in memory of Luigi Colazzo

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BOOSTING UP DATA COLLECTION AND ANALYSIS TO LEARNING ANALYTICS IN OPEN ONLINE CONTEXTS: AN ASSESSMENT METHODOLOGY

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Nowadays learning analytics has been growing as a science, and at the University of Turin we are interested in its potential to enhance both the teaching and the learning experience. In the last few years we have gathered data from two projects: Orient@mente, and start@unito, with the latter offering open online university courses in various disciplines. In addition, we have also studied and analysed the results of the teacher training experience carried out for the start@unito project, as well as those obtained from a survey involving secondary school teachers and the possible employment of the start@unito OERs in their everyday teaching. Our sources of data are students' activity online, the results of formative automatic assessment, and the questionnaires given to the learners; the types of questions range from Likert scale evaluations to multiple choice, yes/no and a few open questions. In this paper we discuss the different tasks we completed in our projects and evaluate their adherence with the learning analytics techniques

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in terms of structure, availability, statistics, outcomes, interventions and, in general, their usefulness and effectiveness. In this way, the insights gained from both usage tracking and questionnaires can be used whenever possible to make interventions to improve the teaching and the learning experience; at the same time, when such interventions were not possible, we reflected on why this happened and how we can change and improve our approach.

1 Introduction

Learning Analytics (LA) techniques, according to the definition provided by SoLAR (Society for Learning Analytical Research) in 2011, include the measurement, the analysis and the communication of data relating to students and their learning contexts, in order to understand and optimize learning and the context in which this happens. The use of these techniques concerns different disciplines, such as education, psychology, pedagogy, statistics and computational sciences. Despite knowing that there is no universal agreement on an LA definition, the one provided by SoLAR best describes our approach and is in line with the learning-centred approach in which we believe. Moreover, George Siemens (2012) underlines how LA techniques concern a series of training activities, as they refer to the whole student learning experience, such as university pre-enrolment, learning design, teaching/learning processes, assessment and evaluation. At the University of Turin, our Data Collection and Analysis (DCA) tasks are devoted to profile users in order to accommodate diverse population, take data-driven decisions, build better pedagogies and structures, build adaptive formative assessment, improve academic performance, reduce the dropout rate and discover new patterns. Our main projects are start@unito (Bruschi *et al.*, 2018) and Orient@mente (Barana *et al.*, 2017). The first one aims to promote and facilitate the transition from secondary school to the university system through the creation and dissemination of a series of open online courses, related to all the main disciplines; the second one has been designed to help students make a responsible choice about academic studies by offering interactive paths for university guidance, preparation for admission tests, OOCs (Open Online Courses) for revision of basic knowledge, and e-tutoring. Both projects offer open online courses delivered on a Moodle platform integrated with an Automatic Assessment System (AAS), a Web Conference System and an Advanced Computing Environment (ACE). Moreover, we dealt with two non-traditional type of learners, namely university professors (Marchisio *et al.*, 2019b) and high school teachers (Marchisio *et al.*, 2019a). These non-standard learner groups present considerably smaller numbers than the traditional student population. The present paper will be devoted to the analysis provided in the context of the start@unito project, considering the differences between different categories of learners. More

specifically, our data come from three main sources. First, students' activity online: subscriptions, clicks, testing and assessment, time spent online. Second, questionnaires given to high school and university students, high school and university teachers, grant holders and generic users. Third, information and data gathered during individual and group meetings. It is also important to mention that the courses offered on our online platform are tutorless, therefore besides a central coordination service there is no expert staff who manages individual courses. The data obtained are analysed by technical staff supporting the scientific committee of the project.

Learners are students of a given subject, and generally we think about university students. In our experience managing the start@unito project, we encountered many different types of users who, at one time or another, acted as learners attending one of the courses offered on our platform: students, university professors, grant holders, high school teachers, generic users.

Even though it may seem that these characters have different features, they have one thing in common: they are learners, and their difference is precisely what drove us to focus on understanding the learners' contexts.

Since the field of LA is relatively new to our research team, with this paper we intend to understand and evaluate the quality and relevance of our DCA. After an outline of the theoretical framework, the research question and methodology will be presented, along with the results and discussion.

2 Theoretical framework

According to the NMC Horizon Report 2016, one of the trends in higher education nowadays is the measurement of learning. Especially when dealing with online learning, a huge amount of data is available which, if used wisely, can provide vital information on learners' habits and performance. Given that, the paradigm of higher education has shifted in favour of a more student-centred approach, the insights gathered from the data can be used to improve learning (Doug, 2013) and generate actionable intelligence (Campbell *et al.*, 2007). After all, the focus of learning analytics should always be, indeed, learning (Gasevic & Siemes, 2015). In the present paper we assume that LA can be carried out on data generated by learners in a broader sense, since we are not only considering university students but anyone who is in a learning position, including university professors participating in a training course. In fact, the aim of our research group is to analyse, improve and perfect the online learning experience not only for the average student, but for a wider range of professional figures. As far as the students are concerned, the data gathered from LMSs such as Moodle include "institutional information such as student demographics and course selections, pace of program completion, learning

platform engagement statistics, and concept mastery" (Horizon Report 2016). According to the literature, data gathering techniques raise the question of which data are useful for advancing learning outcomes, as well as issues of privacy and ethics. Moreover, learning analytics and adaptive analytics manage to bridge the gap between traditional classroom learning and the more solitary online learning by offering students feedback and personalization which, according to recent studies and reports, is something students crave constantly during the process of learning (Hanover Research, 2016). Although some models for the use of LA have been proposed (predictive modelling, social network analysis and SNAPP method, usage tracking, content and semantic analysis, recommendation engines), there is no standardized methodology, therefore LAs have been implemented using various approaches tailored for different objectives. (Papamitsiou & Economides, 2014) studied the impacts of LA and educational data mining on adaptive learning. Among the benefits of LA we can find "targeted course offerings, curriculum development, student learning outcomes, personalized learning, […] improvements in instructor performance, post-educational employment opportunities, and enhancement of educational research" (Hanover Research, 2016), which are coherent with the objectives of the Orient@mente and start@unito projects. Among the models for the use of LA, two in particular are worth mentioning: the first one is Campbell and Oblinger's five-step process (Campbell & Oblinger, 2007): Capturing, Reporting, Predicting, Acting, Refining. The second one is Clow's learning analytics cycle (Clow, 2012). The cycle is composed of four phases. First, learners: the category of learners is defined and analysed. Second, data: the generation and capture of the data about or by the learners. Third, metrics: processing of data to obtain insights into the learning process. Fourth, interventions: the data gathered are used to make improvements.

3 Research questions

We focused our attention on how we construct and adopt analytics and general DCAs related to the learning process in our projects. We asked ourselves the following questions:

- Which of the DCA we adopted are coherent with good practices provided in the literature about LA? Which of these DCA can be considered LA?
- Can we devise an evaluation framework to assess the quality of DCA and their adherence to the definition and models of LA?

4 Methodology

Considering the theoretical framework presented, the analysis we carried

out followed the following steps:

- Recognition: understanding and recognizing which of the measures we adopted can be close to the definition of LA;
- Search: scanning the literature in order to understand and compare the quality of the DCA we adopted in comparison to other experiences and standards.
- Evaluation: evaluating each DCA in terms of outcomes and interventions. On a scale 0-5, the outcomes criterion refers to how relevant the data gathered are, and the interventions one to the actions taken to improve the learning experience.

After a short description of the DCA we adopted, we evaluated its quality according to the following criteria:

- Structure: a short description of the main features of the DCA;
- Population: the number and the typology of learners involved;
- Availability: are the data easy to gather and interpret? Are the data in real time?
- Statistic methods: did we apply the right statistics to the data?
- Outcomes: what did the DCA accomplish?
- Interventions: what actions were taken to improve learning experience? Does the insight derived from DCA impacted positively on the learn path of majority of the learners?

5 Evaluation phase

Our DCA are based on data mining, tracking and collection techniques, which seem to be the most popular form of LA methods (Khalil & Ebner, 2016).

5.1 DCA 1

The first type of learners we analysed with DCA1 are high school and university students. They had the opportunity to attend some of the courses in the subjects they study fully online. This is nowadays quite a general learning context; most universities provide online and distance learning options. In this case, the courses are open and, until they subscribe to university, without tutoring. After attending the online course and passing a final test, students must submit a questionnaire about their learning experience. Thus, the sample of students is provided by those who attended and completed the whole course, exercises and self-evaluation tests.

Structure: the questionnaire asks the students to evaluate the main features of the course. Our aim is for the users to reflect on their online experience

and evaluate the course effectiveness and the usability of the automatic assessment system. Questions regard the usefulness, the clarity of the structure, the preferred types of resources, the time spent engaging with the course, the devices used to access it and the general difficulties encountered. Since the questionnaire contains a section for comments, we considered for our DCA comments by students provided by email or via helpdesk, too.

Population: the population so far is made up by almost 900 students who completed one of the online courses of the start@unito project.

Availability: the data are easy to gather due to the potentialities of the Moodle Learning Management System (LMS). However, some issues arose since the data are stored into a single database. It is possible to filter them course by course, but this process is more time-consuming. Setting up different databases for each course would have been possible, but in this case the merging of all the data would have required a similar kind of effort.

Statistic methods: we applied standard statistics (median, average) provided by the system only from the descriptive point of view. A validation of the data via other indices or tests, like Student's t-test, Fisher's test, analysis of variation (ANOVA) may be applied in the future.

Outcomes: we obtained a general description of the users who attended online courses. Users said that the course was useful, the structure clear and the assessment contained enough questions for learning (median 4 out of a 5-point Likert scale, in which 1 was "not useful" and 5 was "very useful"). Two main remarks: textual resources were more appreciated than videos: the course is a full university module, so it requires a deep understanding of the concepts, typical of textual resources. Despite the widespread use of portable devices, most users attended the courses via PC (71%).

Interventions: Even though the students rated the learning experience as good, some interventions were felt to be useful. Since the project is only at the very beginning, so far, we have provided more indications in order to reach the desired resources and activities, especially close to the final test, which contains useful information for sitting the exam. Even though students' questionnaires generated a significant quantity of data, the action we took to improve their learning experience was still minimal.

5.2 DCA 2

Data from students were analysed with DCA2, through the tracked online activity, too.

Structure: the information was gathered from the databases of the platform and the user activity log (update 24th July 2019), using SQL queries.

Population: the platform hosts more than 10000 users; thus, the population

size is quite large.

Availability: when requested, administrators can run the query, anytime. Some of the queries we implemented scan the database of all logs more than one time, providing a non-immediate result (anyway less than a minute).

Statistic methods: the amount of data is quite large; therefore, it is very difficult to filter with the proper information to understand and improve the learning environment.

Outcomes: out of 34 active courses, we counted the amount of resources and activities which are delivered by the platform: 1201 files, 847 video resources (without counting the embedded ones), 561 web pages, 410 tests, 237 books, 167 folders, 71 lessons, 48 Maple worksheets. In August 2019 we had on average more than 60000 monthly logins, corresponding to around 900 distinct users, in a single month.

Interventions: we reported to the scientific committee of the project, which sets the pace for the future development of the platform with new courses, taking advantage of the analytics. This intervention did not have a direct impact on the learning experience: this is mainly due to the large amount of data, which makes it hard to extract information.

5.3 DCA 3

University professors and grant holders were considered with DCA3. In order to prepare online courses for the start@unito project, university professors were trained in all topics related to the design and implementation of an online course, from the pedagogical to the technical issues. Professors were accompanied by grant holders (master students or PhDs) who acted as technical and academic support. The training programme consisted mainly in two parts: in-person meetings and online contents. Before and after these programmes, grant holders were requested to submit a questionnaire, in order to evaluate their previous experience about e-learning and the overall progress after the training. The results arising from these data have been discussed in (Marchisio *et al.*, 2019b).

Structure: we obtained feedback and data from grant holders both from questionnaires, and meetings. The aim of the two questionnaires is an evaluation of the quality of the training course (in-person and online). We previously asked about the experience of the grant holders with e-learning in three main areas (didactic, organizational and technical). After the course, they evaluated the same aspects, together with the usefulness of the meetings and of the online resources. Moreover, we organized monthly group meetings and individual sessions on request where we discussed the main issues grant holders were facing and found solutions together.

Population: 29 over 30 grant holders who participated in the development of an online course of the project start@unito submitted the questionnaire.

Availability: the data are reserved, but easily available by manager of the training course, who publish only aggregated data.

Statistic methods: the amount of data is related to a small group of people, thus we applied standard descriptive statistics.

Outcomes: we obtained a general view of the improvement in the confidence of grant holders, from a score to low/average to good (out of a 5-point Likert scale). The usefulness of each meeting was evaluated, with medians 4 and 5 of a 5-point Likert scale. Due to the blended nature of the training programme, the online materials were not widely used by all people involved, but they all stated that the online resources were quite useful (5 out of a 6-Point Likert scale).

Interventions: since the numbers are small, we received specific feedback from grant holders, and took specific actions in order to provide them with resources and utilities they needed. Since we obtained very good results, we will not apply important interventions on the eventual future training course. The online discussion forum, another tool we adopted, was mostly employed by us for remarks of general interest, but it was scarcely used by grant holders, despite our efforts to encourage them to post their questions for everyone to see and reflect upon. This may be because most issues with which grant holders needed our help were very specific and subject-related. However, we noticed a certain amount of resistance towards the use of the forum even for problems related to the correct use of features of the Moodle platform or the integrated Maple TA automatic assessment system, which everyone had to deal with throughout the creation of the course.

5.4 DCA 4

DCA4 considers high school teachers, which are involved in the learning process because they are the main interface with education for high school students who will probably enrol in a university course. Teachers can take advantage of the open feature of the start@unito courses and use the online materials for their regular classroom activities, for self-study and improvement, to help students with special educational needs or for students' autonomous review and practice (Marchisio *et al.*, 2019a). We asked high school teachers to evaluate the online materials they consulted.

Structure: we asked teachers to open and browse the online courses of the project start@unito in order to evaluate the quality of the materials, the possibility to use them in their daily didactics and the overall experience. The feedback from teachers was provided by a questionnaire that contained Likert-scale, multiple choice and open questions.

Population: 136 Italian high school teachers.

Availability: the reserved data are easily available by project managers, who publish only aggregated data. The variety of subjects taught by the teachers involved in the survey and the different types of high school provided an added value to our research.

Statistic methods: the amount of data is related to a not-so-large group of people, thus we applied standard descriptive statistics.

Outcomes: statistics provided us with a general description of teachers (Italian, of all ages) who answered and a view of the situation of OERs in high schools. It emerged that not all teachers are fully aware of what OERs are and their potential and that the ones provided by the start@unito platform are suitable for high school students and useful for teaching.

Interventions: we encouraged teachers to use the OERs with students. The evaluation by teachers was good, so this DCA produced no intervention.

6 Discussion

Through a careful study and analysis of the vast, however not very specific, LA literature, we realized that we had already been practicing LA. However, not all the data collecting and analysis we performed can be considered LA, since data per se are not meaningful if the interpretation of such data is lacking or does prompt the necessary interventions. Evaluating DCA1, we realized that we would obtain more useful insight if the questions about the contents of the course were more detailed and that the questionnaire may be expanded in order to understand better how students relate to this kind of learning environment (fully online, without tutoring), and whether the student profile (working student, student with disabilities, etc.) influences the answer. Evaluating DCA2, we came to understand that the middle-up approach adopted by our research group so far only produces learning analytics if the numbers are small. When the numbers are more consistent, a top-down approach is more advisable, finding objective criteria that will allow us to analyse and interpret data both quantitatively and qualitatively, and act promptly and coherently according to the results. DCA3 and DCA4 both concern small numbers and thus allow for qualitative analysis as well as quantitative analysis. Nevertheless, while in DCA3 we were to make meaningful interventions by catering to professors' individual needs and personalizing the learning experience, in DCA4 we did not manage to make such interventions, due to the totality of positive feedbacks. The following table summarizes the evaluation phase and reflect on the comparison with literature about LA.

Table 1
ARE THE DCA WE ADOPTED ADHERENT TO WELL-KNOWN LA TECHNIQUES?

DCA	Outcomes	Interventions	Adherence to an LA technique
DCA 1	4	3	Yes
DCA 2	3	1	No
DCA 3	4	3	Yes
DCA 4	4	0	No

Conclusion

In the present paper we have attempted an analysis of the DCA employed at the University of Turin in various projects on which our research group has been working, and we tried to define a methodology to evaluate the adherence of these amorphous practices to well-known LA techniques as defined in the literature of LA. Although our DCAs are not methodologically fully refined yet, we can report some interesting findings: first, the idea that LA can enhance the learning experience in a broader sense, considering also teacher training as such. Secondly, the questionnaire methodology, which we have largely employed, has proved a source of reliable data, both quantitative and qualitative. However, data extraction techniques still must be improved, especially when dealing with huge amounts of data. Large data requires more design and more awareness of how to deal with them. We firmly believe in the fact that open online education can provide unique opportunities to learners, and so far we have enacted out tasks to improve course design and teacher training on the one hand, reflecting on our own practices and gathering experts' feedback; on the other hand, they are helping us understand the learner's experience in the online environment, and we plan to use the insights gained thanks to the data to make it an even more stimulating and rewarding experience.

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