (zero budget).
- Simple to use.
- Focused on the Moodle LMS and the source of generated data.
- Interoperability with the organisation's primary academic records system(s).
- Able to differentiate Moodle user roles (editing teacher/Student/Guest/custom roles).
- Able to differentiate between device type and OS (desktop/table/mobile).
- Able to configure/filter data by: School (comprised of programmes), programme (comprised of courses), course.

- Able to configure/filter data by: resource/activity (e.g. forum, quiz, resource).
- Minimal disruption to existing systems, processes, policies.
- Macro-level focus: the ability to observe site-wide trends, behaviours.
- Minimises ethical and security issues to ensure anonymity and transparency.
- Leverages existing web-based analytical tools.
- Data can be easily presented.
- Scalable.

Although possible, EIT deliberately excludes individual, personalised tracking from its solution. This is at odds with other learning analytics approaches where personalisation is often a requisite. However, as Sade and Prinsloo have argued, there is a considerable ethical dimension to data capture and analytic capability, especially tracking individual users (students/staff) to that level of granularity (2013). The research is only now beginning to chart the ethical dimensions to personalised data capture (Stevens & Silbey, 2014); there is still more to be done in establishing frameworks for ethical data use and governance. The solution designers considered the risks and benefits and decided individual tracking would require significant policy development in the area of Data Governance. This is an area that, for now, EIT has not yet explored sufficiently.

EIT's current solution was developed as a Moodle plugin to facilitate sharing with other academic partners and the wider Moodle community. The solution reduces the dependence upon programming and technical skills to install and use, subsequently removing a barrier to uptake and adoption. The principle behind this solution is the same as that first developed by M J Hughes of City University, London. In 2011, Hughes developed a method for using Google Analytics code to aid in Moodle tracking (Hughes, 2011). This method uses semantic, also known as "friendly," Uniform Resource Locators (URLs) to aid in tracking Moodle page use. By definition, semantic URLs improve usability because they present conceptual or descriptive information easily readable to a non-expert user . In 2013, EIT developed its own solution, written in the PHP scripting language, based upon Hughes' "friendly" URL principle. Up to the time of publication, EIT's solution has undergone further development iterations.

EIT's solution works in a similar manner to the Google Analytics code by injecting tracking code into the page upon each page request. It differs from the typical Google Analytical method in that the URL is tailored to the Moodle environment. Any Moodle authenticated user clicking on a page thereby activates the analytics code. Using the Moodle API, the plugin code generates a "friendly" URL tailored to fit into the Google Analytics code without breaking the existing functionality of the Google code. Each user click is a contextual per-page click, meaning specific information on what the user is clicking on the page is added to the analytics code before it is sent off to Google's web-based analytics aggregator. By using Google Analytics to collate and visualise the data, we gain access to a suite of powerful, industry-grade analytical tools and reporting features. Google Analytics' abilities surpass any currently available Moodle community analytics software or functionality.

URL transformation: before and after

Existing Google Analytics code takes a website's page URL and sends that to its aggregator. So for a Moodle site, a typical URL would resemble the following structure:

- http://moodlesite/course/view.php?id=1695

Some of the components of the Moodle URL can be easily discerned and interpreted, such as the Moodle instance and course access. However, this information is generic and limited. There is no indication of context-- the type of user, the nature of the activity or the specific programme/course involved.

A semantic, tailored Moodle URL with added contextual information resembles the following structure:

- http://moodlesite/[School or department]/[User Role]/[Course Category]/[Short/ long course code]/[Task page]/[Task name]

The composition of the URL follows basic semantic URL conventions and is generated by the Moodle plugin through the Moodle API before it is presented to the Google Analytics code. None of the above fields are left empty which means there will be pre-set or default values applied in the event a piece of information is not readily available from Moodle. There is a measure of consistency with some of these values in the semantic URL that allows us to collect and filter the data. The following list outlines some of the consistencies maintained by the tailored URL:

- [School or department] This will be the name of the one of the institute's schools or, should this be omitted, it will default to "public" or a user-defined pre-set value.
- [User Role] This is based on the inbuilt user roles which should rarely change but may be added to e.g., editing teacher, student, guest, etc.
- [Course Category] This is a category set up in Moodle that, depending upon the LMS category structure, could name the academic programme offering e.g., Bachelor of Nursing 2013.
- [Short/ Long Course Code] This is the course code within an academic programme. This would either be the course name or course code.
- [Task Page] This is the nature of the Moodle resource/activity taking place on a particular requested page e.g., course-view-topics.
- [Task Name] This is the specific name of an individual resource/activity created for an academic course. The resource/activity is specific to each course, having been created by the course designer. If there is no task name for a particular Moodle page activity, a default "unknown" is specified.

The result of a Moodle transformed semantic URL that is to be sent to Google Analytics could typically look like the following:

- http://moodlesite/public/learningtech/bachelor+of+nursing+2013/bn5.701/course-view-topics/unknown

Notice the inclusion of the Moodle contextual information compared to the non-transformed Moodle URL - the information is readily discernible. There is no confusion as to what the particular Moodle page is about when compared to the original URL:

- http://moodlesite/course/view.php?id=1695

	Page	Pageviews	Unique Pageviews	Avg. Time on Page	Entrances
		511 % of Total: 100.00% (511)	248 % of Total: 100.00% (248)	00:00:53 Site Avg: 00:00:53 (0.00%)	74 % of Total: 100.00% (74)
1.	/public/student/staff+development+&+support/eit_staff_help/course-view-topics/unknown	1 (0.20%)	1 (0.40%)	00:00:14	0 (0.00%)
2.	/public/student/staff+development+&+support/eit_staff_help/backup-restorefile/unknown	1 (0.20%)	1 (0.40%)	00:00:07	0 (0.00%)
3.	/public/student/sandpits/sand_yhamilton2/mod-forum-view/news+forum	2 (0.39%)	1 (0.40%)	00:00:07	0 (0.00%)
4.	/public/student/sandpits/sand_yhamilton2/mod-forum-discuss/news+forum	1 (0.20%)	1 (0.40%)	00:00:04	0 (0.00%)
5.	/public/student/sandpits/sand_yhamilton2/course-view-weeks/unknown	7 (1.37%)	1 (0.40%)	00:01:46	0 (0.00%)
6.	/public/norole/staff+development+&+support/blsd2012/mod-forum-view/everyday+carry+exercise	1 (0.20%)	1 (0.40%)	00:00:00	1 (1.35%)
7.	/public/norole/site-home/sand_yhamilton2/blocks-completionstatus-details/site-home	6 (1.17%)	1 (0.40%)	00:00:30	0 (0.00%)
8.	/public/norole/site-home/my-home/user-profile/my-home	4 (0.78%)	3 (1.21%)	00:00:33	0 (0.00%)
9.	/public/norole/site-home/my-home/user-editadvanced/my-home	9 (1.76%)	3 (1.21%)	00:00:13	0 (0.00%)
10.	/public/norole/site-home/my-home/user-edit/my-home	1 (0.20%)	1 (0.40%)	00:00:00	0 (0.00%)

Figure 1: Semantic "Friendly" URLs presenting within Google Analytics

Figure 1 shows the live dashboard for some of the incoming semantic URLs pushed from the Moodle instance. It should be noted the URLs are easily readable as a result of the URL transformation by the plugin on the Moodle instance.

Typically, Google Analytics takes the URL from a site--with no client-side writing or coding additions. By transforming the URL with contextualised information, information deemed valuable, it is now possible to enrich the data and define the values by which meaningful filtering and analysis can take place. That specificity of context is critical as it allows the data to be filtered according to the values and attributes of the URL generated by the code. This method also allows for additional refinement and customisation, depending upon the organisation's requirements. However, the current release of the Moodle plugin provides enough meaningful information/analytics to meet the needs of a preliminary release.

The Moodle plugin interface: in brief

Figure 2: Moodle plugin interface, displaying configuration settings

The plugin is installed in the same manner as every other Moodle plugin--packaged as a single zip archive that can be uploaded by the Moodle site administrator without the need to gain access to the physical machine. Upon installation, the administrator will be presented with a few crucial settings where some are set to default. Figure 2 shows the settings available for the current release of the plugin at the time of writing this paper.

The most important setting for the plugin is the Google Analytics account; there is no default value and the plugin assumes the administrator has created one. A Google Analytics account is required in order for the analytics solution to function properly. The creation of a Google Analytics account is out of the scope of this paper. The remainder of the settings have default values. The second most important setting is the manner in which the Google Analytics code is injected into the Moodle pages. The injection method is dependent upon the version of the Moodle LMS, as indicated in the setting's comments. The default loader can be overridden should issues arise or if the Google Analytics code is not presenting in the Moodle pages.

In regards to managing the release of potentially sensitive information, in this case the presence of the "editing teacher" role, there is a setting to only push "student" related roles through the code, whereby all other roles will take on the value of "norole". Although the data is anonymous, this additional flexibility allows organisations to minimise anxieties around the capture of "staff-as-user" data. Should the collection of staff data prove to be a barrier to adoption, the organisation needs only to select to capture student user data. It may not be considered the best approach to managing role-specific data but in the effort to provide protection and transparency to its users it is the approach currently adopted by the plugin.

Displaying Moodle instance data in Google Analytics: screenshot examples

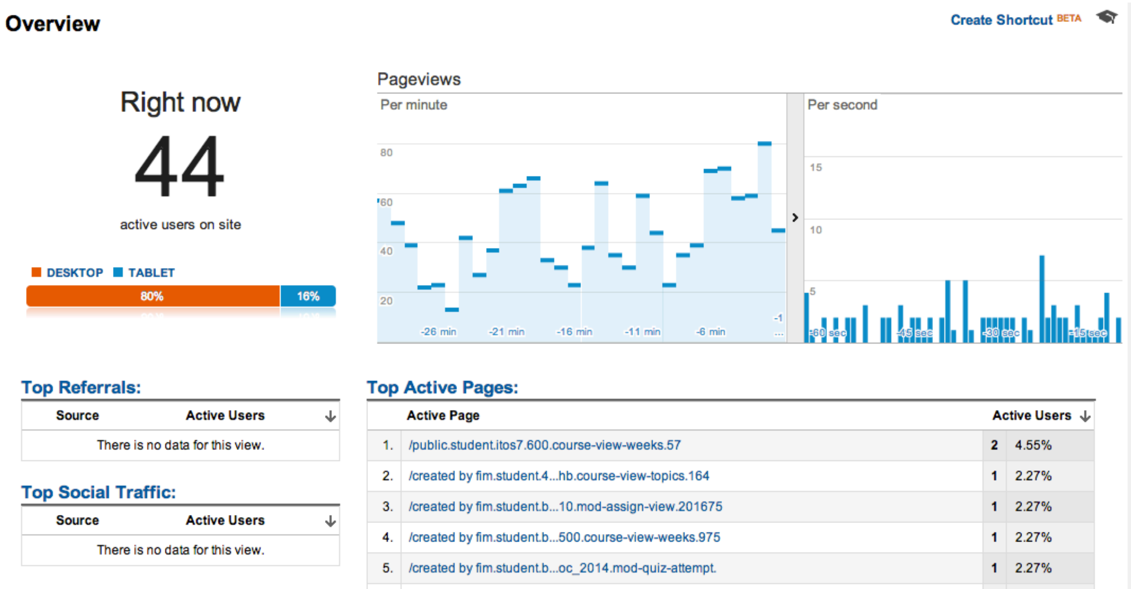

Figure 3: Screenshot of Google Analytics live analytics dashboard displaying Moodle site data

Figure 3 shows a real-time analytics view of the activity for a live Moodle instance. Note the dynamic user counter, Pageviews per minute and second generated by active users, and user device type (Desktop/Tablet). This is a live dashboard view and offers the analyst an immediate view of Moodle LMS activity. There is the possibility of generating reports of this activity for a specified time period.

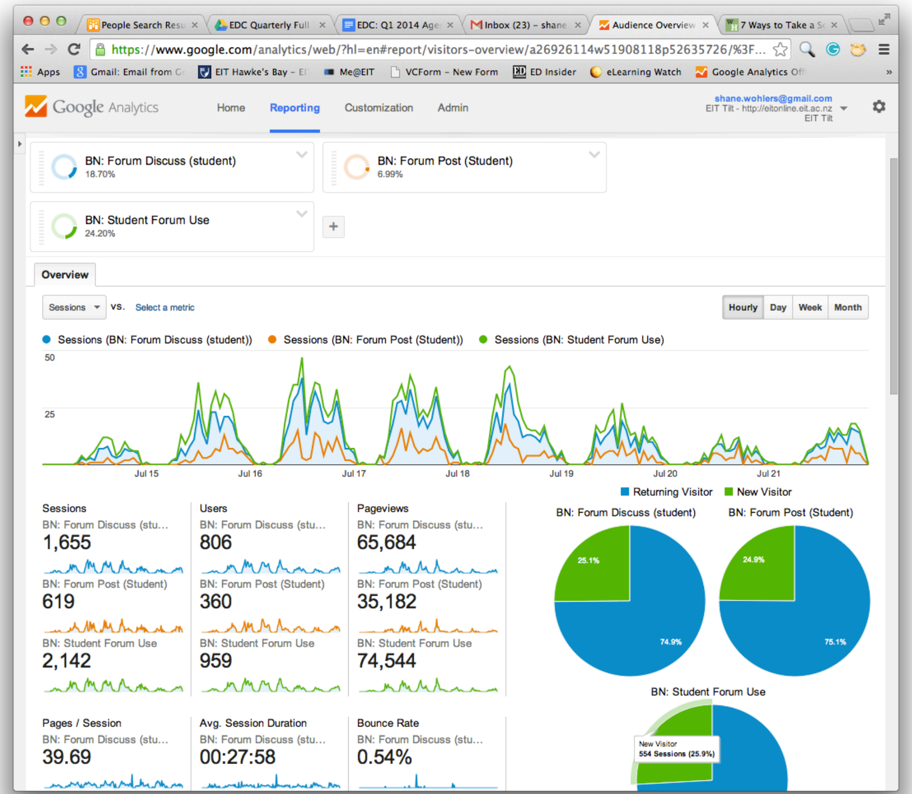

Figure 4: Screenshot of Google Analytics data visualisation of forum pageview access metrics across a defined student cohort and date range.

Figure 4 depicts an example of a capture, spanning an eight-day period, of student forum activity across EIT's three-year Bachelor of Nursing Degree. The data visualisation plots three segments: the number of overall forum sessions (Student Forum Use), discussion pages accessed within a forum (Forum Discuss), and the number of pages viewed when composing a post (Forum Post). The figure depicts the relationship between total forum page views, forum post page views and forum composition page views.

The Google Analytics segments feature may be used to filter and sort the data. Segments allow the user to define and isolate specific types of data and site traffic to aid in custom reporting. Figure 4 shows the use of three custom segments that isolate the student cohort on EIT's Bachelor of Nursing degree and cross filtering by their forum page type. These segments may be shared with other Google Analytics users. Importantly, segments may be built using the values captured in the "friendly" URL and also Google Analytics' own values, thus it becomes possible to build segments that display data filtered by role, programme, course, mobile device type, screen resolution, Internet provider, location, time period. Segments may also be compared to other segments, making course, programme, School, and resource comparisons possible.

Importantly, reports may be exported as pdf, CSV, TSV, Excel, Google Spreadsheets for further analysis and circulation. Alert triggers may be configured to notify administrators of particular events, for example a user-defined percentage increase in mobile device use or a decrease in user activity.

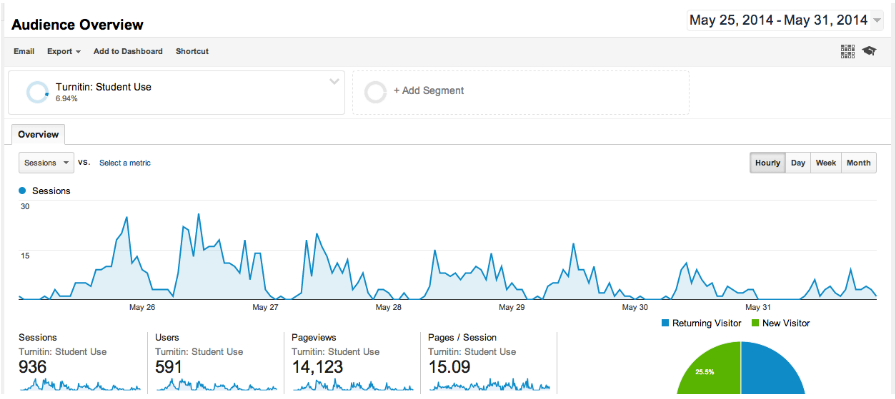

Figure 5: Screenshot of Google Analytics data visualisation of Turnitin student user activity within a Moodle LMS.

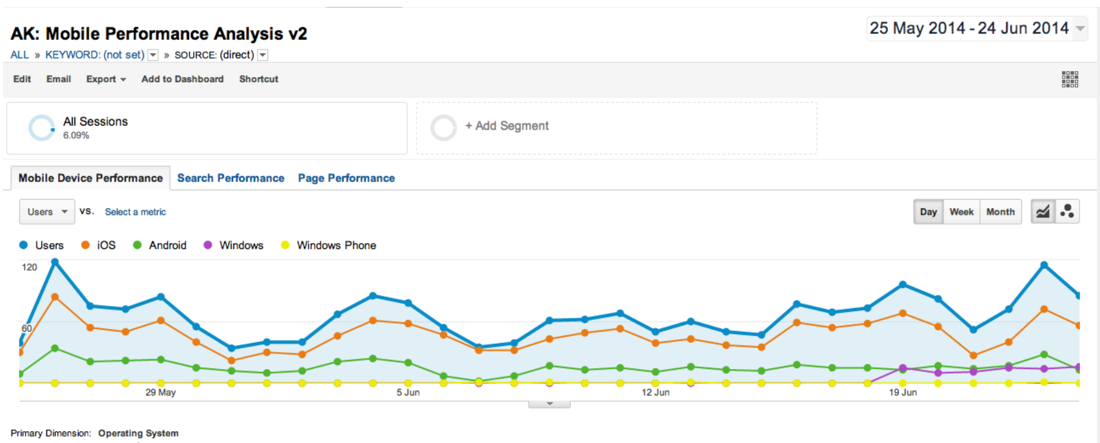

Figure 6: Screenshot of Google Analytics data visualisation of user sessions filtered by mobile device OS type, displaying the four most popular devices over a defined time period.

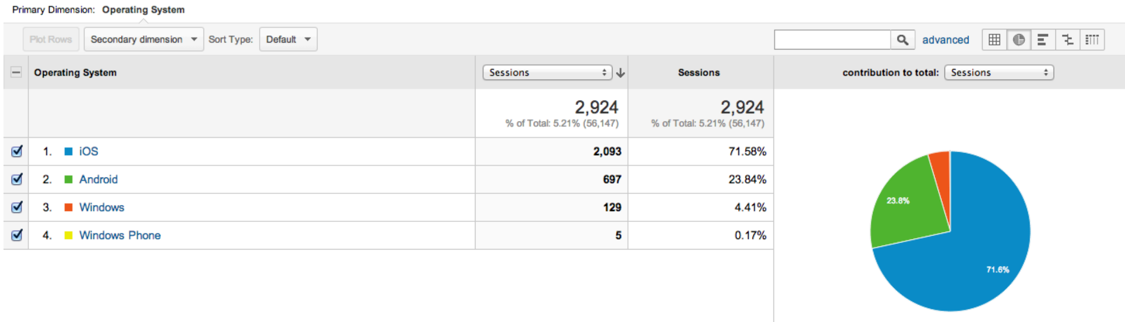

Figure 7: Screenshot of Google Analytics data visualisation of user mobile device OS type, displaying the four most popular devices over a defined time period. Alternate depiction of data presented in Figure 6.

Conclusion

To date, information gleaned from this solution has begun to inform a variety of projects and committees across EIT. Data has been used to calibrate a range of institutional activities, including adjusting Moodle CRON timings and backup synching, prescribing institutional downtime periods, designing and deploying student support resources, prioritising staff development in respect to blended and online delivery, as well as providing evidence to inform resourcing and CAPEX budget setting. Evidence derived from the data has been instrumental in shaping EIT's 5 year IT strategic plan and its associated projects; this includes cloud/BYOD strategies. To date, only some programme and course-level information has been shared with Schools directly. However, EIT plans to develop reporting processes to feed data to Schools and programme coordinators in order to augment its programme self assessment practice.

EIT recognises that there is much further to go on its analytics journey. As Norris observes, "Most conversations in universities about data, information, reporting, and analytics begin with a focus on enterprise technology and tools for reporting and analysis" (2013, p. 30) and indeed, that is where EIT began. Having now developed an in-house analytics solution, one based upon accessible technologies and methods, EIT is now in a position to refine and apply this data across its decision-making structures. An immediate priority is to design appropriate policies and procedures that ensure the safe and ethical application of this kind of data. Building the tools to capture and display data is not enough to realise the full value of analytics, but it is in itself an achievement from which to move forward; and as Bre Pettis famously asserts: "Done is the engine of more" (Pettis & Stark, 2009).

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