Learning Analytics and Dashboards for Education Systems

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Abstract
The rapid growth of the usage of learning management systems in the education system is becoming more common nowadays. With easy access to the internet, learners, educators, learning management systems are well connected. Access devices like smartphones, phablets, tablets, wearable devices, smartwatches, all-in-one laptops, etc. are now more affordable than ever. These access devices are promoting online activities. Both learners and educators' online activities generate an enormous amount of data that are traditionally either wasted or dumped into storage devices. Since computing power is continuously evolving and increasing, there are opportunities to process and analyze the data for improving the learning systems. The learning analytics is the process of educational data analysis, data mining, monitoring, assessing, reporting, etc. The result of learning analytics is delivered to the users in a display to a consolidated and arranged display on a single screen so the information can be viewed at a glance called dashboard. This paper introduces blended learning, learning management systems, learning analytics, and learning analytics dashboard that can open a new perspective for educators and education data miners.

Introduction
In the quest of educating learners, various pedagogical methodologies have been researched, designed, and delivered to engage students in learning that is meaningful, relevant, and accessible. Most widely adopted pedagogical method is the combination of the online learning system and in-person classroom learning system called blended/hybrid learning systems. Blended learning (BL) systems incorporate the use of Internet technologies which made the learning environment more realistic, authentic, and engaging. One of the key components of the blended learning system is the educational content delivery using an appropriate learning management system (LMS). LMS is the online environment that allows interaction between educators and learners in virtual space by automating the administration and the management of the courses. The everyday activities in LMS generate massive data which needs to be collected, analyzed, and measured to support the learning process and to optimize the learner's learning ability. The process of extracting useful information from the collected education data emerges as a new area of research field called learning analytics (LA). LA measures, collects, analyzes, and reports learner's data to optimize the learner's learning ability. Reporting of LA is presented to the educators and learners in an application called learning analytics dashboard (LAD) which tracks the learners' activities and visualizes the overall results at a glance.

Blended Learning
The internet and computer technology have become a necessity for everyday activities for all walks of life. Today's education systems have widely adopted and integrated the use of the internet and the computer systems that enables, enhances, and improves the development and delivery of online learning. E-learning, distance learning, remote learning, distributed learning, or web-based

learning are different terminologies of online learning. These many terminologies within this field remain ill-defined (Oliver & Trigwell, 2005). Online learning may be entirely automated, can be accessed at any time, or instructor may be available for interaction online. The interaction between the instructor and learners online at the same time, often called online live course learning. According to the Babson Survey Research Group Report, online learning is defined as one in which at least 80 percent of the course content is delivered online (Allen & Seaman, 2014). In-person classroom learning includes 0 to 29 percent of the content delivered online including both traditional and the web facilitated courses. The blended course learning has between 30 and 80 percent of the course content delivered online. However, there is a number of definitions of these terms (Oblinger & Hawkins, 2005; Dublin, 2003).

Blended learning is an integration of in-person classroom (face2face learning) learning and online learning (Graham, 2013). There are many definitions of blended learning (Oliver & Trigwell, 2005). According to the U.S. Department of Education BL is defined as "a combination of online and in-class instruction with reduced in-class seat time for students" (Lewis & Parsad, 2008). Though it has many definitions, it can be said that it is a technology-assisted and computer-driven learning process to enhance and accelerate the learning process. So, this method requires a computer application called the learning management system.

Learning Management System (LMS)

Learning management system is a core component of blended learning for content delivering, tracking, and managing training activities. LMS usually provide learners with various resources types including graphics, quizzes, forum discussion boards, simulations, rich multimedia contents, etc. Traditionally standalone software systems are used for creating and managing learning materials, delivering statistics and keeping track of the user's personal data. The data exchange between traditional standalone software systems can become cumbersome. This causes 24/7 availability issues and lowers the overall training speed and efficiency. LMS comes and plays a central role of integrating existing standalone software to a centralized system ensuring 24/7 availability over the internet to ensure a simple training process for all participants, providing electronic repositories of learning materials, and offering features for online collaboration. When all training related resources are stored and managed by a single software system, it eases administration as well as it enhances easy access and streamlines training process ("Important LMS features for Blended Learning", 2017). LMS software has been embraced by many institutions. Based on Edutechnica (LMS Data - Spring 2019 Updates, 2019), Blackboard Learn and Instructure Canvas have been widely adopted by more than a thousand universities which are clearly visible in Figure 1.

	Blackboard Learn	D2L Brightspace	Instructure Canvas	Moodle	Sakai	Other
Institutions	1062	381	1050	607	85	257
	30.9%	11.1%	30.6%	17.7%	2.5%	7.5%
Enrollments	6,184,074	2,215,737	6,647,255	2,325,467	622,115	745,388
Average Size	5823	5831	6337	3831	7319	2900

Spring 2019, aggregate 500+ FTE students, www.edutechnica.com

Figure 1: Higher Education LMS Market Share, Spring 2019 (LMS Data - Spring 2019 Updates, 2019)

Popular LMS software platforms are listed below:
   a) Blackboard
   b) Moodle
   c) Canvas
   d) Desire2Learn
   e) ANGEL
   f) Sakai

Learning Analytics

Learning analytics (LA) is a multi-disciplinary field involving machine learning, artificial intelligence, information retrieval, statistics and visualization (Chatti et al, 2012). It deals with the development of methods that harness educational data sets to support the learning process. The early definition of LA by first International Conference on Learning Analytics and Knowledge 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" (Learning Analytics and Knowledge, 2010).
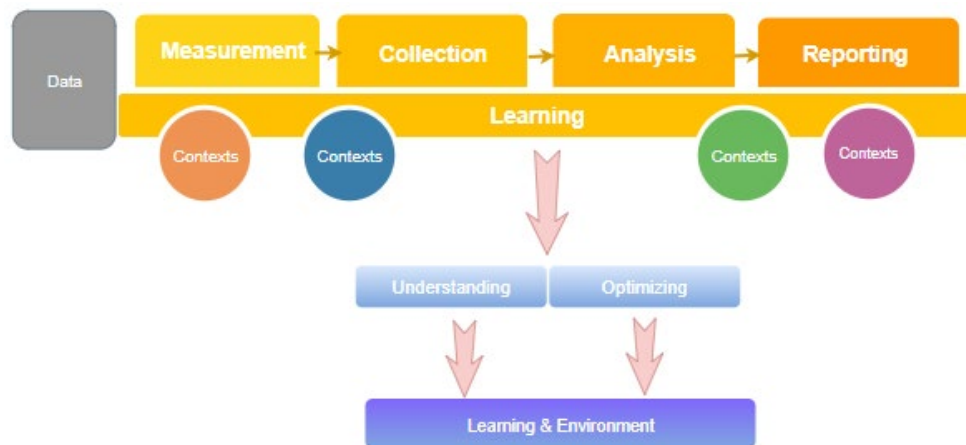

Figure 2: Learning Analytics

LA concepts and methods are drawn from a variety of related research fields including academic analytics, action research, educational data mining, recommender systems, and personalized adaptive learning (Chatti et al, 2012).

There are two primary features of learning analytics (Welsh, n.d.):
a) the leveraging of data management systems to effectively collect learner data in a timely fashion, and
b) the utilization of analytic tools and techniques of other disciplines to interpret the data.

Learning Analytics Process
Learning analytics process has three major steps (Chatti et al, 2012):
a) Data Collection and Preprocessing
b) Analytics and Action
c) Post-Processing

Data collection is the first step in learning analytics. Most often raw data contain unnecessary or irrelevant data for the processing which needs to be filtered, trimmed or normalized to convert into suitable data set or format and to avoid unnecessary computing processing overhead called preprocessing data. Preprocessed data is analyzed to explore the hidden pattern on the data set, to extract the meaningful information. The meaningful information is used for assessment and feedback, adaptation, personalization, recommendation, reflection, monitoring, etc. Post-processing of data is performed for continuous improvement of the LA cycle by refining data set, determining new attributes required for the new iteration, identifying new indicators/metrics, modifying the variables of analysis, or choosing a new analytics method (Chatti et at, 2012).

Benefits of Learning Analytics
By leveraging learning analytics, learners, educators and administrators can improve learning and course outcomes, and develop more engaged and effective teaching and learning techniques. Learning analytics provides feedback to individual learners and faculty but can also surface trends across schools or other scopes of interest, for example within specific programs, subject disciplines, class sizes, or other contexts (A Transformational Methodology to Education, n.d).

The key benefits of learning analytics (Learning Analytics, 2018):
a) institutional administrators to take decisions on matters such as marketing and recruitment or efficiency and effectiveness measures,
b) individual learners to reflect on their own achievements, course contexts, and patterns of behavior in relation to others,
c) educators to get engagement trends and course material effective in the classes they teach,
d) educators and support staff plan supporting interventions with individuals and groups,
e) functional groups such as course teams seeking to improve current courses or develop new curriculum offerings.
f) administrators for offering perspective on activities and outcomes in programs, departments, and curricula they direct

g) school Administrators in offering perspective on trends and impacts supporting decisions of broader oversight and investment
h) instructional designers and support staff to provide perspective on the impact and effectiveness of online course design choices
i) analytics questions, insights, and perspective from each audience help inform and guide the fashioning and offering of integrated analytics to each of these analytics audiences.

Learning Analytics Dashboard (LAD)
Learning management systems produce many educational data sets. These data sets are analyzed using various learning analytics methods. The result of the analysis needs to be presented in a useful way at a glance called a snapshot. These snapshots of the overall progress of the learner's activity and necessary action items are presented in a dashboard view. A dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance (Few, 2007). It presents large amounts of data in a way that supports exploration by both teachers and learners (Verbert, Duval, Klerkx, & Govaerts, 2013).

Dashboards are used in many applications. When they are used in education or learning analytics contexts, they are called learning analytic dashboards (LAD). These dashboards can be categorized in many ways based on the context of the application. Volaric & Ljubic (2017) considers the dashboards that can be generally divided into three types:
a) dashboards for teachers only,
b) dashboards for teachers and students, and
c) dashboards for students only.

Joris, Katrien & Erik (2017) categorizes dashboards as:
a) Dashboards that support traditional face-to-face lectures, to enable the teacher to adapt the teaching, or to engage students during lecture sessions.
b) Dashboards that support face-to-face group work and classroom orchestration., for instance by visualizing activities of both individual learners and groups of leaners.
c) Dashboards that support online or blended learning, an early famous example is Course Signals that visualizes predicted learning outcomes as a traffic light, based on grades in the course so far, time on task and past performance.

According to Jacques H., & Shawn G. (2017), a well-designed dashboard, applied with human factors principles, data analytics, and visual analytics, should produce its most noteworthy following advantages:
a) All visualizations need to fit on a single screen
b) Displays the most important indicators to be monitored over time
c) Periodic, on-event, or on-demand updates of data
d) Should be easy to understand, should have less information complexity, and used by anyone with access
e) Reduce the number of alert conditions and instead improve the differentiation of alerts
f) Aggregate and integrate disparate information
g) Include analysis of past performance

h) Ensure visual salience (the ability to focus on the right things for the right reason at the right time)
i) Ensure a match between information and its visual representation (the right kind of graphic for the right kind of data)
j) Direct expression of quantitative measures of performance
k) Ensure coherence and understanding of overall context of activities
l) Should provide customization often like filtering and 'drill down' functions which enables users to view the data of most interest to them (e.g., filtering by location, age or gender). The visualizations then update to display only data that meet the characteristics chosen. (Data Dashboard, n.d.):

LAD is an interactive, historical, personalized, and analytical monitoring display that reflects students' learning patterns, status, performance, and interactions. The outlook of LAD includes visual elements such as charts, graphs, indicators and alert mechanisms (Podgorelec & Kuhar, 2011). Information visualization in LAD tries to influence the users' psychologies and actions to drive effective teaching and learning. Screenshot of MicroStrategy demo dashboard is shown in the following Figure 3.
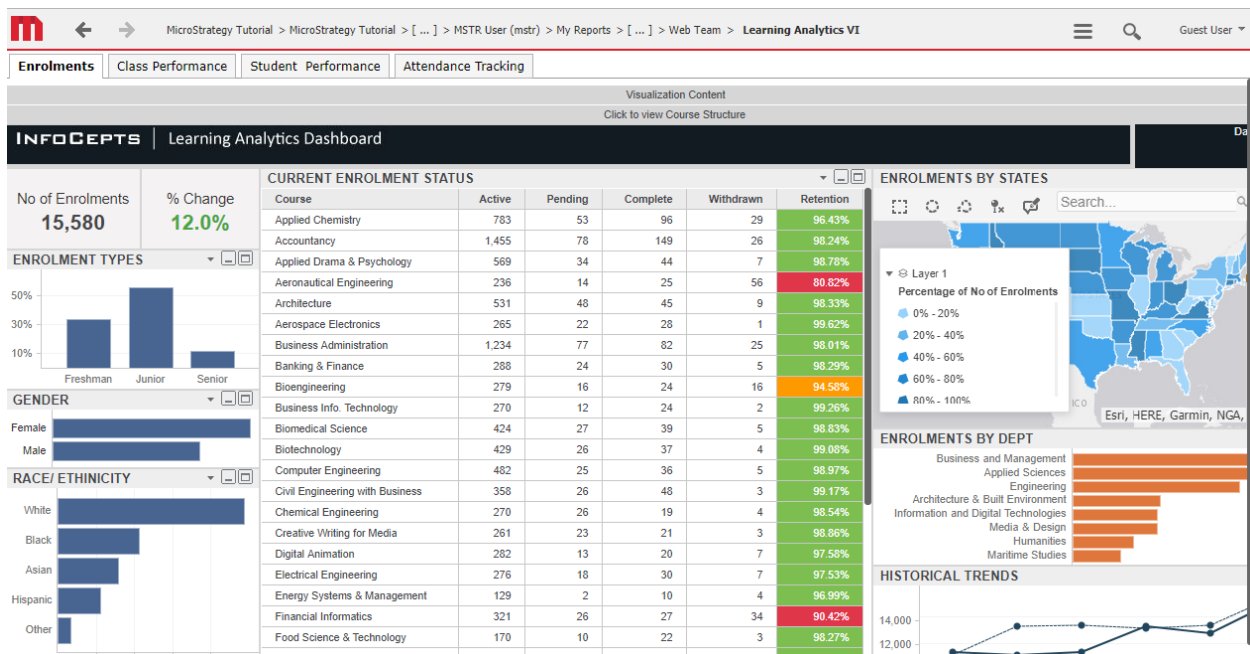

Figure 3: Learning Analytics Dashboard (n.d.) *MicroStrategy* Analytics and Mobility. Retrieved May 12, 2019 from https://www.microstrategy.cn/us/dashboard/learning-analytics-dashboard

Learning Analytics Challenges
There are several challenges that limit the wide adoption and use of leaning analytics. LA challenges are about data tracking, data collection, data analysis, a connection with learning sciences, learning environment optimization, emerging technology, and ethical concerns regarding legal and privacy issues pertaining to the use of student's data.

Some of the major challenges are:
a)   focused mainly on technical aspect of LA rather than pedagogical focus
b)   focused on the needs of institutions rather than focus on the learners' perspective
c)   limited availability of staff and technology dedicated to LA
d)   lack of training and educators reluctancy to adopt LA
e)   lack of resources availability and budget allocation for LA
f)   the analysis of different learning strategies and products in learning analytics research has not received much attention (McNamara et al., 2014)
g)   some instances of LA provide summative data which is insufficient to reflect a clear picture of students' academic performance and learning process (Rogers et al., 2016)
h)   is often difficult to operationalize and limited in providing an accurate description of all learners (Ellis, 2013)
i)   the technical and analytical challenges posed by enormous amounts of unstructured data when using a scalable approach to improve students' learning (Wang, 2016)
j)   lack of leadership capabilities to guarantee the implementation of LA in the environment of the institution (Leitner et. al., 2019)
k)   gaps between the various stakeholders within institutions with regards to understanding LA causes a barrier for the institutional acceptance of LA (Leitner et. al, 2019)
l)   lack of LA Specific Policies and regulations regarding data and ethics, however, few institutions have codes of practice for LA. This lack of clear guidance regarding a practice needs to be addressed (Leitner et. al, 2019).

Future of Learning Analytics Dashboards
The traditional instruction has a paradigm shift due to the proliferation and adoption of learning management systems. The computer-assisted learning is advancing continuously adapting the latest advancements in hardware and software technologies. The capabilities of computers, connectivity to web-delivered content, and rich multimedia content, animated and augmented content, interactive educational video games, simulation, have provided considerable potential for the enhanced learning environment in unlimited course contexts. The rapid growth and popularity of LMS system opened many opportunities in the self-paced customized and immersive learning environment. Learning analytics and dashboard integrated with the university curriculum are available that allows accessing many features like reminders, flashcards, practice quizzes, progress reports, etc. in real time in any device.

Conclusion
In this paper, blended learning, learning management system, learning analytics, and learning analytics dashboard for education where discussed. We started by briefly describing how blended learning leads to learning management systems which have grown tremendously over the past decade and embraced by many higher education institutions. In the latter part of this article, we discussed the benefits of learning management systems, learning analytics, and learning analytics dashboard and their challenges in adopting and updating to new technology for the education system.

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