e-Learning Analytics for Improvement of Education

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Abstract: *The research described in this paper aims to study how learning analytics methods can be used to impact on the process of learning. The novel method for data collection from different Learning systems is implemented. Using the data collected, various analyses and reports are presented and discussed, aiming to disclose important learner's behaviors and regularities during the educational process. Recommendations are made for further improvements of the learning processes. The paper concludes by enumerating some challenges and further works for creating effective Learning Analytics tools.*

Key words: *e-Learning, Learning Analytics, Data Analysis, Students Progress.*

INTRODUCTION

The process of education implies building a complex set of relationships between teachers and learners. In an effort to hand over his knowledge and experience to students, the teacher asks himself a lot of questions, related to increasing the quality of his teaching. „Will my course be useful for the students?", "What is their background and are all of them at the same level?" „Do I need further to adapt curriculum for them?", etc. These are just a small part of the hundreds of questions which answers the teacher tries to find out.

In 2010 new term "Learning Analytics" (LA) was introduced by George Siemens as "the use of intelligent data, learner-produced data, and analysis models to discover information and social connections, and to predict and advise on learning" [1]. This definition was modified during the first international conference on LA and knowledge (LAK11) to "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" [2]. For the purposes of e-Learning we need more flexible technologies for measuring, collecting, analyzing and reporting mobile data in real time.

In this paper we present an attempt in this direction, based on the usage of LA methods, applied to data collected for several academic disciplines from a number of learning systems. Our main goal is to formulate a new approach for applying LA methods, to implement it in practice, and to see what benefits this method can bring for the learning process at University.

The paper first starts with presentation of related work and continue with presentation of the new method for data collection. We explain our main findings and provide analysis of results, concluding by discussion about lessons learnt and ideas for future research.

RELATED WORK

The main goal of LA is to make education more efficient, both for learners and teachers. This research domain appeared as culmination of several close research fields, like Web Analytics, learning systems (LS) usage analysis (analyzing learning traces, generated from learners using LS, like results from evaluation, learning activities, and other specific learner's interactions with the system), etc. In this paper we will focus on applying LA methods for analyzing data gathered from different LSs for several closely related courses at University, in order to optimize the process of learning in these disciplines.

At Harvard University, Erik Mazur and his team developed a Web-based platform called Learning Catalytics, supporting peer instruction. Peer instruction [3]- [4] is a new pedagogical method for teaching and learning, close to inquire-based education, and is assumed to be better than classroom lectures and discussions. The system is collecting all details regarding student activities and is using them to plan next learning activities, like how to group students, what difficulty of problems to offer, how long to wait for student results, what kind of feedback to provide, etc. The amount and usability of data produced

by this system empower professors to adjust instructional practices and to provide customized and flexible support to learners. In 2013, the system was acquired by Pearson [5], which led to widespread adoption and better support.

The Open Academic Analytics Initiative is a project, funded by the Bill & Melinda Gates Foundation [6]. Marist College started a project, aiming to develop predictive models for students with low achievements, and to design and implement interventions aiming to improve their results [7]. Predictive models were trained and tested using Marist College data, and were applied in several higher education institutions. This project has received several awards: the 2013 Computerworld Honors Laureate in the Emerging technology category, Campus Technology Magazine 2013 Innovator's Award in the Teaching and Learning category.

The Course Signals system [8] provides real-time feedback to students on their progress, using a red/amber/green light metaphor. It uses not only evaluation results, but also other personal information like past academic records, amount of efforts used, etc. Students receive their signals as personal emails from their faculty mentor, together with additional personalized feedback [9]. According to system's evaluation reports, students who used the Course Signals system have higher average grades compared to other students, as well as seek additional help resources and feedback at a higher rate.

A comprehensive analysis of enterprise e-learning systems use in a large university [10] was aiming to investigate to what extent the data obtained can inform decision makers and guide them in reviewing and strategic planning of e-learning usage. Authors use analytics platform, data visualization techniques and observations how different stakeholders participate in the e-learning processes. On the base of all data collected they prepared a detailed report for e-learning tools use patterns and trends, including analysis how these findings can be related to student learning results. Authors make a conclusion, that for better institutional planning universities need to apply intelligent analytics processes including more comprehensive analysis of collected data.

Long and Siemens [11] argue, that the use of LS as a main source of information in LA can be explained with the fact, that the data covering all aspect of learning processes is well structured and reflects the way learners interact with the system. They also pointed out, that current LA methods do not take into account activities performed by learners outside of an LS. They stress that future LA models have to take into account all relevant information, from all online information systems, as well as from other sources, like university administration, libraries, etc.

RESEARCH METHOD

Our research method is focused on course level, with three main goals: (1) to improve learning by students; (2) to improve teaching by professors; (3) to improve the overall course organization at faculty level. We will apply the standard triangle of LA activities: collect data; analyze collected data and make conclusions; propose set of corrective measures.

We include wide sources of information regarding the learners' behavior while studying regular courses involving the use of different e-learning tools and systems. We collected data from three learning systems: organizational data from the in-house Learning Management System (LMS) of our University, specific course participation data from the Moodle [12] LS, and more specific content and evaluation related data from the Instructure Canvas [13] LS. All the data collected from these three systems is collected in centralized data base (LA database), and further is analyzed using standard statistical software tools - in our case we use R [14]). All the results of this analysis are entered into LA results database. Finally, this database with results is analyzed by educational experts, who formulate a list of recommendations for improving the process of learning from all stakeholders' point of view. This list is given to the faculty management to be reflected in different policy solutions and actions.

We collected data related to three e-courses in the field of computer networks conducted within one academic year from October 2015 to June 2016. An average of 82 students from two MSc programs in Faculty of mathematics and informatics (FMI) at Sofia University participated in these courses. The main course content is available through the specific installation of the Instructure Canvas LS through the Cisco Networking Academy [15]. Additional training issues, module presentations, lab activities, challenges and organizational items were available through our faculty Moodle LS [16]. These e-learning courses follow the methodology established in a framework of a project "Development of electronic forms for distance learning in the system of higher education" [17] conducted in FMI from 2012 to 2014.

Data collection

Each topic/module is presented by text explanations, demo, video, animations, practice activities, chapter quizzes and ends with online theoretical test and skill challenge. To pass the course students have to cover pre-defined minimum score results of final test and practical cases. All their activities and grades are tracked in the system and are visualized in a dashboard called gradebook. Each learner monitor his/her own progress whereas the instructor observes the status/advancement of the entire course.

Instructure Canvas visualizes in a table or chart view students' activities, differentiating pages view only from active participation, test exam submissions divided into groups, grades for each item with marked total range of results and median. From Gradebooks of all courses additional comparison reports could be extracted helping teacher to improve education.

Course Analytics section in Moodle provides the teacher access to system logs visualizing each event happened during the education. Details like date and time, component, event context and description, IP address of the user are placed at teacher's disposal for monitoring all course activities. Moreover live logs are available for effective real time supervision. These data are extremely useful when real time observation and control are needed.

All LS contain analytical sections with cumulative statistics on the number of pages visited by each user, activities on individual components, assessments submissions marked as „on time" or „late". These data allow to summarize the connection between activity in system and students achievements.

We developed simple database for collecting all the extracted data from the three LS.

In the next chapter we will provide examples how the data collected is used for the analysis of the learning process.

DATA Analysis

In the practice test students answer similar questions like in the final quiz, and we want to encounter how the feedback from this test help them to prepare for theoretical examination. From the analysis on Fig. 1 it could be concluded that this preliminary exam helps students to achieve better results. This is a good starting point to make a decision whether or not this exam needs to become mandatory for the next academic year.

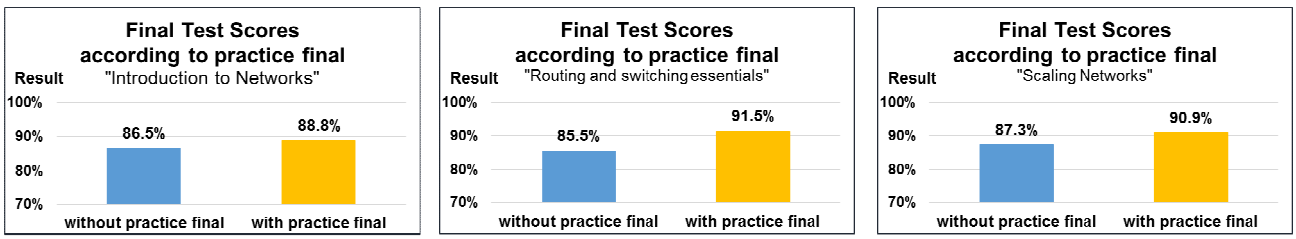

Fig. 1. Final exam scores according to filling or not practice final test

Another useful type of reports concerns the regular preparation of students and their attitude toward training. In the context of the described research the sample report visualizes the final skill challenges results depending on whether students have configured all intermediate practical assignment or they felt satisfied with the required minimum. The results shown in Fig. 2 confirm clearly that knowledge and skills students acquire while configuring various types of cases help them to cope with in a real situation. This analysis is a good reason to make decisions about students' motivation for proper learning.

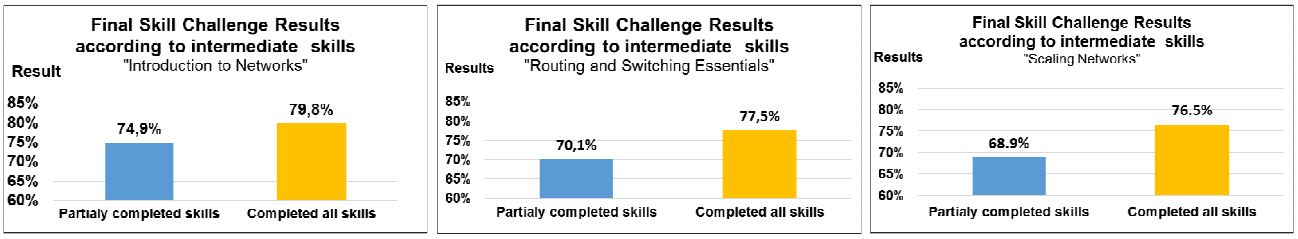

Fig.2. Final skill challenges scores according to the number of intermediate practical assignments

At the end of training it is extremely helpful to make a comparison between outcomes in all courses. Such parallel is shown in Fig. 3 allowing to analyze the overall achievements of course participants as well as personal details for each learner. This kind of report aims to form a global vision for educational state of students and is useful in making large-scale changes.

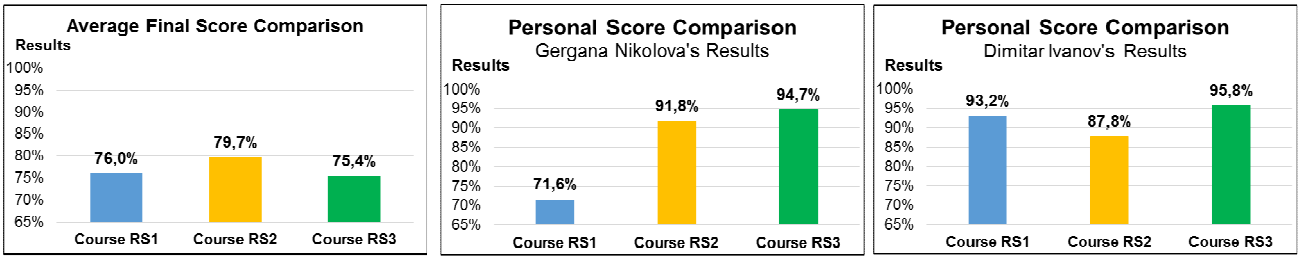

Fig.3. Comparison of results in the three courses

On Fig. 4 are visualized course grades according to students activity collected from Instructure Canvas and Moodle. It is interesting to note that grades in the first two courses show that the increased activity leads to better results. In the latter course, however, this rule was not confirmed. So, we need to have additional experimental data and analysis.

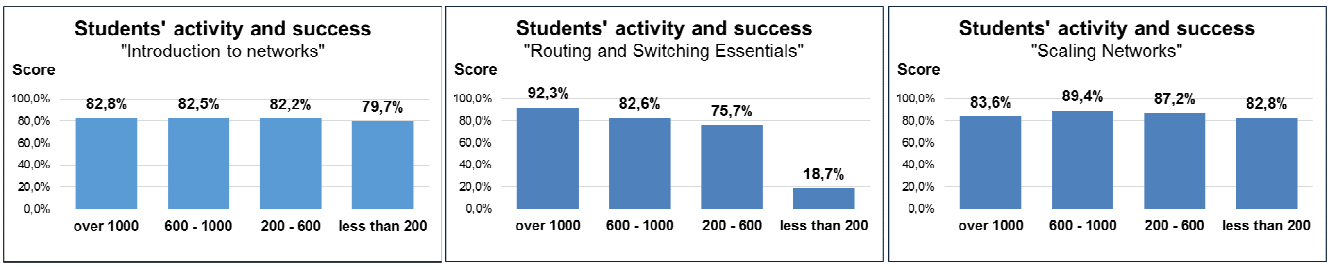

Fig.4. Final score according to course activity

Course activity statistics is one among the useful analytical reports for visualizing in a tabular form cumulative data about how many times each course component is visited. Teacher can track students' interest to every element of the course and can take stock which one needs attention. In Table 1 can be seen that in the course "Introduction to Networks" there are components with almost zero activity that require instructor's attention.

Table 1 "Introduction to Networks" components activities

Activity	Views
News Forum	1490
Skill Challenge Module 2	1403
Skill Challenge Module 6	1097
…	
Assignment Default Gateway	47
Logical Arithmetic	46
…	
Assignment Ethernet Frame	3
Assignment Standard Organizations	2

For teachers with high computer literacy our system suggests a configurable reports which provide requests to the database without using SQL language. These are reports concerning courses and categories details, users and their activities in a course, timeline providing data between start and end time selected. For queries missing in the pre-defined list, SQL command line is available. Besides computer proficiency database scheme acquaintance is required.

MAIN RESULTS

Developing a system, working as a hub between learning systems and processes is an important result, serving students, lecturers, administration and managers in education. Displaying summary data from multiple systems without violating data security and personal privacy is a real success. Users are given the flexibility to define their own personal requests with a visual query language. Using drag-and-drop technology and metadata, IT proficiency would no longer be required.

As a result of analyzing the collected data we made some recommendations to the managers of FMI for improving the quality of education. These include steps to motivate learners to study more actively, by doing more theoretical and practical assignments during the training. Another suggestion is to make further analysis of all course component visits and initiate review and optimization of courses' curriculum. In relation to the developed system additional analysis is needed to track the most asked dependences between courses for students and for teachers.

CONCLUSIONS AND FUTURE WORK

The presented research is a culmination for more than 2 years of activities and experiments. The obtained results are given to the management of the faculty for taking the measures for improving the quality and efficiency of learning. The presented tools and methods give to teachers the possibility to monitor course performance and to solve encountered problems in a timely manner. In the same time, they offer a valuable information for students aiming to improve their learning activities and results. This can play an essential role for successful course completion with better results. Further improvements of the system are planned to enhance the usability and the interface.

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The paper has been reviewed.