

ATHABASCA UNIVERSITY

IMPROVING STUDENT PERSISTENCE WITH LEARNING ANALYTICS  
TOOLS AND DASHBOARDS

BY

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## **DEDICATION**

I dedicate this essay to my late father, Magnus, who encouraged me to study computer science and mathematics; and to my husband Jeffery, for his love, encouragement, and support.

## **ABSTRACT**

Learning Analytics is a growing field which shows great promise for improving education. Most educational institutions have a large investment in enterprise computer systems and they collect some data on their students, but this data is dispersed amongst systems and under-utilized. In this paper, existing analytical tools and dashboards were investigated. These tools were divided into three sections: those directed towards instructors and designers, those directed toward learners and instructors, and other relevant Learning Analytics systems. These analytic tools tracked and analyzed student data from learning management systems, log data, discussion forums, surveys, email, software applications, and other learning traces. The tools provided activity reports, statistics, data visualizations, recommendations, and data for research. Despite the variety and number of these tools, most were designed for instructors and course designers, and much more can be done to support self-regulation and reflection. A minority of the tools were found to be directed towards learners. Most of the tools and dashboards performed analytics on a course by course basis. None were found that encompassed the learners' entire program at the educational institution. Consequently, student performance and persistence was considered, and freedom of information and protection of privacy was examined. A Learning Analytics dashboard was proposed, one which will encompass the student's entire program and facilitate reflection, self-regulation, and persistence.

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# CHAPTER I

## INTRODUCTION

Higher education institutions invest heavily in enterprise computer systems and store a wide range of student data. However these information systems are more analogous to information vaults than they are to information networks. In spite of the amount of information currently being collected the data is underutilized; there is inadequate application of it to improve teaching practice and the student learning experience [1].

Learning Analytics (LA) is an emerging field closely related to business intelligence, web analytics, academic analytics, educational data mining (EDM), and action analytics [2]. The Society for Learning Analytics Research (SOLAR) defines LA as “the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs” [3]. What differentiates LA from other fields, especially from EDM, is that it has a greater focus on leveraging human judgment and empowering instructors and students [4]. Most educational analytic processes use collected data to improve next semester's course. In contrast LA seeks to use data to personalize and improve learning in real time. Current research in Learning Analytics indicates it has great potential for improving teaching and learning. Proponents believe that for the field to grow and thrive it is necessary for openness and collaboration between technical, pedagogical and social domains [5].

Many higher education courses utilize a Learning Management System (LMS) - also known as Course Management System (CMS) - for course content delivery and discussions. Some researchers believe that LMSs are monolithic and should be replaced by Personal Learning Environments (PLEs) [6]. Duval's research group observes that very little of the relevant activities of the student occur in the LMS, and Duval states that "all LMSs must die, in fact they are already dead" [7]. Other researchers contend that these systems are underutilized and can be improved to support self-regulated learning [1]. There are obvious limitations to the LMS format however they do a very good job of coordinating course material and course-related communication. Institutions invest time and effort to setup and maintain their LMS and it is not cost effective to remove these systems.

Rather than destroy or replace the LMS, a LA dashboard could be utilized in conjunction with the LMS to create a more personalized experience for the student. PLEs can be described as the tools, communities, and services that learners use to direct their own learning and pursue educational goals[8]. These tools, communities and services are not necessarily all electronic resources. PLEs have also been more narrowly defined as a learner-constructed online environments created from web-based tools and technologies [9]. A LA tool/dashboard can emulate a PLE by allowing the student to customize, to pull in the tools and resources that he or she needs. The student could link to resources such as blogs, wikis, the student's participation in other learning venues, and the student's own work and creations outside of the educational institution. Adding LA to the LMS will not create a personalized learning environment per se. However, an appropriate LA dashboard

working in harmony with the LMS would open the door to an enhanced personal learning experience, while still fulfilling course and degree requirements.

Higher Education (HE) programs can benefit from LA tools that combine data collection and analysis with educational goals such as collaboration, awareness and reflection [10]. However the majority of existing analytic dashboards and tools are directed towards teachers and/or designers. Only a few dashboards and tools are oriented towards students, and these are on a course by course basis. To date none have been found that encompass the learner's journey throughout his/her program.

This paper will review existing LA tools in three main categories: 1) those directed towards instructors and designers, 2) those directed towards learners and instructors, and 3) other relevant LA systems. Student resilience, self-regulation, and persistence will be defined and discussed. Next, this paper will outline the design of a persistent Learning Analytics student dashboard. This LA tool will be learner oriented, enable student input, recommendations, self-discovery, and self-regulation. This dashboard concept could be used for higher education students or it could be adapted for secondary/primary school students. The dashboard will combine student data currently dispersed around the institution. It will work alongside the LMS, library, and other resources both inside and outside the institution, facilitating an improved and more personal learning experience for the student. The dashboard will accompany the student throughout his/her journey at the educational institution; it will persist even if he/she changes course direction or program. This concept of persistence differentiates it from other dashboards and tools.

## CHAPTER II

### EXISTING TOOLS AND DASHBOARDS

Upon review of the literature a variety of analytical tools/dashboards are discovered. These tools/dashboards are divided into three sections: those directed towards instructors and designers, those directed toward learners and instructors, and other relevant Learning Analytics systems.

In section one of this chapter, tools directed towards instructors and designers are examined to see which ones provide any student functionality: whether it be statistics, visualizations, or textual information. As a result these tools are further divided into two sub-sections: those with no student functionality (students have no interaction with the tool) and those with some student functionality (students have some interaction with, or some use of the tool). In section two, tools designed for learners and instructors are examined. These tools/dashboards support reflection and self-regulation; they also allow students to compare themselves with peers. Finally in section three, four other relevant LA systems are investigated. These were chosen as examples of tools and dashboards deployed in large businesses and in large research collaborations. Section four provides a brief summary.

Figure 1 depicts the ratio of tools for instructors and designers compared to those tools specifically designed with learners in mind. All except one of these tools perform analytics on a course by course basis.

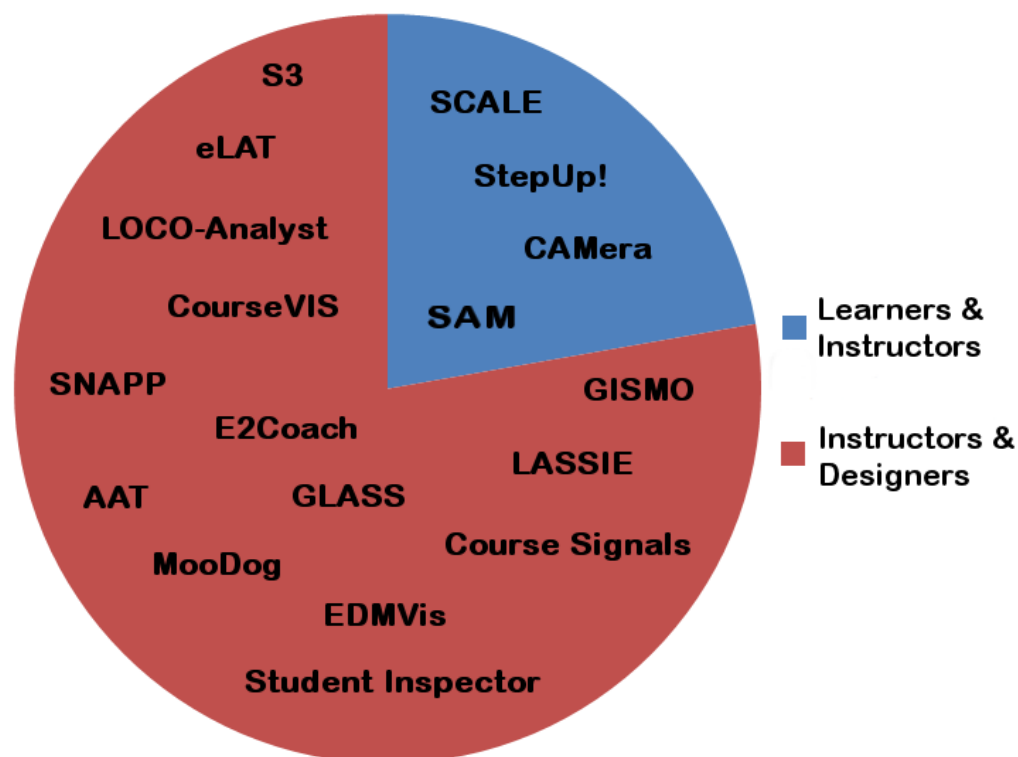


Figure 1: Existing Analytical Tools/Dashboards and their Focus

### 1.1 Tools for Instructors & Designers - No Student Functionality

The majority of existing analytics tools and dashboards are created for instructors and designers. They track and report on student usage, providing text based and visual information. Research has shown they have great potential for improving education. The majority use data from Learning Management Systems. These tools are very informative and they have laid the groundwork for further investigation. The tools and dashboards in this sub-section have no student functionality. Table 1 provides a summary of these tools.

Table 1. Analytics Tools and Dashboards with No Student Functionality

<b>Name</b>	<b>Directed at</b>	<b>Data</b>	<b>Platform</b>	<b>Student Functionality</b>	<b>Development Status</b>
AAT	Instructors / Designers	LMS database	Domain independent	None, perhaps in the future	On-going
CourseVIS	Instructors / Designers	LMS logs	Implemented on WebCT	None	Inactive, ideas continued with GISMO
EDMVis	Instructors / Designers	Log data from various systems; intelligent tutoring, games	Domain independent	None	On-going
eLAT	Instructors / Designers	LMS data	Domain independent	None, perhaps in the future	On-going
LASSIE	Instructors / Designers	Social media system data	Implemented on the Landing; open source standalone plus Elgg plugin	None	On-going
LOCO-Analyst	Instructors / Designers	User tracking data	Domain independent	None	On-going
SNAPP	Instructors / Designers	LMS discussion forums	Moodle, Blackboard, WebCT, Desire2Learn, Sakai	None	On-going
Student Inspector	Instructors / Designers	Log data	ActiveMath e-learning system	None, perhaps in the future	Inactive
Student Success System (S3)	Instructors / Designers	LMS data	Desire2Learn	None	On-going

The Academic Analytics Tool (AAT) allows users to access and analyze student behavior data from any LMS [11][12]. AAT is primarily for course designers but can be used by instructors as well. AAT has no student functionality. The tool extracts detailed information from the LMS database, analyzes the data, and stores the results in a database or CSV/HTML file. AAT is designed to be generic; it is

implemented as a web application using PHP and thus can be used in other learning systems. Users can specify which data and analyses they want performed. Unlike most analytical tools which analyze individual courses, AAT is flexible with respect to the choice of courses. AAT can analyze data from all of the courses at the institution, courses from one or more departments, or courses from different levels such as undergraduate and graduate.

AAT is based on the assumption that each course consists of learning objects: course material, forum postings, quizzes, video and audio files, as well as the course outline. AAT focuses on analyzing the behavior of students in relation to these learning objects. A framework of types of learning objects has been used that distinguishes between general and pedagogical learning objects.

Researchers have introduced an extension of the tool which increases the user-friendliness of AAT and provides users with access to more complex information from educational log data. This extension includes a refined approach for pattern chaining and a pattern creation wizard, enabling the user to explore complex questions without requiring a computer science background.

Future work will include a study where learning designers and educators will test AAT with respect to its usability and usefulness. There are plans to add advanced visualization of data and statistical functionality. The possibility of providing learners with their behavior and performance data will be investigated.

CourseVis obtains tracking data from WebCT learning management system and generates visualizations for instructors [13]. Its design was based on the survey

results of distance learning instructors. Instructors were also involved with its evaluation; consisting of a focus group, an experimental study, and a semi-structured interview. Students themselves were not targeted. Not much information can be found on CourseVis and research is inactive. The WebCT software is no longer available. There does not appear to be any updates or papers written since 2007. The concepts from CourseVis were extended in the GISMO tool.

EDMVis is a domain-independent visualization tool for educators and researchers [14]. EDMVis can visualize log-data from intelligent tutoring systems, computer aided instructional tools, or digital games [15]. EDMVis is used to visualize the behavior a person has demonstrated within one of those tools. According to their website it is still used today [15]. It has no student oriented functionality. To date, no studies are available and there is little other information on EDMVis.

eLAT processes large databases from various LMS to support teacher reflection and improvement of online learning [16]. A requirements analysis led the authors to outline software design goals: usability, interoperability, extensibility, reusability, real-time operation, and data privacy. Indicators which represent specific calculators and visualizations were created. The indicators are organized according to analytics contexts which correspond to teacher questions. Every indicator can have parameters such as date range, content area, etc. Indicators are dynamically calculated depending on the learning environment. The teacher, with a specific question in mind, will choose a context, obtain a list of available indicators, and



supply parameters if necessary. eLAT will then validate the teacher's configuration and generate a report which can be retrieved and viewed. A neutral data model was developed to keep eLAT independent of any LMS architecture.

eLAT was iteratively and incrementally developed from real courses at RWTH Aachen University [17]. Semi-structured interviews of instructing staff were conducted to evaluate graphical indicators. The user interface was developed from user studies and is designed as a launch pad, similar to a dashboard but according to the authors it provides broader analysis options. A variety of line and bar charts are available, from access and usage, student performance, communication forum posts and threads, and activity behavior. eLAT proved to be useful in initial evaluations. Further field tests and studies are required to determine which data is pedagogically meaningful. eLAT is a toolkit for teachers, it provides no analytics or information to students. In the future it may be enhanced for student use with an intelligent recommendation element. Work appears to be on-going.

LASSIE provides useful statistics about the Landing, Athabasca University's social networking site that promotes formal and informal learning [18]. LASSIE is an open source, standalone tool that analyzes learner behavior. The social networking site does not have a structured learning space; rather it is comprised of social interactions such as blogs, wikis, file and photo sharing, groups, tagging, and event scheduling. It is used to communicate and network with other students, teachers, and guests.

LASSIE was designed to examine learning within a social network; extracting data, graphing, and performing statistical analysis. Data can be downloaded into spreadsheet software, SNA software, or the R-language statistical software. Users define course activity themselves, choosing activity groups, tag filters, relationships, and time periods. Interesting correlations have been uncovered, and possibilities for further research. LASSIE was designed for designers and instructors, and provides no analytics to the participants themselves. Research appears to be on-going.

LOCO-Analyst is a feedback tool for teachers to improve content and instructional design [19]. It analyzes user tracking data, and also utilizes semantic annotation to establish semantic relations among learning artifacts and student dialogues. It is built on top of a Learning Object Context Ontology (LOCO) framework, which is a formal representation of learning object context data. The system provides feedback on various levels: single lesson, entire learning module, tests, individual students, and student interactions. LOCO-Analyst can be adapted to any LMS by mapping tracking data to its framework. Initial studies of the first implementation gave positive results. The second version of LOCO-Analyst is enhanced with improved data visualizations and a better user interface [20]. Evaluation groups included university instructors, teaching assistants and research students. The authors included teaching assistants and research students in the evaluations because of their experience with online education. However there is no functionality in the system available to students. It appears that work is on-going with a recent paper released in 2012.

SNAPP (Social Networks Adapting Pedagogical Practice) is a social network analysis tool that provides instructors with visualization and analysis of student interactions in discussion forums [21]. SNAPP is a Java/Javascript tool that visualizes the exchanges between students in a discussion forum. The software installs as a Firefox Bookmark or Internet Explorer Favorite. It can be used with Moodle, Blackboard, and Desire2Learn. SNAPP v1.5 gives educators a visual display of the forum interactions as a network diagram. This enables educators to quickly identify those students who are not participating (isolated and at risk), those students who participate regularly, and those students who are participating at higher levels of engagement (key information brokers).

SNAPP is useful for determining whether the discussion is student-centered or instructor-centered. It is also helpful for determining the amount of collaboration - whether the posts are interactive with lots of replies, or isolated. Functionality that could be added to SNAPP is a) analysis of blogs and wikis, and b) analysis of message content with computational linguistic methods. However there is no mention of any plans to enable students to view their own interactions, and the value of this is not discussed. Work on SNAPP is on-going. It has recently been adapted for the Sakai Collaborative Learning Environment (v2.8 & v2.9) by Marist College [22].

The Student Inspector is a tool developed to allow distance learning teachers to keep track of learners in online learning systems [23]. Student Inspector analyzes

the log data from learning systems and includes a module for AI-based analyses. The researchers presented a questionnaire to teachers in order to determine their needs and preferences for learner data. Their study revealed that teachers were primarily concerned about learners' performance, misconceptions, and topic coverage [24]. Researchers also drew on the experience they gained in complimentary projects: ActiveMath (an environment that aims at delivering tools for personalized learning in mathematics.) and iClass (empowers teachers with tools to better monitor and manage the progress of their classroom students).

Student Inspector presents results in a browser component. Its functionalities (using data from ActiveMath) include:

- Performance measurement - individual / group scores, time of learning session, exercise threshold.
- Learner misconceptions - errors such as forgetting the denominator, raising the exponent instead of lowering it, not simplifying a fraction.
- Topic coverage - finding weak and strong topic areas for a given student.
- Analyser - uses machine learning techniques to predict future learning outcomes and recommend exercises.

A questionnaire was given to a group of teachers, course designers, and course coordinators to evaluate information views available in Student Inspector. All four views received positive feedback. Future work mentioned increasing the functionality and possibly extending the tool to learners.

The Student Inspector was designed for teachers to evaluate their students in the context of one course; because of this the tool is limited to the instructor's short-

term requirements. Simplifying some of the views and presenting information and recommendations to the student directly would be an excellent way to promote student learning and self-regulation. However there has been no recent publications found and no updates to the website since 2008 [25]. Work on the Student Inspector appears to have stopped.

The Student Success System (S3) is an early warning system that utilizes data from the Desire2Learn e-learning system to identify and treat at-risk students [26]. S3 calculates a Success Index which comprises of five indices: Preparation, Attendance, Participation, Completion, and Social Learning. Each of these indices is a composite of student activity tracking variables. S3 uses colored risk indicators similar to the Course Signals system. Green means not at risk, yellow denotes possibly at risk, and red indicates a student at risk. The student's risk is projected at both the course and institution level. Administrators add target courses to the S3 to generate predictions of student success, using prior course offerings as comparison [27]. Instructors use S3 to monitor predictions of student success levels for active and enabled courses on a weekly basis. The instructor is presented with a dashboard showing a class list, colored success/risk indicators for each student, data visualizations, and comparisons to other students in the course.

S3 uses an ensemble modeling strategy, which boosts the predictive generalizability by blending the predictions of multiple base models. Each independent base model incorporates a domain of learning behavior: Attendance, Completion, Participation, and Social Learning. Model outputs are combined into a

second level predictive model using a stacked generalization strategy.

Administrators can exclude domains from the predictive model during each course configuration. At this writing there appears to be no studies testing the prediction model or the system.

While the authors claim that student's risk is projected at the institutional level, the system itself targets success on a course by course basis. The predictive models are used to monitor and design targeted interventions for at-risk students in active courses, and this is used to improve retention and completion. There is no student functionality in S3.

## 1.2 Tools for Instructors & Designers - Some Student Functionality

The Learning Analytics tools and dashboards in this sub-section are primarily designed for Instructors and Designers however some indicators and data are available to the student. Table 2 outlines these analytic tools and dashboards. In most of these tools students will not receive any information unless the Instructor has enabled that feature.

Table 2. Analytics Tools and Dashboards with Some Student Functionality

<i>Name</i>	<i>Directed at</i>	<i>Data</i>	<i>Platform</i>	<i>Student Functionality</i>	<i>Development Status</i>
Course Signals	Instructors / Designers	LMS data	Implemented on Blackboard Vista	If enabled, students see indicator of success/risk; instructors must run the software to update status	On-going
E2Coach	Instructors / Designers	Gradebook data, University Registrar; survey results; in the future Sakai LMS data	Web based, back-end support by computerized tailoring system	Students receive personalized messages with normative data graphics	On-going
GISMO	Instructors / Designers	LMS logs	Moodle plugin, can be adapted for other LMSs (GPL software licence)	If enabled, students see their own data	On-going
GLASS	Instructors / Designers	Learning data stored in a CAM database	Web-based	Students can only view information about his/her ID and some general statistics	Inactive
MooDog	Instructors / Designers	LMS logs	Implemented on Moodle	Instructor chooses, some features visible to students	Inactive

Course Signals at Purdue uses a predictive student success algorithm and data from Blackboard Vista to predict student risk status [28]. It relies on grades,

demographic characteristics, past academic history and student interaction with the LMS. It is designed to allow faculty to provide meaningful feedback to students based on predictive models. Depending on the results of its student success algorithm, a green, yellow or red signal is displayed to the student on his/her homepage. Green indicates a high potential to succeed, yellow indicates potential problems, and red indicates a low chance of succeeding. Instructors implement their own intervention actions.

Course Signals has been implemented at Purdue University since 2007, however not all instructors implement it. The signal lights are not updated in real time - they are only updated when the instructor runs the application. It is up to the instructors to decide how often to update the signals [29]. Clicking on the signal will give the student a list of resources to help him/her improve in the course. Students are warned that the light does not accurately reflect the grade they will receive, rather it reflects whether they are at low, medium, or high risk. Course Signals has been categorized as designed for Instructors and Designers because it is dormant until the instructor runs the application, and information is stagnant unless the instructor updates it regularly.

E2Coach uses survey results and student data from a variety of sources to create personalized messages to students [30]. It has been implemented in introductory STEM (science, technology, engineering, mathematics) courses at the University of Michigan [31]. These courses have a large number of students making it difficult to provide personalized advice and encouragement. E2Coach is a web



application supported by a back-end software package called the Michigan Tailoring System (MTS), developed by the Center for Health Communications Research (CHCR) at the University of Michigan [32]. MTS is publicly available software for creating and disseminating individually tailored health communications. MTS enables E2Coach to address students by name and tailor communications to any information known about them; from the university registrar, surveys, and the departmental grade book.

To evaluate E2Coach a BTE (better-than-expected) score was computed that evaluated how each student performed relative to their incoming GPA. Results showed that the more students used E2Coach, the more likely they were to have a high BTE score and thus outperform their incoming GPA. The researchers point out that tailoring approaches like those used in MTS have been extensively tested in public health, and their effectiveness has been established in peer reviewed journals. E2Coach was first launched in January 2012 in four introductory physics courses, participation was voluntary [31]. Further work and evaluations are planned. E2Coach was deployed in several introductory biology, chemistry, and statistics classes in 2013. With E2Coach, students receive coaching but they have no control over the normative data visualizations they receive. The tool is designed primarily for improved instructor to student communication.

GISMO extracts tracking data from Moodle and generates visualizations for course instructors [33]. It is integrated into the LMS however can be adapted to other learning platforms. GISMO was created after surveying course instructors who

involved with distance education. The authors designed it for three major activities: monitoring classes and individuals, assessing participation in forums, and to facilitate in course redesign. GISMO can be included in any Moodle course as a side block [34]. This block can be enabled so that students taking the course will be able to see their own data. GISMO is set up as a cron job under Moodle, it collects student data from Moodle logs then performs statistical calculations. GISMO is released as free software under the GPL software license. Work is ongoing with support for Moodle 2.x. Student functionality is limited and not readily available.

GLASS (Gradient's Learning Analytics System) is a web-based visualization platform that uses CAM (Contextualized Attention Metadata) schema for storing data [35]. The system is designed to capture student activities in a learning environment. It displays a dashboard that gives teachers feedback on activities and performance of students. The default module provides two visualizations: a frequency timeline of activity events and a bar-chart with events generated by users and groups. Additional visualizations have been added and the system has been tested in different learning scenarios. Preliminary results indicate that visualizations must be made very intuitive for users. It is difficult to analyze the capability and potential of GLASS as no published studies are available at this time.

Although the researchers indicate that the target users are teachers and learners, currently a student can only view information about his/her ID and some general statistics [36]. Due to this reduced functionality GLASS has been placed this sub-section of LA tools and dashboards. There is only one conference abstract

published (to date) and no updates to its website since 2011. Work on GLASS appears to have stalled.

MooDog (Moodle Watchdog), tracks learner activities from Moodle log files and provides information to instructors and researchers [37] [38]. Implemented on the Moodle learning management system, it updates in real time, generating activity reports and providing visualizations. MooDog implements a two-stage calculations model: 1) pre-calculation improves response time by periodically performing basic calculations in the background and storing the results in intermediate tables, 2) on-demand calculations reads data from the original Moodle tables as well as the intermediate MooDog tables.

MooDog inserts a few statistics on the course front page. To reduce clutter in Moodle a link to more MooDog statistics is displayed, and most of the information supplied is on separate pages. Instructors can view student activity reports that detail total views, sessions, online time and viewed resources. By clicking on the name of a student the instructor can bring up detailed usage report that can display information such as which course materials the student has accessed. It is designed primarily for instructors and educational researchers, however some MooDog features can be made visible to students. MooDog has three levels of visibility:

- 1) Teaching staff and students
- 2) Teaching staff only
- 3) Neither staff nor students can view statistics. (However analysis can still be done on both current and previous courses by system administrators.)

MooDog designers believe there is value in presenting the statistics to students, however the choice to do so is controlled by the course instructor. Research may have stalled, there appears to be no papers or activity since 2010.

## 2. Tools for Learners & Instructors

To divide these tools from the others several questions were considered:

- Can students freely access the dashboard?
- Is it merely an analysis / communication tool for the instructor?
- Does the dashboard consistently monitor and capture learning, presenting this information to the student?

Table 3. Analytics Tools & Dashboards for Learners and Instructors

<b>Name</b>	<b>Directed At</b>	<b>Data</b>	<b>Platform</b>	<b>Student Functionality</b>	<b>Development Status</b>
CAMera	Learners / Instructors	Email, MACE web learning repositories; can be expanded to other usage metadata	Web based	Email analyzer run by user, web-based dashboard for MACE activities	Inactive
SAM	Learners / Instructors	Moodle logs	Web based (Flash), plus Widget for the ROLE project	Visualizations of time spent on learning activities and document use statistics	On-going
SCALE	Learners / Instructors	Various. Currently analyzes coding metrics, possibility exists to collect data from any learning domain.	Web based dashboard, Eclipse IDE, Hackystat sensor,	Smart learning environment for the student; customized feedback while student writes programming code.	On-going
StepUp!	Learners / Instructors	Various: Tweets, wikis, blogs, personal time tracking, research paper reading	Web based, plus mobile app	Visualizations of all the learning traces	On-going

The tools/dashboards listed in Table 3 support reflection and self-regulation, most also enable students to compare themselves with peers.

CAMera was designed to collect usage metadata, monitor and report on user actions, and foster learning process reflection and self-regulated learning [39]. The authors maintain that self-monitoring is an essential aspect of self-regulation, and the learning environment needs to provide tools that capture and analyze the learner's activities. PLEs can facilitate self-regulated learning by giving the learner the ability to choose from a variety of services or bring in their own tools. PLEs can also record and analyze activities. CAMera's design is based on a Contextualized Attention Metadata (CAM) schema for representing user actions. It collects usage metadata such as: when text documents are opened, modified and stored; when data objects are moved or deleted; when emails are sent; when chat-messages and search-engine queries are posted, etc.

The component that records email exchange can run continuously or it can run on demand. This email-analyzer provides the user with an interface for viewing his/her social network. The user can control which messages are analyzed by specifying a time interval or by blocking email folders. CAMera also utilizes a Zeitgeist application which is a set of web services that provides an overview on activities within the MACE system of learning repositories. MACE (Metadata for Architectural Contents in Europe) is a pan-European initiative to interconnect and disseminate digital architectural information [40]. The user is provided with a web-based dashboard that gives an overview of his/her activities within MACE. To

capture usage information of the user's own tools, an application named Wakoopa runs on the user's computer. Wakoopa tracks the usage of other applications and sends this information to a server. Individual users can compare their usage behavior with that of other students.

As of 2009 the CAMera tool was under development; informal assessments were positive and a formal evaluation was being planned. Work has continued on CAM schema [41], however no further work or papers on the CAMera tool have been found.

The Student Activity Meter (SAM) assists learners with self-reflection and teachers with awareness [42]. SAM provides learners and teachers with visual analysis of time spent on learning activities and document use statistics. Sam also utilizes CAM data schema but focuses on higher level indicators. SAM will provide the learner with visualizations of their time spent on course activities along with comparisons to their peers. SAM evolved over a 24 month period and was evaluated after each iteration. The stages were:

- 1) Paper mockups evaluated by students.
- 2) Scripts were developed to transform Moodle log events into time spent and resource use, a help function was added, and data visualizations were evaluated teachers and TAs.
- 3) A visualization technique was refined (parallel coordinates). SAM was deployed in an open online course (Moodle) and evaluated by participants (teachers and visualization experts).

- 4) Visualizations were refined, filter and search functionalities were added, and SAM was evaluated by teachers and TAs over an entire semester of a CS course.

The authors determined that providing feedback to students is the most important teacher need that SAM addresses. Their evaluations concluded that SAM is useful to teachers and improves student awareness. Evaluating iteratively, early, and in realistic settings was valuable to the researchers. Further iterations and evaluations of SAM are planned. A SAM widget has been produced for the ROLE Project [43].

SCALE (Smart Causal Analytics on LEarning) is a smart learning system in conceptual development at Athabasca University [44] [45]. It incorporates smart learning components in experimental use at Athabasca: MILA (Mixed-Initiative Learning Analytics), MI-LATTE, and MI-DASH (Mixed-Initiative Dashboard). The goal of SCALE is to capture every possible piece of data from multiple learning environments: track student activities, connect the different datasets together, analyze the data, and improve learning.

The MILA framework consists of a sensing layer, an analysis layer, a competency layer, and a visualization layer. MILA collects learning traces from any learning domain and analyzes those learning traces to extract the underlying competency levels. It is designed to include other sub-tools for different learning environments. Currently any open-source code editor or IDE can be implemented in the MILA framework. It has been tested with the Eclipse IDE, VPL (Virtual

Programming Lab), and MI-LATTE (specialized tutoring software guiding students one line of code at a time in a set of programming exercises).

SCALE has been implemented as a pilot study in a Java programming course at Athabasca University. Students are informed of the research and if they consent their coding data is shared with researchers. At any time the student can withdraw from the research. Participants are asked to use the Eclipse IDE for assignments, and the EIDEE (Eclipse IDE Extension, a Hackystat plug-in for Eclipse) is used to collect student actions during their programming sessions. Hackystat, a Java framework for the collection and analysis of software development process data, marshals and stores the collected XML data, which is stored in an SQL database. A range of coding metrics will be output by MILA and then displayed in MI-DASH. For example, MI-DASH will report to the student information such as the number of errors per build, an abstract syntax tree of his/her source code, and Java error types that he/she is struggling with most often.

Future work will involve converting data and analyses into RDF/OWL ontologies, for input into a specialized inference engine such as BaseVISor. This will create a large web of ontologies which can be queried, enabling students and instructors to detect patterns and expand learning. The researchers also plan to build a distributed no-SQL repository using Hadoop, which will enable distributed data processing and querying across all data sets collected by the SCALE system. In addition, data standardization is a key task, and IMS Global's Caliper Learning Measurement Framework and ADL Tin Can (xAPI) will be utilized for data specifications. The current study in progress at Athabasca University will be assessed and performance



of students using the system will be compared to performance of those who took the Java course before the system was implemented.

StepUp! is a tool that enables higher education students to reflect on their own activity as well as the activity of other students [46][47]. The tool is designed for both learners and teachers. The authors' view is that Learning Analytics is the collection of traces that students leave behind and the analysis of those traces to improve learning. Students should be encouraged to manage their own learning activities and StepUp! is designed to help them do this. It relies on software trackers that collect relevant traces from Web sources such as blogs and Tweets. A time tracking application called Toggl is also used, which can be run manually (student specifies activity, duration, etc.) or in semi-automatic mode (students click on a stop or start button). The data is made available in a complete "Big Table" view, and the researchers discovered that almost all of their evaluation students accessed this view once per week. They have also developed a mobile app that provides a view which is more personalized and easier to understand.

The authors found that time tracking was a useful indicator for students, and it helped them to reflect on how they spent their efforts. StepUp! supports the open learning approach used at their university. There are issues that require further research, for example quantitative data does not indicate the quality of the time a student spends on a course. Capturing relevant student data can be challenging, and there are privacy and control issues. The authors recognize that not much research has been done on the topic of student-centered dashboards.

### 3. Other Tools of Interest

This section contains examples of analytic tools and dashboards in large businesses and in large research collaborations. They are summarized in Table 4.

Table 4. Other Analytic Tools and Dashboards

<i>Name</i>	<i>Focus</i>	<i>Who</i>	<i>What</i>	<i>Directed At / Purpose</i>	<i>Development Status</i>
Coursera	Education	An education platform that partners with Universities and Organizations	Tools and services to present free massive open online courses. Charges only for verifying identity and issuing certificate. Analytics integrated into the system.	Learners worldwide	In production, On-going
Narcissus	Business	University of Sidney, Computer Human Adapted Interaction research group	Visualization tool that analyses activity in a software project management system	Small collaborative groups in the workplace	On-going
PDC (Professional Development Center)	Business	Farmers Insurance (University of Farmers, Claims')	Application that provides personalized training and analytics throughout employment	Managers and Employees	On-going
ROLE (Responsive Open Learning Environments)	Education	European / China research collaboration	Tools and services to build open personal learning environments (PLEs)	Instructors and Researchers	On-going

Coursera is an education platform that collaborates with universities and organizations to deliver free online courses [48]. Although their web site does not specifically use the term MOOC (massive open online course), this is essentially what they provide. Coursera utilizes a mastery learning approach to ensure that students understand a topic before moving on, and peer assessments where students evaluate and provide feedback on each other's work. Many of their partner

institutions use the platform to provide their students with a blended learning experience. Recently Coursera has begun to verify student identities and sell certificates after certain courses have been completed. Coursera provides mobile apps for iPhone, iPad, Android smartphones, and Kindle Fire tablets.

In 2014 Coursera announced ten specializations, or focused programs in popular fields [49]. Specializations are a feature that enables students to demonstrate mastery in an area of interest. The student completes a list of courses plus a capstone project to earn a specialization certificate. Specializations include topics such as Data Science (John Hopkins University), Foundations of Teaching for Learning (Commonwealth Education Trust), Challenges in Global Affairs (Universiteit Leiden & University of Geneva), and Systems Biology (Icahn School of Medicine at Mount Sinai).

Much of Coursera's inner workings are not revealed to the general public. They do not publish all of the details on what data is collected and with whom it is shared. Nor do they elaborate on the internal research they conduct. From documentation produced for partner institutions (the Flipped Classroom Field Guide) we learn that Coursera provides an analytics dashboard to Instructors, with four ways of accessing analytics for their course [50]:

- Activity Tracking displays activity on the level of individual lectures and quizzes.
- Course Overview Statistics gives a concise overview of the level of activity and student performance in the class.

- Export Statistics allows Instructors to investigate how the data shown in the Course Dashboard has varied over time.
- Raw Data can be requested from Coursera for a more detailed overview of student performance and activity.

Coursera also gives instructors access to a number of quiz exports:

- Quiz Summary: histogram data from responses of a quiz.
- Detailed Quiz Responses: details on all submissions from all users in a quiz.
- CSV Responses: details on individual submissions from a quiz in CSV format.
- Assignment Submissions: copies of student files submitted to programming assignments.
- Class Gradebook: all student final grades from all assignments.

Coursera's blog reveals that they research topics such as motivation and boredom in online classrooms [51]. They have instructors experimenting with different formats to make lectures more interesting, such as Socratic-style roundtables, hand-drawn visualizations, and playing games.

Coursera declares that at any given time they will be running various A/B tests on their site, such as [52]:

- Testing different default tab names on the learner's course page.
- Testing types of visualizations for instructor's analytics dashboards.

The results of the tests are used to continuously iterate upon and build better products for learners, instructors and university partners. For example, e-mailing

students to remind them of upcoming deadlines made them less likely to continue, but e-mails summarizing student's recent activity boosted engagement [53]. The company is building a new A/B testing platform that will integrate tightly with their metrics and dashboard pipeline.

Coursera is included as a learning analytics tool because it is a global scale, rapidly evolving, big learning data platform. Analytics and testing are designed into the environment. The courses are freely available to anyone with a computer and an Internet connection. Massive learner data is being collected and analyzed. As of January 2014 there were over 22,000,000 enrollments from students representing 190 countries [54].

Narcissus is a mirroring and visualization tool that analyses activity logs of the Trac System [55]. Trac is a web-based project management system that is composed of a wiki for communication and documentation, subversion for source code management, and a ticket system for task management and software bugs. Narcissus is focused on long-term work by small groups that are typical in the workplace, and it is available as a plug-in for Trac.

Narcissus portrays group, individual, and project visualizations to support small group work. The activities of each group member are mapped with different colors for the wiki, subversion, and ticket system. Information displayed in Narcissus is linked back to the Trac system, so that a user can click on a visualization to review the activity that generated it. Narcissus enables group members and facilitators to

view how the group is operating and gain understanding of both individual and group dynamics.

Narcissus was evaluated using students from a software project course. Users were observed as they learned the system and explored the interface, after which they completed a questionnaire. Users found Narcissus easy to use and effective, and the links back to the Trac system were very useful. While it is focused on the workplace, Narcissus was developed using students and the researchers believe it is useful for both education and business.

The Professional Development Center (PDC) of Farmers Insurance (University of Farmers, Claims') is an application for personalized employee training. Each employee has a dashboard that they and their supervisors and mentors can access, and learning is tracked throughout employment [56]. The dashboard contains an executive summary, a developmental "flight plan", a journaling tool, and a learning communities tool. It enables employees to find and connect with mentors and sponsors. It provides training and development resources from inside and outside the company. The PDC is not used as a performance assessment or performance rating tool, rather it is meant to be a safe learning environment for the employee. It tracks the employee's progress towards completion of skills and development objectives. The system is designed to put more power in the hands of the learners. Although there are some essential training tasks, it is up to the individual to decide how they use the tool. The employee can post and maintain a talent portrait that can be visible to hiring managers. The PDC gathers data from multiple internal and

external sources including: survey feedback, performance ratings, customer service scores, feedback. The system uses its data to analyze the skills that people are working on individually so that it can focus on useful skills and the areas of greatest need. The PDC can target clusters of learners as well as individual needs.

The PDC is a pertinent example of a learning analytics / personal learning environment created by a large organization. Providing a safe learning environment and giving choices encourages learners to discover what tools and techniques work for them. Farmers Insurance is currently in the rollout of the PDC and is anticipating positive progress.

The Responsive Open Learning Environment (ROLE) is a collaboration of 16 research groups from six European countries and China [57]. ROLE's technology is centered on self-regulated learning. ROLE has five main objectives:

1. To support the individual assembly of accessible learning services, tools and resources in responsive open learning environments.
2. To research and develop a psycho-pedagogically sound framework for supporting the individual composition of learning services in ROLE.
3. To create new engineering methodologies to enable significant contributions to ROLE from learner and developer communities from outside the project consortium.
4. To develop and sustain an evaluation methodology to systematically demonstrate the effectiveness of ROLE in test-beds focused on the transition of learners.

5. To exploit and disseminate the ROLE results to wider communities and markets.

ROLE relies on small software applications known as widgets [9]. A widget container enables the assembly of various widgets. Learners and teachers use a widget store to select and rate learning widgets. User activities and resources are tracked and data is gathered using the CAM format. Additional core technologies include inter-widget communication (IWC) and authentication and authorization services to protect data. Widgets can communicate locally in the PLE or remotely to widgets in other PLEs to foster collaboration. They can access the CAM service to provide personalized recommendations and visualizations that promote self-reflection and awareness. ROLE's project code is open source. Anyone can download the software developer's kit and create a widget.

#### 4. Summary

This review of Learning Analytics tools and dashboards exemplifies the need for a tool that addresses the learner's program and larger goals, not just a specific course and minor goals. A variety of tools for instructors and designers have created a greater awareness within the research community of the possibilities of LA. There exists a limited amount of tools which are directed towards students and their particular needs. All of the tools are generally focused on individual courses. None of the tools and dashboards reviewed in this paper adequately addresses the learner's entire program, and their need for resilience and self-regulation in order to persist and graduate.



## CHAPTER III

### RESILIENCE, SELF-REGULATION, AND PERSISTENCE

#### 1. Definitions

The ability to make adjustments is essential to student success. Researchers at the Canada Millennium Scholarship Foundation describe student resilience as “the capacity to overcome obstacles, adapt to change, recover from trauma or to survive and thrive despite adversity” [58]. They discovered that many students who discontinue their post-secondary studies will later re-enroll, often in another program. Resilience is an essential quality of those students who persist and graduate.

Researchers observe that self-regulation is a key strategy of resilient students. Zimmerman describes these qualities in self-regulated learners [59]:

- They approach tasks with confidence, diligence, and resourcefulness.
- They are aware of which knowledge and skills they possess and which they lack.
- They pro-actively seek information and help when needed.
- When they encounter obstacles they find a way to succeed.
- They view knowledge acquisition as a systematic and controllable process.
- They accept greater responsibility for their achievement outcomes.

Self-regulated learners are flexible, they persist and succeed despite setbacks and difficulties. These are attributes that educational institutions need to promote. Shattock explored the factors that define institutional success, and revealed that the highest ranked universities for research in the UK are also the highest ranked for

teaching; excellence for both goes hand-in-hand [60]. He also discovered that there are “strong links between academic success and success in broadening the university’s role in a wider economic and social agenda”. Institutions that cultivate successful learners also foster research activity and respect. This raises the question: how can an institution support or even create learners who are resilient and persist? In his research into self-regulated learning and academic achievement, Zimmerman declares that “all learners use regulatory processes to some degree, but self regulated learners are distinguished by (a) their awareness of strategic relations between regulatory processes and learning outcomes and (b) their use of these strategies to achieve their academic goals”[59]. In other words, these successful learners are keenly aware of, and actively using, regulatory strategies. An educational institution that provides tools and coaching to foster these regulatory strategies will foster students who persist and succeed.

## 2. Self-Regulatory Processes and Phases

Zimmerman described eight key self-regulatory processes [61]:

- setting specific proximal goals for oneself
- adopting powerful strategies for attaining the goals
- monitoring one's performance selectively for signs of progress
- restructuring one's physical and social context to make it compatible with one's goals
- managing one's time use efficiently
- self-evaluating one's methods

- attributing causation to results
- adapting future methods

Zimmerman divides these self-regulatory processes into three cyclical phases:

- 1) Forethought Phase. Includes task analysis (goal setting, strategic planning), and self-motivation beliefs (self-efficacy, expectations, interest and value).
- 2) Performance Phase. Includes self control (imagery, self-instruction, focusing, task strategies) and self-observation (self-recording, self-experimentation).
- 3) Self-Reflection Phase. Includes self-judgment (self-evaluation, causal attribution) and self-reaction (self-satisfaction, positive affect, adaptive/defensive responses).

Pintrich lists 4 general phases of self-regulation and states they are neither linear nor hierarchical; rather they are ongoing, simultaneous and dynamic [62]:

- 1) Forethought, planning and activation. Involves time and effort planning and perceptions of the task and its context.
- 2) Monitoring. Awareness and monitoring of effort, time use, and need for help.
- 3) Control. Efforts to control and regulate, increase or decrease effort, change or renegotiate the task.
- 4) Reaction and reflection. Reactions and reflections such as persist or give up, seek help, evaluations of the task/context.

Regardless if one adheres to Pintrich's or Zimmerman's structure, one can observe that self-regulated learning has identifiable phases and it is a dynamic process that is continuously evolving. Successful learners set goals and tasks,

understand the power of motivation, are self-aware, make efforts to control their learning environment to suit their goals, and evaluate their performance in real time.

### 3. Strategies and Tools

Which tools and strategies will promote and foster successful learners? In Pintrich's model of self-regulated learning there are three general categories of strategies [63]:

- Cognitive learning strategies - rehearsal, elaboration, and organizational strategies.
- Self-regulatory strategies to control cognition - planning, monitoring, and regulating.
- Resource management strategies - managing and controlling their time, effort, environment; as well as other people (teachers and peers) through the use of help-seeking strategies.

From a student point of view much information relating to their program is dispersed. For example, the course requirements and student summary of a HE student is often distributed among many emails, several electronic documents, the Learning Management System, the Registrar's site, some written correspondence, or perhaps not documented at all. The information is scattered about the institution and the student's world. Researchers Boud and Falchikov point out that learning in educational institutions tends to be decontextualized [64]. Courses are like islands, separated from each other and from the bodies of knowledge on which they focus. Literature related to lifelong learning often neglects students' ability to reflect on what

they have learned and plan accordingly. A tool such as a LA dashboard can draw together this information currently scattered about, and enable the learner to organize, plan, monitor, and reflect.

Common questions that students ask include: “how am I supposed to complete this task?” and “what are other students doing?” Students often wonder if they are spending too little or too much time on an activity. An LA dashboard can help answer these questions, by giving students time management visualizations, recommendation engines, strategies and advice from other students. "For learners and teachers alike, it can be extremely useful to have a visual overview of their activities and how they relate to those of their peers or other actors in the learning experience"[65].

How can institutions positively motivate students? Pintrich outlines three general types of motivational beliefs [63]:

- 1) self-efficacy beliefs (judgments of the student's capability to do the task)
- 2) task value beliefs (beliefs about the importance of, interest in, and value of the task)
- 3) goal orientations (is the focus on mastery and learning of the task, is it on grades or some other extrinsic reason for doing the task, is the goal a social comparison with other students)

Pintrich's research concludes that self-efficacy and task value beliefs are positively related to self-regulated learning. He also concludes that adopting a mastery goal orientation is the most positive goal orientation for self-regulated learning.

In order to promote persistence, a LA dashboard should enable learners to set goals and tasks, be continuously evolving, provide help when needed, promote a mastery goal orientation, and show learners how they can control their learning environment to further their goals. An appropriate LA tool that follows students throughout their educational experience could enable them to self-regulate, to see roadblocks to avoid, and to create patterns of success. Consider the benefits of a dashboard application such as Farmer's PDC [56] that could be a central point for planning, correspondence, self-regulation and other educational needs throughout student's time at the institution.

# CHAPTER IV

## A PERSISTENT DASHBOARD

This chapter outlines the design of a dashboard that is student oriented, enables student input, recommendations, self-discovery, and self-regulation. It will accompany the student throughout their journey at the institution, even if they change course direction or change program. This concept of persistence differentiates it from other dashboards and tools.

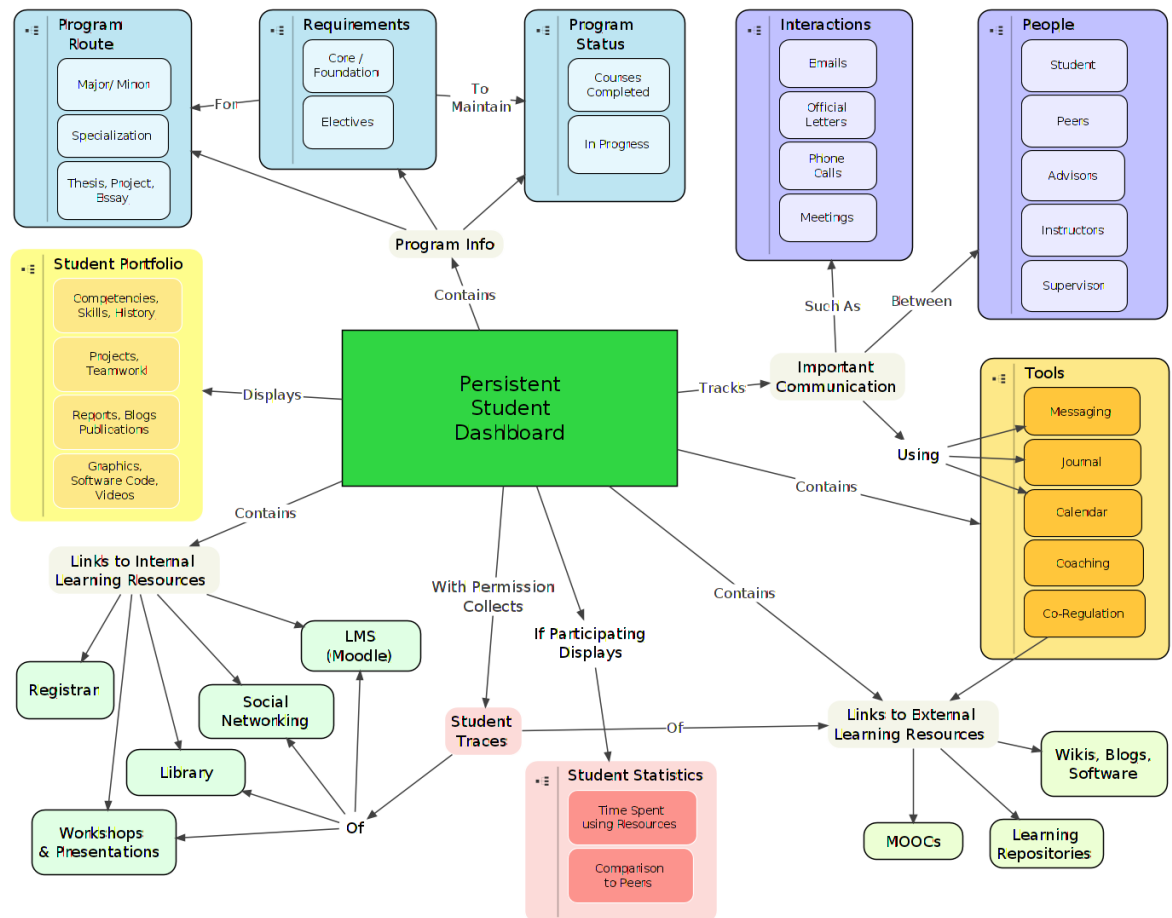


Figure 2. Concept map of the Persistent Student Dashboard

Figure 2 displays the concept design of a persistent dashboard. Students will see their core courses required, those in progress, and those completed. They can view possible course routes or program routes such as essay, project or thesis. Students will be able to search for extra learning opportunities both inside and outside the institution: presentations, workshops and MOOCs. There will be communication sections to track personal and general correspondence: email, announcements, important program messages from student advisors, etc. Students will be able to consent to participate in extra tracking/analytics and then see the benefits of their participation.

It is easy to lose track of goals and it would be helpful for the student to have a picture of where they are headed and what needs to be accomplished. It can be encouraging to see progression and accomplishments. Unfortunately the student's educational plan is usually buried amongst emails and official letters. A Learning Analytics approach would consolidate the data and present it in a manner that improves the learning environment.

Macfadyen and Dawson's study suggests that students obtain higher overall final grades when they [66]:

- Engage in discussions with peers.
- Are actively engaged with course materials.
- Stay on top of administrative details.

If student success in courses can be predicted, likewise we can infer that students who follow the same guidelines in their program will also prevail and graduate. Therefore the design of the persistent dashboard incorporates tools to



promote discussion, engagement, and effective management of administrative details of the program.

### 1. Program Information

When beginning a HE program the student receives a list of requirements (some of which can change during the program) including: requisite and elective courses, start date, time limits, minimum passing grades, and requirements to maintain program status. This can involve a specialization, a major subject of concentration, and/or a minor subject of concentration. This information ends up buried, tucked away in files distributed between the educational institution and the student. Course offerings fluctuate every year, and there are policies, procedures, and deadlines that need to be regularly communicated to students.

The persistent dashboard will display program route, requirements, and program status. It will give the student a visualization of how they are progressing, what they have achieved and what tasks remain in their program. The dashboard will promote a mastery approach in the student, a sense of achievement. It will enable the student to stay on focus. In the middle of a difficult course it is easy to have tunnel vision and become wrapped up in current issues; the persistent dashboard can remind them of the big picture, the long-term goal.

If the student changes courses or program the dashboard will also display this information. Analogous to a trail of breadcrumbs the student will be able to reflect on where he/she started, what decisions were made, what changes were made (and why), discovering strengths and weaknesses. For example if a student does poorly

in certain topics, perhaps he/she needs to re-examine and change their program route. Resilience is the ability to make adjustments as needed, and this includes changes to the program. Students may not be aware that program changes are permitted, or that re-aligning goals and trying a different strategy is possible.

## 2. Communication & Tools

A great deal of time is spent in interactions outside of the classroom, whether it is online or face-to-face. A variety of communication takes place between students, peers, advisors, instructors, teaching assistants, and supervisors. These interactions can occur over an incredible mixture of communication methods such as: written correspondence, telephone, face to face meetings, email, instant messaging, texting, Twitter, Skype, and Adobe Connect. Some correspondence should be kept private, yet it is sent via unsecure methods such as email. Certain correspondence is critical and should not be sent via email. Unfortunately most LMS provide a secure communication method only for individual courses. The persistent dashboard design will contain the tools listed in the following paragraphs.

Messaging Tool. The student dashboard will provide a secure messaging tool, giving a secure mechanism for staff and student correspondence. Similar to the secure tools online banks provide their customers, correspondence occurs within a secure environment and the receiving party is informed via email that a message is waiting. Messages won't be lost and critical program communications will be safely accessible and archived.

Journaling Tool. This tool is a means of recording thoughts, experiences, and learning insights. It can assist the student with synthesis of new ideas and reflection on their HE program as a whole. A searchable, centralized location for notes, meeting details, contact information, and study ideas.

Calendar Tool. The calendar will be automatically populated with key dates pertaining to the student's program, holiday closures, and system downtimes - information which is currently scattered around the campus. Students can schedule as they see fit, adding study group meetings, research meetings, etc.

Coaching Tool. Automated reminders of events accompanied by a recommendation engine to inform the student of:

- General program related events such as program updates and changes, course registration and exam dates.
- Personal program events such as a yearly reminder of credits needed to maintain program status.
- Personalized messages giving advice and encouragement.
- Notices of upcoming workshops, presentations and competitions that correlate with the student's program, interests and needs.

Co-regulation Tool. This tool provides an interface for discussion, suggestions and feedback from peers. Discussion tools exist within the LMS, however these forums are temporary and limited in scope, restricted to a single course offering with a small set of students. The co-regulation tool would exist outside of the LMS to give students a safe environment to facilitate sharing throughout the program. Students

can share what strategies worked, gain suggestions from other students, and give a “thumbs up thumbs down” on various learning materials.

### 3. Internal & External Resources, Student Traces & Statistics

The LMS is merely one facet of a student's learning environment. The institution's library, the Registrar's online services, student workshops and other presentations are examples of learning resources at the institution. In addition there may be a social networking site such as Athabasca University's Landing. The student's learning environment also includes learning resources outside the institution such as wikis, blogs, learning repositories, Massive Open Online Courses (MOOCs), and other web resources. In order to fully understand the entire learning environment, educational institutions need tools and techniques that analyze learning which occurs outside the LMS. There is a need to analyze the social pedagogical aspect of learning [67].

Research has shown how traces of student attention can be collected, filtered and analyzed, providing awareness and recommendations [65][6][39][42][46]. The collection of student traces will provide an exciting opportunity for research into learning. Viewing their own attention metadata can give students an overview and visualization of their study habits, enabling reflection and self-regulation.

The persistent student dashboard will provide an interface to explain privacy issues, gain student consent, collect usage data of internal and external learning resources, and provide visualizations to those students participating in the collection of learning traces.

#### 4. Student Portfolio

The student portfolio will be a tool for students to track their competencies obtained. This is not a portfolio to show employers, rather it is a repository for the student to record his/her achievements, abilities, and learning history. The Student Portfolio will be an electronic warehouse from which the student can display competencies, review and redesign goals, and withdraw specific information when needed. A resume is typically only two pages and merely a summary of work experience and skills. The curriculum vitae (CV) is a longer document relating to research, teaching and publications. From his or her portfolio the student will create a resume or CV as required. From the portfolio the student can also create a document to publish publicly, such as a PDF document or a web page, or copy the information to an external portfolio such as a LinkedIn page.

The student portfolio will enable the student to list their skills and competencies, projects and teamwork. They can include, or link to, demonstrations of their skills such as reports, blogs, videos, software code, pictures, graphics, and other publications. The student can list conferences, workshops, and MOOCs attended; presentations attended or given, research groups, and any teaching or tutoring experience.

The student can include personal projects that have evolved from the competencies they have gained. A computer science student could include coding projects done for personal reasons, e.g. an app for their Smartphone, a Wordpress plugin for their web site, or a Java program. An Interior Design student could include

photos of a personal space they created. An education student could include experience tutoring or details of a personal-interest course they developed.

## 5. Benefits and Implementation

There are several advantages of this dashboard. Students will have a central site for their information and to manage the administrative details of their program. The institution will have a better interface to track interaction data, such as how much communication via email is occurring between student and academic advisor, or how many phone calls between the student and the instructor. The LA dashboard can analyze the frequency, topic and duration of interactions. This information gleaned could include:

- Which programs and courses have more interactions.
- The type of communication and duration.

Analyzing communication could result in identifying:

- Whether the communication indicates a broad problem or general interest.
- Common communications which could be automated (coaching).

Enabling a student to accurately examine their successes and failures is crucial to correctly attributing causation to results and maintaining motivation [61][62]. When a student decides a poor grade is due to a limitation in ability, his/her motivation will be negatively affected. However if the student believes that the poor score is due to wrong study habits - this is a process that can be controlled. A student who sees that changes can be made and that other approaches exists, will remain hopeful.

Ideally, the LA dashboard will act as a mirror that enables learners to become more reflective and less dependent [68]. The dashboard will facilitate the move from a course based, LMS centric view to a learner focused, personalized learning environment.

SCALE (Smart Causal Analytics on LEarning) [44] [45] could provide an excellent platform on which to implement the Persistent Learning Dashboard, for the following reasons:

- SCALE is designed to collect learning traces from various domains.
- Understanding and improving student learning is its goal.
- It will be able to analyze and present information from various sources.
- It is scalable.
- The RDF/OWL ontologies will produce abstractions that can be queried and investigated.
- A web-based dashboard (MI-DASH) for students is already part of the system.
- SCALE provides information to the students and the functionality to accept or withdraw from the research at any time.

## **CHAPTER V**

### **ISSUES, CHALLENGES AND TRENDS**

#### 1. Privacy, Ownership, and Transparency

Privacy and ownership of educational information is a complex topic. Privacy and freedom of information varies from country to country and between public and private sectors. In the United States for example, although customers perceive their data as their own, corporations maintain that all data is legally the property of the business[56]. In Canada, different privacy acts apply to private and public sectors. According to the Office of the Privacy Commissioner of Canada, public educational institutions are under provincial authority, and the federal Personal Information Protection and Electronic Documents Act (PIPEDA) does not apply to their core activities[69]. However private educational institutions are considered a different situation, and should assume that they are subject to PIPEDA unless substantially similar provincial legislation applies. British Columbia, Alberta and Quebec are the only provinces with laws recognized as substantially similar to PIPEDA.

Alberta's Freedom of Information and Protection of Privacy Act (FOIP Act) applies to public bodies such as municipalities, universities, school boards, and others[70]. Post-secondary institutions covered by the Act include universities, technical institutes, and public colleges [71]. The FOIP Act defines a record as any information in any form, stored in any manner. All records in the custody and control of the post-secondary institution are subject to FOIP unless a special exclusion applies. Custody includes situations where the records of a third party are kept on



the premises of an institution. Control means the authority to manage the record, including restricting, regulating and administering its use, disclosure and disposition.

Alberta's FOIP permits researchers to use institution records only in accordance with section 42 of the Act (see Appendix A) and the institution's own policies on research and data sharing. Records that identify individuals must be stripped of identifiers, unless the researchers demonstrate:

- The lack of these identifiers will thwart the research purpose.
- The record linkage will not be harmful to the individual.
- The benefits to be gained are clearly in the public interest.

This essay is written from the viewpoint that the educational institution is not an owner but a custodian of data and responsible for its control. This researcher is required to act in accordance with Alberta government regulations and Athabasca University's ethics policies. Therefore the persistent student dashboard design has an interface that explains Alberta's FOIP, the research into collecting student usage data (learning traces), and the relevant policies. The student will be given the opportunity to opt-in or opt-out of the research at any time.

## 2. Big Learning Data and Ethical Practice

Big data generally refers to three qualities of data: volume, velocity, and variety[9]. Unique issues arise when collecting student traces due to the amount, granularity, and variety of data that can be collected. While it may not match the volume of data that global web services like Google, Twitter, and Facebook can collect, it is appropriate to consider it “big learning data”. What are significant about

the learning traces are the relationships amongst the data. Boyd and Crawford state that Big Data is notable not because of the amount of data, but because of its relationality to other data; Big Data is fundamentally networked [72].

Masie describes four common mistakes that occur in big data learning environments [56]:

- Deferring completely to digital data in decision making and missing the data sources stored in people, in their experiences and expertise.
- Using data to confirm assumptions; mistaking variances that cannot be easily explained (data noise) and creating false correlations.
- Sharing too much data; subjects who know they are being observed will modify their behavior as a result (the Hawthorne effect).
- Expecting to uncover predictive analytics quickly or consistently.

In this era of affordable large data storage and the ability to track traces of learner activity, it might seem like every mouse click is under scrutiny. Students could begin to feel like experimental subjects, or that an authority figure is constantly watching them, which would dis-empower them rather than help them. Therefore it is important to explain why and when data is being collected. Not only that, but allowing students to see the results of data collection can empower them, they can become collaborators in the research. Thus the institution is not creating another performance rating tool, but a tool that promotes reflection and self-awareness.

After examining ethical challenges and power relations among stakeholders, Slade and Prinsloo list the following principles for an ethical framework for Learning Analytics (LA) [73]:

- 1) Learning Analytics is a moral practice, focusing on understanding rather than measuring.
- 2) Students are agents and collaborators, not mere recipients.
- 3) Student identity and performance are temporal dynamic constructs. LA provides snapshot views of a learner at a particular time and context. Student profiles should not become “written in stone”.
- 4) Student success is a complex and multidimensional phenomenon. Data is incomplete and noisy, and analyses are vulnerable to errors and bias.
- 5) Transparency is required and blanket permission should not be assumed.
- 6) Education cannot afford to ignore this data. Regardless of whether they are private or public, institutions are obligated to make the best use of the data they collect.

## CHAPTER VI

### CONCLUSION

Twenty-two existing LA tools and dashboards were reviewed and divided into 3 categories:

- Fourteen were directed towards instructors and designers.
  - 9 of these had no student functionality. Students do not have access to these tools and were (in most cases) unaware that they exist.
  - 5 had modest student functionality. If the tool is enabled, the student may see some basic information: possibly their own data, a graphic, or a personalized message.
- 4 were directed towards learners and instructors. They were designed to provide students with information that supports reflection and self-regulation.
- 4 were other relevant LA systems. They were pertinent examples of learning analytics tools in the private sector and in research collaborations.

Most of the existing tools and dashboards take a teacher-centric, short-term, course-based view. The majority were directed towards instructors and designers with very little student utility. Their focus is on teacher requirements, one single course at a time. Very few inspect the social interactions related to learning, although research indicates that social networking should not be overlooked [24][74]. Current LA tools and dashboards function on a course-by-course basis. Courses in HE institutions have become like islands, separated from each other and from the bodies of knowledge on which they focus. Students, especially in distance

educational institutions, often feel isolated and wonder what other students are doing, and if they are managing their time and resources well.

The business sector is much more advanced in capturing data to better inform its strategic decisions [75]. HE institutions invest large amounts of money in their institutional systems yet there is a large untapped potential in integrating currently disparate systems. Meanwhile businesses such as Farmers Insurance (University of Farmers, Claims') [56] are creating large, internal learning development and learning analytics applications. Collaborations such as Coursera [48] are gathering and privately analyzing large amounts of learning data. Dawson, Heathcote, and Poole outline that the next steps in the development of academic analytics are to gather disparate data into one data warehouse, and to keep pedagogical goals in perspective while analyzing this data [75].

Resilience, self-regulation, and the ability to make adjustments are critical to student success. Successful learners are flexible, they set goals and tasks, understand the power of motivation, are self-aware, make efforts to control their learning environment to suit their goals, and regularly evaluate their performance. Educational institutions can foster learners who persist by providing tools that facilitates Pintrich's strategies [63]:

- Rehearsal, elaboration, and organizational strategies.
- Planning, monitoring, and regulating.
- Managing and controlling their time, effort, environment; as well as other people (teachers and peers) through the use of help-seeking strategies.

Pintrich observed that self-efficacy and task value beliefs are positively related to self-regulated learning, and that adopting a mastery goal orientation is the most positive for self-regulated learning.

In order to promote student persistence, a LA dashboard was proposed. The Persistent Student Dashboard included:

- Program information such as program route, requirements, and program status; a visualization of how students are progressing, what they have achieved and what tasks remain in their program.
- Communication, journaling, calendar, co-regulation and coaching tools.
- Student usage and statistics of Internal & External learning resources; to promote awareness, recommendations and research.
- Student portfolio; a repository for the student to record his or her achievements, abilities, and learning history.
- An interface to explain privacy issues, gain student consent and collect usage data in accordance with the government's FOIP legislation (Freedom of Information and Protection of Privacy Act).

The dashboard will assist the learner in setting tasks and achieving goals. For example, using the program information tool, a visualization of their program route can be expanded into a roadmap of future tasks. In the calendar and coaching tools the student will be able to find current course offerings, research funding opportunities, tutoring, or suggested workshops that will complement their program route. The journaling and co-regulation tools can enable the student to retrospect, by reviewing their own notes and observations and comparing themselves to their

peers. This can assist the student to identify areas of weakness and strength. Through the coaching and co-regulation tools the student can find feedback, solutions, camaraderie and encouragement. The usage and statistics tool can show learners facts about their learning such as how much time is spent on coursework or class discussion. Students can investigate their own correlation between coursework, collaboration activities and achievement. This will enable students to control their learning environment to further their goals.

The dashboard was designed to follow students throughout their educational experience and enable them to self-regulate, to see roadblocks to avoid, and to create patterns of success. With the Persistent Student Dashboard, learners will have a central location for their information and to manage the administrative details of their program. The educational institution will have a tool to collect and analyze learner data. The dashboard will facilitate the institution's move from a course based, LMS centric view to a learner focused, personalized learning environment. Future work would examine the interest of instructors, administrators and students in such a tool. The design concepts would be expanded, and possible platforms for implementation would be examined.

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## APPENDIX A

### Section 42 of Alberta's Freedom of Information and Protection of Privacy Act

#### **Disclosure for research or statistical purposes**

- 42** A public body may disclose personal information for a research purpose, including statistical research, only if
- (a) the research purpose cannot reasonably be accomplished unless that information is provided in individually identifiable form or the research purpose has been approved by the Commissioner,
  - (b) any record linkage is not harmful to the individuals the information is about and the benefits to be derived from the record linkage are clearly in the public interest,
  - (c) the head of the public body has approved conditions relating to the following:
    - (i) security and confidentiality,
    - (ii) the removal or destruction of individual identifiers at the earliest reasonable time, and
    - (iii) the prohibition of any subsequent use or disclosure of the information in individually identifiable form without the express authorization of that public body,
- and
- (d) the person to whom the information is disclosed has signed an agreement to comply with the approved conditions, this Act and any of the public body's policies and procedures relating to the confidentiality of personal information.

1994 cF-18.5 s40