

Data Analytics Tools in Higher Education

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Abstract

Nowadays, data analytics tools play an important role in the improvement and the optimization of processes in different business areas. The wide range of the collected data has led to increased interest in the analysis of data to support data-driven decision making at all levels of educational institutions. In this regard, many companies, organizations and higher education institutions developed software tools that extract data from all systems used at the university and provide the summarized data in an appropriate format for each stakeholder group. The paper presents 35 data analytics tools that have been developed and deployed by higher education institutions. Further it offers a short analysis addressing whether those tools offer means in favor of typical university processes and corresponding stakeholders.

Keywords ¹

Data analytics, Software tools, Dashboards, Higher Education Institution

1 Introduction

Nowadays, higher education institutions (almost without exception) use many software systems to automate the ongoing processes in all main areas (admission of students, training, student support, quality assurance, management, etc.). The wide range of the collected data has led to increased interest in the analysis of data to support data-driven decision making at all levels of educational institutions and stimulates research in the field of data analytics. In this regards, many organizations and universities are beginning to develop software tools that extract data from their systems and provide aggregated data in an appropriate format for all stakeholders.

Data analytics tools have huge potential in higher education. They can offer personalized services to stakeholders that would not otherwise be available - e.g. a comprehensive view of the institution, the curricula, the teachers and the students; the opportunity of the university to improve the quality of the conducted training and the ongoing processes, etc.

The paper presents an analytical overview of 35 data analytics tools implemented and developed by higher education institutions.

2 Data analytics tools

The AWE [1] is an early alert engine designed and built to enhance learner engagement and retention at the University of New England. The AWE is based on the successful Emoticons identification activity embedded in the online student portal (myUNE) and other data in different university systems (e-Motion, e-reserve, LMS, SRM-student relationship management, SMS-student management system, unit discontinuation poll and the Vibe) related to students' interactions with the university and their teachers, use of facilities and their responsiveness to deadlines. The AWE helps teachers identify high-risk students who may be struggling or experiencing disengagement from their

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courses. Based on the indicators, the AWE generates daily or weekly wellness reports which contain reasons for withdrawal and wellness-happiness ratings within individual schools and courses.

The **Benchmarking Suite** [2] is available to college deans, associate deans, and department chairs, and provides benchmarked comparisons of scholarly activity at the departmental and Ph.D. program levels to user-defined peer groups over user-defined time windows.

Blackboard Analytics [3] includes data analytics tools that help higher education institutions optimize learning. The system aims to improve instructional design, evaluate the effectiveness of the curriculum and improve the results of the annual assessment, support intensive counselling to increase student retention rates, improve achievements, increase enrollment and graduation rates, and student engagement. With the help of Blackboard's evidence-based solutions and colleges, identify and overcome barriers to student success, keep learners on track for graduation with high-quality credentials, and optimize institutional outcomes. Blackboard offers the depth and breadth of analytics solutions institutions need to support a truly comprehensive, integrated, and evidence-based approach to teaching, learning and student success. Blackboard Reporting provides the insights administrators need to measure adoption of learning tools across the Blackboard EdTech platform. Blackboard Analytics for Learn allows institutions to optimize course design for academic performance, improve reporting efficiency, support faculty development, promote self-regulated learning, and measure return on their educational technology investments. With the ability to slice, dice, and drill into a vast amount of longitudinal information about learning management system use, institutions are optimizing their learning environments, improving faculty development, empowering their students, and performing high quality research, to set their students on the path for long-term success. Blackboard Intelligence boosts institutional performance with a complete student information system data warehouse and reporting solution in support of enrolment management, retention, financial aid, strategic finance, human resources, advancement, and more. Blackboard Engage (formerly Blackboard Predict) is a student success solution that can be rapidly deployed that leverages data and advanced analytics to identify students at risk, making early intervention possible, personal and scalable. Increase retention and graduation through focussed advisement on the basis of early alerts. Blackboard Assessment & Accreditation Solution help institutions reach their desired vision for institutional and program assessment and accreditation. The approach is structured to ensure benefits are realized quickly, yet flexible enough to support institution-specific processes.

Canvas [4] is a cloud-based learning management system with an embedded data analytics module that tracks student and faculty staff activity in courses. The module allows administrators and teachers to monitor access to training courses, interaction with the learning content (files, links, pages, forums, etc.), course activity (including posts in forums and blogs). The module generates reports which allow teachers to identify students who may need support, monitor student performance, predict how students will respond to the exercises, assess the effectiveness of their teaching strategies and make a quick overview of the student's achievements in the course.

Checkin+ [5] is a student attendance monitoring tool suitable for all higher education institutions. The tool connects directly to the data from institutional timetabling system so stakeholders can produce meaningful insights with definitive timetable sessions to proactively monitor student attendance, attainment and achievement, while increasing visibility whether they're learning online or on campus. The tool allows teachers to know which students should be in their sessions with the functionality to better understand attendance measures such as arrived late, left early and notified absence. Both students and academic staff can easily visualise Checkin+ attendance data via the staff and student dashboards or study goal app. This effective, electronic register management system will help institution to improve student experience and performance metrics.

The **Course Signals** [6] system uses educational data to predict student performance and reports the outcomes to the students via a personalized email. The system collects grades and data for past academic history, students' demographics and learning engagement measures. The reported information contains a stoplight or traffic signal used to show how each student is performing. The students' emails make them aware of their current learning performance and, in the case of at-risk students, would detail needed changes to improve their probability of success.

The **C4S** [7] is a proactive, university-wide and fully automated system based on enrolment data and predetermined triggers (demographic data, behavioural data, student survey and self-report) supplemented with triggers fed from the other data sources (Blackboard, RightNow, academic referrals,

mid-semester grades). The system seeks to improve student success, retention and graduation rates. The C4S automatically flag students who are likely to require extra support to complete their studies. When the C4S team identify, it refers them to the appropriate services in the university. In addition to daily reports, consolidated reports are sent to support services and faculties in the university.

DataHero's education analytics and KPI dashboard software for Educators [8] give meaningful insights that help institutions move education programs forward. It allows stakeholders to build customizable data dashboards for student retention, student engagement, strategic enrollment and more. Higher education institutions can connect Datahero directly to the cloud services used at the institutions or upload files and then visualize their education data with our simple drag-and-drop interface. DataHero makes it easy for institutions to get insights and share them with stakeholders, teachers, or students. The use of technology can improve integrated planning in higher education curriculum by gathering student performance and learning information using big data, helping instructional design processes and data collection, and cross-checking with best practices using artificial intelligence.

The **Degree Compass** [9] is a course recommendation system that helps learners make an informed choice of modules. The system reviews the curriculum of each user, the history of the modules and the grades from the studied disciplines and, referring to the data of students from previous years with a similar profile, recommends modules that it considers appropriate for the students.

Echo360 [4] records student usage data from recorded sessions, such as when and how much recording was viewed. The tools of the active learning platform also record who answered questions/tests created during the lessons and watched slides for presentations.

Eduten Playground [10] data analytics tool is intended for use by parents, teachers and managers. The tool allows teachers to track students' progress, increase their motivation and personalize learning. In addition, by using Eduten Playground, they can provide appropriate challenges for the most talented students. The tool allows top management to evaluate the performance of students and teachers based on the learning outcomes and make data-informed decisions about changes. With the Eduten Playground's, students are more motivated, want more work to learn faster

Faculty Insight tool [2, 11] aggregate and match data of individual faculty members in six areas of scholarly activity (book publications; journal article publications; journal article citations; published conference proceedings; federal research grants; and professional honorific awards). All faculty members enter information into the tools and should keep it updated throughout the year. Data collected includes faculty credentials, courses taught, research and presentations, professional development, public service, and much more. Data is captured in the tool from faculty entry and by automated feeds from other internal systems. The tool makes reporting easy by collecting data once and providing unlimited uses. The tool is available to academic leaders and faculty members. This tool displays the scholarly activity and products for individual faculty members, and provides them with possible funding sources, honorific award opportunities, and research collaborators based on this data. The Faculty Insight tool streamlines regulatory and accreditation reporting with pre-built templates and allows for customization of ad-hoc reports to meet individual needs. Faculty can easily generate their own reports and create customized CV's. Additionally, top management can use the tool to help assign faculty to courses and dissertation committees.

GISMO [12] is a graphical interactive monitoring tool that provides useful visualization of students' activities in online courses to instructors. GISMO allows teachers to control the activities of students (attendance, reading of learning materials, submission of assignments, solving tests) in courses in Moodle for the entire training or selected period. In addition to the standard Moodle reports, GISMO provides comprehensive visualizations that gives an overview of the whole class, not only a specific student or a particular resource. GISMO allows teachers to perform analysis of the whole class, and may have a "clear picture" of what the class is doing, or has done in a period in the past.

GLASS (Gradient's Learning Analytics System) tool [13] supports visualizations derived from a dataset with many recorded even derived from the tools used by students. The tool's default visualization module provides a frequency timeline of activity events and a bar chart generated by different user groups. GLASS simplifies the implementation of new visualizations – to display information related to students, instructors, and the learning process.

The data analytics tool developed by the digital services and solutions organization **JISC** [14] consists of 5 components: a data analysis application, staff dashboard, a warning and intervention system, student dashboard and a data warehouse. The data warehouse collects data from the Student

Information System, learning management system and the library system. The tool allows students to track their activity during training (access to the learning management system, attendance at the university and the library) and to compare it with this of other students, their success, as well as to choose study modules based on data from students from previous years with similar activity and achievements. Students receive signals on their devices through the application if their activity data is below an acceptable level. The warning and intervention system sends alerts to teachers and students to provide an opportunity to manage the intervention activity.

LATch [15] retrieves data from student information system of the University of Plovdiv and Moodle and allows faculty (dean and vice-deans) and university managers (including rector, vice-rectors for quality of learning) to generate reports with summarized data for students' activity and results which allow them to track the learning outcomes of students and compare the results with those of students from previous years, identify programmes in which students do not have satisfactory results, monitor trends in students' success rates as compare average grades of students at the end of each academic year, track student grades in graduation, track the percentage of students who have dropped out of their training, etc. Generated reports for each indicator allow university managers from different levels to make informed decisions to improve the quality of training and the results achieved and determine whether the measures taken are effective and sustainable.

LATqe [16] is developed at the University of Plovdiv for the needs of quality experts in Bulgarian higher education institutions. The tool extracts data from student information system and Moodle. It allows quality experts to generate dynamically reports allowing them to monitor and evaluate the quality of learning and achievement of students and faculty staff in all courses from all bachelor/master programmes for the needs of evaluation procedures. Generated reports contain tables and diagrams and allow users to perform various analysis on the retrieved data.

Learning Catalytics [17] is a web-based platform for interactive classroom management. It encourages team-based learning by using students' smartphones, tablets, or laptops to engage them in interactive tasks and thinking. Teachers can engage students with questions (with numerical, textual, or graphical answers) to help them develop critical thinking skills while monitoring responses with real-time analytics to find out where they're struggling. Learning Catalytics lets teachers manage student interactions by automatically grouping students for discussion, team-based learning, and peer-to-peer learning.

The mobile applications **Mobile APP** [18] and **Mobile TeacherApp** [19] (developed at the University of Plovdiv) allow students and teachers to trace out the values of the indicators (students' activity, success rate, adherence to the learning schedule). The set of indicators for both applications is based on an analysis of the data generated by participants in the learning process (students and lecturers) in Moodle. Using the mobile application students [18] are able to track their activity and success rate during the training, and to compare their average level of activity and success rate with the other students, in order to increase their success, as well as to track whether they adhere to the learning schedule. The developed mobile application allows teachers [19] to identify the opportunities for improvements the quality of courses, and enhancing the performance of their students. Teachers can use the application to keep track of the activity and progress of their students, adherence to the learning schedule, as well as to quickly identify students who are at risk of failing or dropping out at an earlier stage than it otherwise would be possible.

One of the most popular e-learning environments, widely used and in Bulgarian universities (incl. Sofia University "St. Kliment Ohridski", University of Plovdiv "Paisii Hilendarski", New Bulgarian University, University of National and World Economy, etc.) has a built-in data analysis module that supports stakeholders to make data-driven decisions. The **Moodle Learning Analytics API** [20] is an open system that can become the basis for a very wide variety of models. Models can contain indicators (predictors), targets (the outcome we are trying to predict), insights (the predictions themselves), notifications (messages sent as a result of insights), and actions (offered to recipients of messages, which can become indicators in turn). Once models have been enabled and trained, insights will be generated. There are three built-in models: "Students at risk of dropping out", "Upcoming activities due" and "No Teaching".

MyUni [21] allows teachers to identify students who do not achieve satisfactory results and are likely to drop out. The teachers receive summarized data about the activity of the students in the course,

the assessments, the implementation of the set tasks. The system allows students to track their activity during training and their success.

Next-Lab [22] increases the teacher awareness for student activity (access to learning resources, use of applications, etc.), tracking learning and informed decision-making. The system provides students with basic information about the learning process, recommends activities and resources for self-study and provides guidance on tasks they cannot handle.

The **Open learning analytics platform (OLAP)** [23] is developed for four stakeholder groups - students, teachers, administrators, researchers and data analysts. The platform allows students to track basic statistics on their progress, participation in lectures and online activities, forum posts, assignments and exams, and to compare their results with this of the other students. Based on the collected data, the system can recommend students learning paths and strategies for catching up with the learning material. Teachers can use the platform to track the activity of students and explore factors that affect the activity of students in the course. Teachers have access to summary information from the student dashboard, which allows them to track how students control their progress and certify it through their activity. The platform allows teachers to compare current analysis results with results of data analysis of other anonymous datasets within the faculty, other faculty data and data from similar courses at other universities. Administrators are interested in summarized data related to the strategic priorities of higher education institutions for the success and satisfaction of students, the success rate in courses and resource allocations. Administrators can analyze the effectiveness of programs and learning resources to improve the quality of teaching materials, course design, and teaching. Researchers can ask questions and evaluate the tools and analysis strategies used by stakeholders.

The **Open Learning Initiative (Open LI)** [24] provides students with access to learning materials, opportunities to practice what they have learned and provides personalized feedback based on student performance. The teacher has access to a dashboard where receives information about students' performance and possible problems in real-time.

Personalised Adaptive Study Success (PASS) [25] is an early alert tool designed and built to enhance learner engagement and retention in an online learning environment. Based on individual characteristics, social web, curriculum and physical data drawn from several systems (e.g. My study center-study buddies, smart thinking-online study support, discussion forums, social media pages, student success hub and others) are processed and analyzed by a data analytics engine. Based on the various indicators used, the PASS generates visual signals, performance levels, self-assessment, predictive course mastery, highlight social interaction, recommends content and activities and provides a personalized environment. PASS helps teachers to identify high-risk students who may be struggling or experiencing disengagement.

Pyramid Analytics Higher Ed Program [26] allows institutions to take research and collaboration to the next level. Pyramid delivers a robust end-to-end solution so that data analysis spends less time on the data cleansing and processing and more time for extracting key insights. Users can easily import, manage, and work from multiple data sets - no need to work with data outside the Analytics OS platform. In addition, they can apply powerful statistical and machine learning tools and techniques to take their research to the next level. Pyramid allows users to share their research workspaces with graduate students, research assistants, and other faculty collaborators anywhere in the world.

SEAtS [27] uses machine learning algorithms and statistical modelling techniques to quickly and accurately predict and identify at-risk students and to help improve outcomes and attainment for all students. Student attendance data provides current insights. Predictive Analytics uses historical and current data to anticipate student interventions even sooner.

The **SIGNALS** system [28], developed at Purdue University, extracts data from LMSs and helps students track their progress, seek timely support and increase their success. The system allows teachers to identify problems, send poor performance messages and provide timely support to students.

The **Social Networks Adapting Pedagogical Practice (SNAPP)** [29] tool generates visual representations (social network diagrams) of user interactions, activity and patterns of behaviour on discussion forum posts and replies. The visual mapping illustrates the users' level of engagement and activity to identify students at risk of underperforming due to lower levels of participation in comparison to other learners.

Teacher Ease [30] provides data analytics software to support standards-based learning. Users can hold all learning data in one place, store and analyze data from common summative assessments,

external benchmarks, and formative assessments. Powerful tools help teachers make thoughtful decisions and generate analysis quickly and create timely action plans.

UniVu [31] is a big data analytics platform adapted to the requirements of higher education institutions. UniVu extracts and aggregates data from ERP systems, student information systems and learning management systems. Based on predefined or adaptive KPIs, the system retrieves critical and predictable data that can be represented to top management. The top management of higher education institutions can use UniVu as a data source of a data analytics system that can help various stakeholders (students, faculty, administration, curriculum developers, funding institutions).

Zoola Analytics [32] integrates with learning management systems (Moodle and Totara Learn) and allows data analysis and comparison of assessments for continuous improvement of the learning process. The system gives users opportunities to assess the students' engagement in the course and the learning effectiveness and monitor the progress.

With **5Lab** [33], administrators can capitalize on the rich insights contained within their student data, regardless of where that data resides. The tool allows higher education institutions to combine all of their data (eLearning activity, internet access, attendance tracking, discipline, course enrollments, race/ethnicity, socioeconomic status, and more) and present information in easy-to-understand visual dashboards. Users can customize dashboards to answer the key questions a district is wrestling with to accelerate decision making. Using the tool, stakeholders can monitor student performance and progress, identify students who are falling behind for the need of intervention plans development, pinpoint “blind spots” to ensure equity and access for all students, identify gaps and gain further insights. The tool allows users to benchmark comparisons across schools, grades, and student groups in their district.

3 Analysis: Data analytics tools versus university processes

This section presents a short analysis that addresses whether the considered data analytics tools (see section 2) meet the needs of basic university processes and corresponding stakeholders.

The typical university processes [34] can be classified into three groups according to their purpose—business process, facilitating process and management processes. Business process provide four main business areas of university activities – *Admission, Training, Research* and *Social environment and support*. Facilitation processes accompany the main business areas and belong to two areas – *Administration* and *Quality Assurance*. The *Management* area, with processes that support HEI management for planning and decision-making, covers all other processes falling into main business areas and facilitating areas.

The analysis performed aims to determine to what extent the tools discussed in the previous section provide support to the processes from the seven areas of university activities.

Table 1: Data analytics tools and university processes

Tool	Admission	Training	Research	Social Environment and Support	Administration	Quality Assurance	Management
AWE		X		X			
Benchmarking Suite		X					X
Blackboard Analytics		X		X	X	X	X
Canvas		X		X			
C4S	X	X		X			
DataHero		X				X	
Degree Compass				X			
Echo360		X					
Eduten		X		X			X
Playground							

Tool	Admission	Training	Research	Social Environment and Support	Administration	Quality Assurance	Management
Faculty Insight			X				
GISMO		X					
GLASS		X					
JISC		X		X			
LATch		X		X		X	X
LATqe						X	
Learning Catalytics		X		X			
MobileAPP		X		X			
Mobile TeacherApp		X		X			
Moodle Learning Analytics API		X		X			
MyUni		X		X			
Next-Lab		X		X			
OLAP		X		X	X	X	
Open LI		X		X			
PASS		X		X		X	X
Pyramid Analytics		X		X		X	
SEAtS				X			
SIGNALS		X		X			
SNAP		X		X			
Teacher Ease		X		X			
UniVu		X		X		X	X
Zoola		X					
5Lab		X		X		X	X

Each of the 35 data analysis tools was examined in terms of supported processes typically taking place in higher education institutions. The results from the examination (see Table 1) clearly show that none of the considered tools offers support for processes in all seven areas.

4 Conclusion

The results of the conducted analysis show that most of the reviewed data analytics tools do not allow monitoring of ongoing processes in all areas and by all stakeholders. The analysis presented in the paper is part of scientific research, the purpose of which is to propose, study and test appropriate methods, models and software tools for data analysis in higher education institutions.

In the next step of the research, prototypes of software tools will be designed and developed, which on the basis of intelligent analysis of big data generated during 73 specific processes for higher education institutions in the defined areas, allow for the relevant stakeholders (students, teachers, managers from different levels and responsibilities, etc.) to monitor and make informed decisions in the management of these processes (taking place in the institution) in real-time, and hence to improve and optimize the ongoing processes.

Project results will have a wide practical application in higher education institutions and will be tested among representatives of all stakeholders in monitoring and improving the selected target university processes.

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