

Toward a Learning Analytics System in Bulgarian Higher Education Institutions

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Abstract – The paper presents a study in the area of Learning Analytics – a scientific field that is still in a relatively early stage of study in Bulgaria. The study aims to offer, develop and test software tools for Learning Analytics that will improve the learning outcomes in the field of higher education. Using data mining methods for analysis the data produced in the learning process (extracted from different data sources), intelligent software tools will be developed to improve the quality of outcomes in different elements of the learning process (learning, teaching, monitoring, etc.), and for the needs of different stakeholder groups.

Keywords – Higher Education, University Information Systems, Data Extraction, Intelligence Systems, Learning Analytics.

1. Introduction

The planned study is related to a relatively new and especially up-to-date scientific field, namely Learning Analytics. A number of definitions can be found in literature concerning Learning Analytics. According to some authors, Learning Analytics refers to the process of collecting, evaluating, analysing, and reporting organizational data for decision making [1] and for the purpose of improving learning processes [2]. Other authors define Learning Analytics as the measurement, collection, analysis

and reporting of data about learners and their contexts, in order to understand and optimize learning and the environments in which it occurs [3]. Siemens [4] defines Learning Analytics as “the use of intelligent data, learner produced data, and analysis models to discover information and social connections for predicting and advising people's learning”. In Horizon Report 2013 Learning Analytics is defined as one of the most important trends in technology-oriented learning and teaching [5].

During the recent years, extraction and analysis of data as a result of training has become increasingly important. Modern technologies allows students to experience the benefits of Learning Analytics through the use of mobile and online applications, which track data for studnets' performance in the learning process, and raise awareness of the learning process [6]. Many higher education institutions worldwide have already used Learning Analytics to improve the quality of learning [1], student success and retention [7], [8], comprising automatic delivery and immediate feedback [9], and to provide a personalized experience for students [10]. Many of the existing Learning Analytics tools are developed as an additional module to LMSs and do not allow tracking of the learning process, as well as the achieved outcomes in a full degree and by all stakeholders.

In Bulgaria, research in the field of Learning Analytics is at a very early stage. However, some related studies could be mentioned. For example, in the frame of studies for dynamic quality assurance and evaluation of higher education, experiments have been carried out for automated data retrieval from information systems, including data on the used learning materials, infrastructure, e-learning environment, tools for communication and collaboration, student assessment system, flexibility and adaptability of the learning process, student support, team qualification, quiz results, etc. For the need of experiments, the following tools are developed:

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- an additional module to track the duration of students' participation in learning activities in LMS Moodle [11].
- experimental web services for data retrieval from LMS Moodle [12].
- a software tool for e-learning quality evaluation, with respect to the satisfaction of the students in the training (on the basis of surveys conducted in an electronic form).
- a mobile application for survey results processing.
- a software tool for test quality evaluation (TQE) which automate the activities of stakeholders (authors, lecturers, students, experts, quality managers, etc.) in order to ensure the quality of electronic tests throughout their lifecycle.
- software tools for processes automation, bringing dynamic quality evaluation in higher education.
- a common model for automated accumulation and aggregation of data for quality evaluation in higher education.

The developed mobile applications 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 LMS Moodle. Using the mobile application students 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 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.

The paper presents the essence and expected outcomes of a research in the field of Learning Analytics. Using data mining methods for analysis of data produced in the learning process (extracted from different data sources) will lead to intelligent software tools which are to be developed, in order to improve the quality of the achieved outcomes in different elements of the learning process (learning, teaching, monitoring, etc.), and for the needs of different stakeholder groups. The software tools will be tested by all stakeholder groups, in which learning, teaching, monitoring, quality assurance,

decision making, etc. can be checked and improved if it is necessary.

2. Essence of the study

The theme of the study is in a scientific field known in the world research area as Learning Analytics¹, which is still in a relatively early stage of study (and in Bulgaria is very little explored). Learning Analytics combines approaches, methods and results from different scientific fields such as intelligent data analysis and business intelligence, predictive modelling and pedagogy. Nowadays, the rapid development of digital technologies and the fact that higher education institutions (almost without exception) integrate e-learning into the learning process (in the form of distance learning, blended learning, problem-based learning, etc.), use a large number of software systems to automate their activities, simultaneously enforces and stimulates research in the field of Learning Analytics. When users apply these systems, they leave the so-called "digital footprint", and generate large amounts of data every day. Namely, methods, techniques and tools designed for automated retrieval and analysis of big data (generated by or related to learning activities) from repositories are the subject of research in the field of Learning Analytics.

The planned studies are designed to ensure and improve the quality of education and the achieved learning outcomes through intelligent analysis of training data retrieved from different information sources.

The study focuses on models and methods for retrieving and analysing data accumulated in the learning process, using different information systems through which intelligent solutions can be created for the needs of different stakeholders. Within the study on the basis of these models and methods, tools for intelligent data analysis will be offered, explored and tested to improve the learning outcomes.

The study is based on the following **scientific hypothesis**: Intelligent analysis of data accumulated in different digital repositories and from different information systems in the learning process can:

- significantly improve the learning outcomes of students (before completing the training in the course):
- help teachers and their achievements in the teaching process, incl. to track students' progress and to identify students who do not show satisfactory results at the earliest stage, or

¹ Learning Analytics is closely connected and largely intertwines with Educational data mining and Academic analytics.

to identify the components that would help improve course quality, etc.;

- provide opportunities for monitoring, decision making and quality evaluation of training to other stakeholders - program managers, quality commissions, faculty and university leadership, external experts.

A classical combined method of study, involves both theoretical and empirical investigations. Furthermore, it is suggested to be used in the research. Four main tasks, which are broken down into two stages (see the following two sections), will be carried out during the study:

- **Stage I.** Studying models and methods for intelligent data analysis from different university information systems, which includes:
 - Investigation and analysis of popular methods, tools and best practices for tracking the learning process and their application to improve educational outcomes;
 - Proposition of methods and models for extraction and analysis of data from university information systems for the needs of different stakeholders.
- **Stage II.** Testing and improving the developed models, development of software tools for Learning Analytics to improve educational outcomes for different stakeholders needs:
 - Developing software tools for Learning Analytics in regard to improvement learning and teaching outcomes;
 - Conducting experiments with the developed models and software tools.

2.1. *Planned tasks during Stage 1*

All planned tasks will be consistently resolved in the study on the basis of **analyses of well-known methods, tools and best practices** for tracking the learning process, and their application regarding the improvement of educational outcomes, include:

- Comparative analysis of popular software tools for tracking the learning process;
- Comparative analysis of best practices for implementing Learning Analytics tools to improve learning outcomes;
- Areas of application of Learning Analytics tools for different stakeholders;
- Review of software solutions for retrieving, analysing and visualizing data from different information sources.

The solution of the problem for retrieving data on ongoing training from university information systems requires a **systematic analysis of university information systems** to be done. This analysis aims to identify the appropriate data sources (which of the data are stored for the training, and how it can be retrieved and analysed), that can be used in order to improve learning and teaching outcomes.

According to this analysis, models with sets of indicators will be developed to allow each stakeholder to track training and achievements as follows:

- a model with a set of indicators for students – allow students to substantially improve their learning outcomes (before completing the course) and compare the results they achieve with the average level of the course;
- a model with a set of indicators for teachers – allow teachers to track students' progress and identify students who do not show satisfactory results at as the earliest stage, or identify components that would help to improve course quality;
- a model with a set of indicators for programme managers – allows monitoring and quality evaluation of the training and the results achieved by the students in all courses of the bachelor/master programme;
- a model with a set of indicators for members of quality committees – allows monitoring and quality evaluation of the training and the results achieved by the students, and by the teachers in all courses from all bachelor/master programmes in the faculty;
- a model with a set of indicators for faculty leadership – allows monitoring and quality evaluation of the training and the results achieved by the students and by the teachers, in all courses from all bachelor/master programmes in the faculty;
- a model with a set of indicators for university leadership – allows monitoring and quality evaluation of the training and the results achieved by the students and by the teachers, in all courses from all bachelor/master programmes in the higher education institution and comparing results across faculties;
- a model with a set of indicators for external experts – allows monitoring and quality evaluation of the training and the results achieved by the students and by the teachers, in all courses from all bachelor/master programmes in the evaluated faculty.

2.2. Planned tasks during Stage 2

Concerning the developed models with indicators, corresponding software tools will be **implemented**, which implies:

- the use of institutional information infrastructure (e.g. university digital repository, university information systems and LMSs, etc.) as a data source for the training and the results achieved;
- designing intelligent data analysis tools to improve learning outcomes for the needs of different stakeholders (students, teachers, programme managers, quality commissions, faculty and university leadership, external experts);
- developing software tools for intelligent data analysis to improve learning outcomes for the needs of different stakeholders (students, teachers, programme managers, quality commissions, faculty and university leadership, external experts);
- integrating software tools into a single Learning Analytics platform.

The developed models and software tools for Learning Analytics **will be tested from different stakeholders**. The experiments will be carried out in the e-learning process, and according to the results obtained, certain measures will be taken in order to improve the quality of the training, and the results achieved. Particular attention will be paid on the evaluations and opinions of real users, with reference to the software tools and the results obtained with their help. In conjunction with the conducted experiments, an analysis concerning the applicability of the developed models and software tools will be made on the point of view of the study objectives. The planned experiments allow a cyclical verification of the credibility of the hypothesis, by analysing the experiments results and improve the proposed solutions.

3. Expected results

The main result of the study are the proposed models, methods and software tools for intelligent data analysis to improve the learning and teaching outcomes in higher education. Following a large-scale study of the possibilities for extraction and intelligent analysis of data from university information systems, a number of **scientific and applied research results will be achieved**:

- an analysis of the information systems used to determine the appropriate data sources that can be used to improve learning outcomes;
- created models with a set of indicators that allow tracking of learning outcomes (for the needs of different stakeholders);
- designed intelligent data analysis software tools to improve learning outcomes for the needs of different stakeholders (students, teachers, programme managers, quality commissions, faculty and university leadership, external experts);
- a developed prototype of intelligent data analysis software tools to improve learning outcomes for the needs of different stakeholders and a single Learning Analytics platform;
- conducted experiments with the developed software tools, etc.

In particular, **intelligent software tools** for data analysis designed to improve learning outcomes will be implemented in the institutional information infrastructure. The adequacy of the developed models and software tools will be evaluated in the process of their adaptation and use at the University of Plovdiv.

The **main scientific contributions** of the study are the developed models with a set of indicators which allow tracking of learning outcomes, as well as the proposed methods for extraction and intelligent analysis of data from different university information systems.

The study will have **significant scientific and applied contributions**, too. The developed software tools will be tested by stakeholders (students, teachers, program managers, members of quality commissions and governing bodies, external experts) in order to perform real-time monitoring of the training regarding the quality improvement and promote activities to achieve higher results.

The scientific results and applied research results will be **widely applied in education**. The developed models (with sets of indicators for different stakeholders) and methods serve as a basis for developing software tools to improve learning outcomes. The software tools will be tested by all stakeholder groups - students, teachers, programme managers, quality commissions, faculty and university leadership, external experts. The software tools will provide intelligent support and will meet the needs of the target group, in order to improve learning, teaching, monitoring, quality assurance, decision making, etc.

Because of its community, the study results will be applicable for different HEIs.

4. Conclusion

The **actuality of the study** comes from the willingness to propose solutions to the one of important issues within the new educational paradigm (which is still not given enough attention) – ensuring the quality of the training regarding intelligent analysis of data generated during training.

The **originality and innovation of the conducted research** is related to the development of intelligent Learning Analytics tools for the needs of all participants with a certain interest in learning (students, teachers, programme managers, members of quality commissions, faculty and university leaderships, external experts), so that it is possible to follow the training process and take timely corrective measures which can improve the quality of the training (even before the completion of the student's education). The developed software tools will be integrated into a system, and that will be the first integrated system for Learning Analytics in Bulgaria. This system will meet the requirements and needs of all stakeholders.

The results obtained will **enrich the scientific achievements in the field**, and will meet the needs of all stakeholders. Opportunities for the use of innovative methods of tracing the learning process and results will be provided as a result of the study, in order to increase the interest and motivation of the students in the learning process (in accordance with the Strategy for the effective implementation of ICT in education and science, 2014-2020). Different activities for monitoring the learning process by different stakeholders will achieve higher quality and higher learning outcomes which will be automated, as well.

The future plans for development of the study are the possibilities for automation of e-Learning activities (including optimization - reduction of costs and deadlines in performing different tasks, as well as for achieving higher quality of the educational activities and materials and greater objectivity, e.g. when evaluating). Using the results achieved, it is possible to create models and intelligent systems to monitor more general institutional processes with dynamic retrieval and aggregation of data from different data sources (internal and external for the institution).

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