
PRE-TERTIARY LEARNING ANALYTICS SYSTEM WHICH SUPPORTS EQUAL OPPORTUNITIES

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Abstract

In this paper we elaborate the design of pre-production National Learning Analytics (LA) and Data Mining System. Research and reports about LA System (LAS) development lag on both the national (regional) and individual (school) level. Our approach to the design consists of the following five phases: objectives setting, user needs analysis, data availability analysis, dashboards development (goals settings and defining dashboard functionalities) and specification of the tender. To increase the usability of LAS the involvement of users is essential and for the student's dashboard it is important to reflect diversity of student body and to support equal opportunity concept. LAS is developed with the bottom-up approach. The design process consists of several rounds of user consultations with a special focus on the interests of learners. Consultations start with focus groups and panels followed by the relevance evaluations. Finally, targeted users give feedback on the pre-production functionalities of each dashboard. Further development needs to acknowledge the challenges of collection and protection of data, interpretation of results and continuous adjustment to meet the users' needs. Additionally, LA interventions, by design, must account for the diversity of the student body.

Introduction

By definition of Learning Analytics (LA) students and support for their learning, motivation and success are at the very heart of LA. Namely, learning analytics has been defined 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” (Siemens, 2012).

In this paper we will present the design for Learning Analytics pre-production system development for pre-tertiary educational sector in Croatia with the special emphasis on the dashboard design phase and how LA can support equal opportunities. The methodology and the approach presented in this paper is developed in the scope of the project “E-schools: Establishing a System for Developing Digitally Mature Schools (pilot project)” (E-schools) (CARNet, 2016). The project is due to run from 2014 to 2022 with a budget of EUR 180 million, where 85% of funding comes from EU funds and 15% from national and local budgets. The coordinating body of the project is the Croatian Academic and Research Network – CARNet and the University of Zagreb, Faculty of Organization and Informatics

(FOI) is one of the project partners. The overall goal of the “E-schools” pilot project (2016-2018) is to establish a system for the development of digitally mature schools through the pilot project and the evaluation of the application of information and communications technologies (ICT) in the educational and operational processes of 150 schools in the Republic of Croatia (CARNet, 2016). One of the project results is the development of Learning Analytics and Educational Data Mining System for pre-tertiary education system in Croatia and that process will be elaborated in this paper. FOI, as a project partner, is responsible for the research and design of scope and functionalities of Learning Analytics System (LAS). In Croatia LAS is essential to support students and teachers to enhance learning and teaching outcomes, schools to embrace more autonomy and national authorities to set, monitor and evaluate the strategic development.

State of the art – From needs analysis to a dashboard

In this literature review we give a short overview of research about the framework for introduction of learning analytics with the emphasis on primary and secondary schools and how LA can support diversity of needs and equal opportunities for students. A framework for setting up learning analytics services in support of educational practice and learner guidance, in quality assurance, curriculum development and in improving teacher’s effectiveness and efficiency based on six critical dimensions of learning analytics is presented in (Greller & Drachsler, 2012). The stated six dimensions of the proposed LA framework are: stakeholders (students, teachers, learners, other), objectives (reflection, prediction), data (open, protected), instruments (technology, algorithm, theories, other), external constraints (conventions, norms) and internal limitations (competences, acceptance). Authors’ conviction is that only the consideration of all six dimensions in the design process can lead to optimal exploitation of LA. Additionally, it listed problem areas that influence the acceptance of LA such as data ownership and openness, ethical use and the danger of abuse, as well as the demand for new key competences to interpret and act on LA results. Further, (Scheffel et al., 2014) based on the results of the Group Concept Mapping study conducted with experts from the field of learning analytics, authors proposed a framework of quality indicators for learning analytics. Proposed framework includes the following five criteria and quality indicators (Objectives, Learning Support, Learning Measures and Output, Data Aspects and Organizational Aspects). The aim of the proposed framework is to provide a means to capture evidence for the impact of learning analytics on educational practices in a standardized manner.

In order to ensure the use of educational data for LA in an acceptable and compliant way and to overcome the fears connected to data aggregation and processing, (Drachsler & Greller, 2016) described the instrument for educational institutions to demystify the ethics and privacy discussions on LA. The developed eight-point checklist named DELICATE (Determination, Explain, Legitimate, Involve, Consent, Anonymize, Technical, External) shall be applied by researchers, policy makers and institutional managers and institutional managers to facilitate a trusted implementation of learning analytics. The research (Greller & Drachsler, 2012) was used by authors of (Rodríguez-Triana, Martínez-Monés, & Villagrà-Sobrino, 2016) and applied to a primary school classroom. In this paper authors indicate that

the main barriers which had to be faced in the new educational context were legal and ethical issues related to identity and data ownership as well as the potential benefits of applying LA in primary education. Additionally, research from (Sancho, Canabate, & Sabate, 2015) contextualizes the goal of the PILAR project (Smart Learning Analytics Platform to enhance Performance in Secondary Education) in the wider panorama of learning analytics with references to the situation in the Spanish context. Authors considered the implementation of learning analytics as a promising way that can timely provide teachers with the information needed to detect motivation issues early.

Further, (Mittelmeier, 2015), used Social Network Analysis and LA methods to explore the role of social networks in classroom participation and attainment for ethnic minorities and international students, highlighting replicable interventions that can help promote social cohesion in the UK. The significance of such successful interventions can contribute to the increase in areas such as social cohesion, student engagement, intercultural awareness, and opportunities for more equal societies. An interesting study of policy frameworks and processes of ethical review are given in (Willis, Slade, & Prinsloo, 2016) where cross-institutional review of three universities (the University of South Africa, the Open University in the United Kingdom, and Indiana University in the United States) provides an opportunity to compare practices, values, and priorities. As a result there is proposal for the typology of different ethical approaches to LA that can be consulted.

Finally, even though there has been a lot of learning analytics research published since 2010 there are very few that deal with pre-tertiary education and especially with the development of LAS on the national or regional level and not just level of an individual school. Therefore, there have been limited benchmark possibilities for designing the pre-tertiary LA national system for “E-schools” project in Croatia.

Development of LA system for pre-tertiary educational system in Croatia

Within the “E-schools” pilot project the design for development of Learning Analytics system for pre-tertiary education was prepared and until now it has reached a pre-production design phase. The approach consists of the following phases: (a) setting overall objectives and vision (in this preparation phase of the project and the process of adoption of the Strategy of the Education, Science and Technology (2014) (Ministry of Science, Education and Sports of the Republic of Croatia, 2014), all the stakeholders for pre-tertiary education participated and the goals were discussed and recognized); (b) user needs analysis (developed the methodology for needs analysis for learning analytics system in pre-tertiary education and implemented it in Croatia as presented in (Divjak & Vondra, 2016)); (c) data availability analysis (analysis of the available data sources – a very demanding process due to fragmentation and incompleteness of data bases, data ownership issues, interoperability challenges, ethical concerns and integration of data collecting online and in physical school environment); (d) dashboards development (setting aims for each dashboard and designing dashboard functionalities with user evaluation of examples of dashboard design and functionalities) and (e) tender specification. The results of the performed user needs analysis were the basis for defining

functionalities of dashboards. The main outcomes of the six phases are presented in Table 1. 628 representatives of users participated in relevance and assessment phases, of which 164 were primary and secondary schools students.

Table 1: The main outcomes of the six phases

Phases	Results
1. Scope identification phase	Identified four goals Identified 6 target groups: 1) Students/pupils and their parents, 2) Teachers, 3) School management and support (principal/ pedagogist / psychologist), 4) Local and national education authority (School founders/ Ministry/ Agencies for Quality Assurance), 5) Policy making bodies and researchers and 6) Project partners on "E-schools" project.
2. Users' questions collection phase	Collected questions per target groups: students 48, teachers 90, school management 52, Educational authorities 87, Policy bodies and researchers 60, project partners 29
3. Relevance survey phase	Collected answers on question relevance per target groups: Students 116, teachers 39, school principals/ pedagogists /psychologists 32, local and national authorities 50, policy bodies and researchers 21, project partners 4
4. Data analysis phase	Performed descriptive statistics and prioritization and identified the most important questions that are interesting for each target group (presented below)
5. Consistency evaluation phase	Confirmed consistency with the identified goals of introducing LAS to pre-tertiary education in Croatia

The most relevant questions which present students' interest and were gathered during the needs analysis phase are related to comparison of the student's achieved competencies and competencies required in the labour market; comparison of student's achievement and the preconditions for enrolment into secondary school/higher education; teachers' performance; risks students have in achieving their goals; how students can improve their performance; impact of various factors on student's achievement (such as social status of a family, school equipment and design, working atmosphere, school practice, team work, absences from school, time spent on independent work) and the impact of various factors on the achievement of competencies.

Today, teachers face different challenges in classroom and should balance between different requirements from students who are culturally and linguistically diverse, who have different educational background or socio-economic status and students with other disabilities in learning. Concerning learning analytics as a promising tool that can help in assessing and handling diversity in learners' background and performance, we will present below the dashboard for students, developed according to the results of performed needs analysis.

Dashboards design

The fourth step of model for the development of LA system in pre-tertiary education is designing dashboards for identified target users. According to (SOLAR, 2011) the dashboard is the sense making component of the LA system, presenting visualized data to assist individuals in making decisions about teaching and learning. Here we will present the main functionalities of dashboard for students. Dashboard for students is very essential and fundamental because it answers the most important questions coming from students and it is a starting platform for generation of five other dashboards for other users groups. In

dashboards for other users groups, personal data about students are not going to be available with exception of a teacher dashboard.

The aim of the dashboard for students and parents is data collection, data analysis and visualization adjusted to students in order to achieve better results (learning outcomes) in educational sense and to raise their motivation for learning and learning self-regulation. The dashboard provides data about opportunities for the development and support to every student. Students have a central place in order to grasp all information about themselves, their teachers and school including personal development space and a parent corner. “Me” area consists of three parts: awareness and reflection, predictions and interventions. The description of the basic dashboard element and the reflection on support diversity and equal opportunities are given in the Table 2.

Table 2: Main elements of student’s dashboard

Dashboard element	Description	Support diversity and equal opportunities
Success and progress:	Review of student’s success and progress – overall student’s grade average, grade average per subject, obtained badges. Review of student’s grades for previous school year.	Allows teacher to address individual student needs and implement personalized differentiated instruction for every student. Student has opportunity to follow their progress. For this functionality preparation of students and teachers is essential in order to interpret and use data and analysis for motivation and planning and avoid negative connotations and consequences.
Me and others:	Comparison with other students in classroom (statistically aggregated), in school and students from other “similar” schools according to different factors (e.g. average grade, students’ activities, number of absences).	Provides teacher insight into students’ cooperation, students’ preferences on group work and identifies disconnected students. Finally, performed Social Network Analysis on students’ activities allows teacher to timely react and create comfortable working atmosphere in classroom regardless of diversity issues.
My network:	Students’ position according to centrality measures in different networks (e.g. team work, informal communication, sharing documents, activities at different systems such as LMS, activities at forum, group membership etc.).	Students and teachers can assess student workload and balance it over time. Students with help of teachers and parents can develop planning and decision making skills. Teachers and school support staff are able to identify students at risk according to different criteria and then focus their attention and interventions to students at risk.
My obligations:	Students’ past, current and future activities such as homework, test, self-assessment, essay presentation etc.)	Every student can ask teachers or support staff for help without sharing their problems with classmates or even talking in person with them.
How am I doing:	Early warning system. Review of possible risks that could threaten students’ success (e.g. negative grades, absences from school, warning from teachers).	Allows teacher to assign tasks to every student and give recommendations depending on their needs and also to recommend special support (for example for a student with disability).
My needs:	Allows students to request help from teacher/pedagogist/psychologist.	
Tasks and recommendations:	Review of tasks and recommendations assigned to student by teacher.	

Further, students can set some educational goals for themselves and then trace their achievements using gap analysis or obtaining badges (Personal development part). There is also the Survey module that can be used to ask students to assess or evaluate the school and teachers and also their own motivation, attitudes and needs.

Discussion

Basic functionalities

The national LAS in Croatia has been planned to have rather wide objective starting from supporting diversity of students and teachers in enhancing learning and teaching outcomes, then boosting schools to embrace more autonomy and national authorities to set, monitor and evaluate the strategic development in pre-tertiary system. Although from different aspects, all user groups focus on students' success, students' problems, i.e. potential risks and their needs, special educational needs, which gives impression that students really are at the very centre of the whole LAS development. However, based on the literature review and needs analysis, we realized that there are several issues that have to be considered with special attention. Therefore, in addition to the presented dashboards, we predicted three additional modules within LAS architecture: Consent System, System for Warning and Intervention and Success Planner.

Privacy and ethical issues

As evident from the performed research review, legal and ethical issues related to data control and data ownership can become the main problem in the process of LAS implementation, especially when underrepresented and disadvantaged groups of students are involved. In order to facilitate trusted implementation of learning analytics (Drachsler & Greller, 2016) and taking into consideration that the largest user group of LAS is underage, we planned the Consent System within LAS. The Consent System, regarding points Consent and Anonymise from the checklist DELICATE (Drachsler & Greller, 2016), will allow users to see the way their personal data have been used (what data, for what purpose, on which locations they are stored and which system uses them). The Consent System will also allow users to give or refuse their consent for using personal data, or part of it, for specific purpose. Informed consent and the procedures of opting-in, opting-out are necessary but not enough for LA. LAS should address the needs of a variety of underserved groups of students, including individuals from less privileged backgrounds, those having some form of disability or those who temporally have health or family issues, to prevent potentially harmful effects of using student data.

Prediction

Motivated by the potential and opportunities that LA offers, we planned the System for Warning and Interventions. The prediction elements are incorporated in several functionalities such as Successor and How am I doing. Additionally, authors (Yeonjeong & II-Hyun, 2015) state that "descriptive dashboard" which they developed was not recognized as significantly usable from students' aspect. Some of the problems are derived from the fact that students do not know how to interpret the presented data. Except on the system level, teachers can also consult and guide students through their learning process but by using prediction elements incorporated in LAS students can get timely and adequate support also in semi-automatic ways. As for the further development, a careful process of data interpretation as well as the education scenarios shall be further designed to give students and teachers

possibilities to use the information meaningfully. Additionally, special attention should be given to incorporate approaches that ensure encouragement and recommendations, and not just quantitative data that only send pessimistic or optimistic signs.

Success Planner

The final system which supports LAS is Success Planner. We predict to embed Success Planner in LAS in order to encourage students' reflection on their learning goals, desired success and competencies that want to acquire i.e. to develop their metacognition skills and approaches. In that way, in an early phase of their educational process, within Planner we strive to give students the sense of where they are, where they can be and how to get there.

Interpretation of the results

Finally, we will shortly discuss the potential hazards threatening within the implementation of learning analytics because as it is stated in (Willies, Slade, & Prinsloo, 2016) data interpretations are subject to biases. A potential danger of using educational datasets for the purpose of learning analytics stems from the misinterpretation of LA results presented within dashboard but also pedagogically sound use of interpretation for supporting student's success and overall well-being. As stated in (Greller & Drachsler, 2012) the data analysis could have dramatic (and unwanted) consequences if not used with the necessary care. Concerning the fact that this system, together with regular upgrades, is predicted to be used by half a million of underage students (pupils), this issue should be taken very seriously. The correct interpretation of data presented within dashboard is a basis for conclusions and decision making which follows analytics process. This implies the development of skills and competencies for all users of the LAS.

Conclusions

The research presented in the paper deals with designing national learning analytics system for pre-tertiary level based on the E-school project that is underway in Croatia. Design and implementation of such a system has been demanding and complex as the available research on learning analytics system for primary and secondary schools. In the case study presented in this paper we put a strong emphasis on needs analysis of identified user groups. There are six main user groups but the central ones are students and teachers. The main objectives emerging from the users' requirements are to support students' success, to allow early identification of students at risk based on available data, to allow educators to friendly monitor students' success, progress, needs and timely intervene to prevent students' failure. The central part of Learning Analytics System is Data Analysis System. Very important part of the LAS is the Consent System that allows students and teachers finer control of how their personal data is used. The System for Warning and Intervention helps students and teachers to deal with risks, and finally Success Planner enables the development of students' planning competencies and other metacognitive skills. Special consideration is given to supporting diverse student body and providing equal education opportunities for all to ensure effective teaching and learning strategies and access to students' support. Ethical decision making

about the design of LAS, as well as the ethical conduct of use of LA are key to this project but also to every LA project that involves children, adolescents, and young adults (presumably unable to give their own informed consent formally at some age) of different socio-economic, ethnic, cultural and religious backgrounds, and from different geographical regions/countries.

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