Making Learning Analytics accessible for improvement of the Learning Design both during and after the course.

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Abstract.
Educational institutions are designing, creating and evaluating learning activities to optimize effectivity, efficiency or satisfaction for students and teachers. Furthermore, they are searching for solutions to provide more personalized learning. Learning Analytics (LA) applied on a Learning Design (LD) provides opportunities that can lead to more personalized learning experiences if implemented thoughtfully. By using LA during the run-time of a course, real-time insights in the course progress become available through learning dashboards and provide possibilities for intervention. However, attention must be paid to metacognitive competences so teachers and students will be able to change the(ir) learning behavior.

Keywords:
learning design, learning analytics, learning dashboards, meta-cognitive competences, run-time feedback.

1. Problem definition

Providing high quality education to students becomes increasingly challenging due to the high diversity of the student population that signs up for a study program [1]. At Higher Education Institutes (HEI) different types of students enroll in a study course, such as students from secondary school with no previous work experience, students that aim for a career switch and combine their study with their job, or students that prefer to be educated in close relation to their workplace pursuing further professionalization in their current practice [2, 3]. Therefore, HEI study programs need to become more flexible and take the individual differences in learning behavior into account. Effective use of Learning Analytics (LA) creates opportunities to personalize learning experiences and optimize learning. LA could provide us with precious input to direct design choices in the broad perspective of education. At HEI several ways to gather 'authentic' data regarding student learning behavior are being used; electronic learning environments, digital assessment methods, and student information systems track student learning processes and behavior. Furthermore, digital devices like mobile phones, tablets and laptops can be used to collect activities of students. The availability of this data provides HEI with opportunities to optimize learning behavior and learning outcomes. It is this insight into the students' authentic and real-time learning behavior that, when made accessible in a user-friendly way could enable teachers to evaluate education based on authentic data. It enables them to not only identify ineffective or underused elements of the LD or students at risk for attrition, but also to adapt their course and learning activities "on the fly", meaning during the course's run-time. Additionally, these data could provide students with insight into their own learning behavior in comparison with the course goals, achievements or the performance of their fellow students. This could – if attention is given to students' meta-cognitive competences [4] - enable them to adapt their learning behavior to become more effective or efficient. Enabling students to self-regulate their learning is essential in producing the 'wanted' professionals HEI are striving for. Self-directed learning is an important aim for HEI in order to increase the number of students enrolling and successfully completing the study.

2. Background

Learning Design

To define LD it is necessary to understand the definition of a learning activity. In this research, a learning activity is considered a task that involves interaction with teachers, fellow students, or content items in order to increase students' knowledge, skills or attitudes. The LD is the description of all

elements of the course's design such as the learning activities, the resources needed and the support actions a teacher does to facilitate the learning process [5]. Currently the evaluation of de LD of a course is done mostly by formative assessment during the course, and by summative assessments and qualitative surveys at the end of the course [6]. LA provides great opportunities for evaluative and quality improvement purposes since it enables us to use authentic data of student learning behavior, instead of subjective self-reported measures. This enables us to more effectively improve the LD based on authentic user data, but could also enable teachers to intervene in de LD during the run-time of a course, by e.g. providing personal feedback to students just-in-time.

In the process of developing, running, evaluating and adapting a course several elements can be distinguished. The design time is defined as the period when the learning activities are (re)designed as part of the Learning Design of a course; this is typically before the start of a course. However, also the period after the course has ended, and adaptation based on evaluation results takes place for the next run of the course, is called design time. The runtime of a course is the period in which the course is executed and learning activities take place. During runtime planned learning activities result into student learning behavior that is monitored by using LA and visualized in a Learning Dashboard. These visualization can trigger teachers to intervene in the Learning Design during runtime (e.g. by altering learning activities of providing students with additional feedback). It can also trigger students to alter their learning behavior during the course (see figure 1).

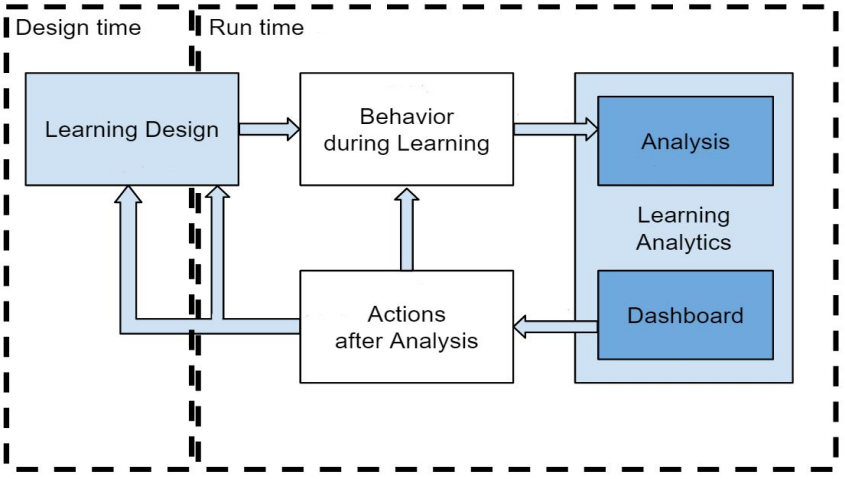

Figure 1. Process of developing, executing/using, evaluating and changing a course.

Effective use of LA as part of the Learning Design changes the design-process of learning activities from a post-evaluation design process into a permanent monitoring design process. This, however, requires that teachers already consider appropriate LA measurements at the design phase of their learning activities. In that way most suitable LA indicators can be used to monitor if the selected learning activities of a course are going as intended or not. Like assessment procedures, LA indicators should be considered in the very beginning of the development of the LD. This means that, e.g. a 'forum discussion' is not only an effective learning activity by itself, but LA can also provide a much more efficient and effective overview of e.g. student participation through social network analysis tools [7] that can provide students with self-monitoring information and make teachers more aware of the learning process of their students and adds possibilities for personalized feedback. Therefore it is of crucial importance for a LA supported LD to consider potential LA indicators already while designing the learning objectives and related activities [8]. What data is relevant and available at Zuyd with regard to the learning design will be addressed in substudy 1.

Analyzing behavior and data from learning activities: Learning Analytics

LA describes all aspects of collecting, cleaning, analyzing and visualizing this data. LA has been

used in experiments for a broad variety of things: to inform students in choosing study programs, curriculum development, design of learning outcomes, get insight into behavior of students and their learning process, personalize learning, improve instructor performance, acquire insight in employment opportunities after graduation, and enhance research [9]. However the scope and scale of its potential has increased enormously with the rapid adoption of technology over the last few years and the dependent growth of tracking data that comes with the use of technology. Despite the great potential surrounding LA, most attempts to implement LA strategies in educational organizations are still at the initial phase [10, 11] because organizations struggle with the complexity of the field of LA.

Digital learning environments often gather and store several data items, methods like xAPI [12] are developed to collect data from digital environments that don't collect it automatically [13] . Structured and unstructured data, distributed storage and large amounts of data are all issues that have to be taken into account when designing a learning analytics solution.

A comprehensive introduction to different domains that are affected by LA was provided by Greller and Drachsler [14]. They developed a generic design framework that can serve as a guide in developing LA applications in support of educational practice. The framework addresses six fields of attention that have to be addressed when using LA: 1. Stakeholders, 2. Objectives, 3. Data, 4. Instruments, 5. External constraints, 6. Internal limitations. The focus in this study is on teachers and students as stakeholders and the fields data and competences. At the field of Goals the study will at least focus on reflection but if possible also give attention to prediction. The identification of data and analyses relevant to the Learning Design is part of substudy 1.

Making learning analysis visible: Learning dashboards.

Rienties and Toetenel [15] state that the challenge in the field of LA is how to put the power of LA into the hands of teachers so that they are able to use it and act upon it and this is exactly what we aim to do in this research project by using Educational Learning Dashboards. A dashboard can be defined as a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance [16]. A learning dashboard can provide both teachers and students with insights into study progress and potential for improvement. Learning dashboards give opportunities for awareness, reflection, sense making, recommendations, and, therefore, could improve learning by helping users raising their ability to act on information [17]. Insight in which design choices work and which don't in comparable contexts enables institutions to increase educational quality.

A diversity of learning dashboards has been reviewed in several studies [18, 19]. The review of Bodily and Verbert [18], reports the effects of using the dashboard on student behavior (15 out of 94), student skills (14 out of 94) and student achievement (2 out of 94). This study illustrates that learning dashboards are developed for different goals. Bodily and Verbert conclude that more research is needed on the actual effects of these reporting systems on student behavior, student achievement and skills. A research question that will be addressed in our study. Schwendimann, Rodrıguez-Triana, Vozniuk, Prieto, Boroujeni, Holzer, Gillet, and Dillenbourg [19], research on the effects of learning dashboards is still young, demonstrated by the considerable amount of exploratory work and limited number of proof-of-concept studies that were rarely implemented (and evaluated) in educational practice. Most of the 53 articles Schwendimann researched recommend more future work such as repeating research including different targets groupes(students instead of teachers and vice versa) and more usability studies in educational practice. The granularity, visualization and interpretation of the information are mentioned as important issues in that type of research. This is underlined by Park and Jo [20] who found that students' overall satisfaction on learning dashboards is correlated with both the degree of understanding and their capability to change their behavior. So, a user friendly presentation of the LA information in Learning Dashboards is a challenge that this study will address in substudy 2, as is the focus on what students and teachers need to act upon the presented information.

Metacognitive competences used to act after using Learning Dashboards.

A definition of metacognitive knowledge is given by Flavell [4]: "*metacognitive knowledge consists primarily of knowledge or beliefs about what factors or variables act and interact in what ways to affect*

the course and outcome of cognitive enterprises". In the context of this research, cognitive experiences are understood as learning experiences. Awareness and interpretation of the information presented from learning experiences and critical thinking on actions and behavior that can be applied on the elements of the learning experience are metacognitive competences. These are competences needed to think of factors necessary to act adequately on the information provided [14] by for example Learning Dashboards.

So not only user-friendly presentation of LA is important, but also providing teachers and students with the competences they need to interpret and act effectively on the information they are provided with. This is seldom addressed in research practice of learning dashboards [19]. We believe it is a crucial factor regarding effective use of Learning dashboard in educational practice and therefor it will be addressed in substudy 3 .

In conclusion, by using LA to acquire on demand insight in authentic learning behavior as part of the LD**,** we create the opportunity to optimize learning by focusing at both student and teacher behavior. However in making the most out of this opportunity, several challenges have to be accepted as part of this research project:

- available data has to be made accessible for teachers and students
- appropriate visualizations have to be selected
- to enable students and teachers to act upon these visualizations attention has to be paid to e.g. meta-cognitive competences

3. Research purpose and questions.

The aim of this research is to bring HEI, especially Zuyd University, a step closer to personalized learning. This can be done by enabling on demand insight in learning activities and the ability to change learning behavior, by the incorporation of LA into Learning Design. This will be done by using learning analytics dashboards that give students and teachers at run-time insight in their learning progress. Given a particular Learning Design LA could influence the behavior of the students and teachers both at run-time and design-time towards more effective and efficient learning and more satisfaction.

The main research question is:

> Can Learning Analytics, by use of Learning Dashboards, improve the Learning Design of a course during run-time and in that way make the learning progress more efficient, effective or increase the satisfaction of teachers and students?

To answer these main question the following sub research questions are to be answered:

1. Which (learning) data of students can we collect?
2. Which analyses of the educational data are supportive to give students and teachers more insights in the learning progress?
3. What metacognitive competences do students and teachers need to interpret and act appropriately on the LA dashboard?
4. What is the additional value of using LA in run-time on study effectiveness, efficienty and satisfaction?
5. How can metacognitive competences be stimulated in a LA for LD solution?
6. Which interventions will be done by teachers on a course during run-time and after the run-time (design-time) of a course when using Learning Dashboards?
7. How does the use of Learning dashboard effect student learning during run-time of a course?

4. Design and methods

A design science research methodology [21] is used for this research. Four substudies (Identification end users and context, Concept development, Tool (Re)Design and Evaluation) are planned as these are known parts in a user centered design research.

Substudy 1: state of the art and identification of context and users.

To go beyond the current state of the art in LA supported Learning Design presented in this proposal we will first conduct a literature review and several experiments. The review will illustrates opportunities and challenges in using LA in LD and focuses on (learning) data, learning analysis and learning analytics outcomes presentation tools from students in associate degree/bachelor education.

In addition, an experiment in cooperation with the SURF Learning Analytics Program will take place, focusing on data gathering and data visualization. The experiment is situated within a Zuyd, HBO-ICT course. Supplementary, data of similar experiments, conducted at 2 - 7 Dutch HEIs and data from a Motivational Strategies for Learning Questionnaire (MSLQ) are gathered within the REFLECTOR project to get a better view of current positions of teachers and students on LA. Furthermore, by using survey techniques we want to identify which analyses are considered valuable for learning progress and for the Learning Design by teachers and students.

This all leads to a clear view of the state of the art and identifies the end users and context so that sub research questions 1, 2 and 3 can be answered.

Substudy 2: developing a Learning Dashboard for Learning Design with run-time usage

The results of the literature review, the experiment and survey will be used as input for the next steps of the research: a first tool design and one iteration of tool redesign are made:

- Tool Design: validity of the dashboard
    a. Development of a first prototype of a LA dashboard for LD
    b. Testing of the prototype in a validation test to evaluate how it fits to the needs of the target groups (teachers and students).

After the first design of the tool redesign is done in two incremental steps to add run-time usage and the possibilities to exploit the metacognitive competences:

- Tool redesign: effect of the dashboard on Learning Design during run-time.
    a. Adjustment of the prototype based on the results of the validation tests from substudy 1.
    b. An experiment will be conducted to measure the effect of the LA Dashboard with regard to Learning Design and run-time actions of students and teachers.

Insight in the differentiation of run-time feedback versus design-time feedback is needed to see effects of the run-time usage of the tool. And if there are differences in metacognitive competences needed to understand the learning dashboard. This substudy is set up to give insight in sub research questions 4 and 5.

Substudy 3: Addressing metacognitive competences in a LA for LD solution.

Based upon the design of the tool at this point an analysis is made of the necessary metacognitive competences for teachers and students at Zuyd HBO-ICT. A solution that addresses the metacognitive competences is designed.

- Tool redesign: effect of the dashboard and solution for bridging competences gaps
    a. Adjustment of the prototype based on the results of the experiment in iteration two
    b. The metacognitive competences of users (teachers, students) needed to use the Learning Dashboard for Learning Design run-time are identified.
    c. Required trainings, methods or tool adjustments for the target groups will be suggested to effectively use the LA dashboard.

In this substudy insight is gained to answer sub research question 6.

Substudy 4: Evaluation of the Learning Dashboard and insight in interventions and behavioral change.

In a Zuyd HBO-ICT course the LA for LD solution is used and evaluated. In thinking aloud sessions

and focus groups the action of teachers after using the Learning Dashboard are studied. How do teachers and students act on the information provided? This substudy answers sub research question 7.

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Issues/problems in your dissertation, feedback that might be particularly useful

- I am very interested to know if there are any running but not published studies (planned) to investigate behavioral change of students or interventions of teachers based upon learning analytics tools?
- Are there any tools/apps/websites/instruments available and used to monitor students moods during/after a learning activity?
- Are there alternatives for the MSLQ instrument that illustrate student motivation, strategy for learning and has a metacognitive scale that isn't as big (81 items) so that students are going to use it. I am aware that the MSLQ can be used per scale. I am curious about any alternatives that are in use?

List of members of ECTEL 2017

I think that all of the persons on the programming committee can help me further in my research. People like Hendrik Drachsler and Wolfgang Greller are already contributing in my research. People like Paul Kirschner and Marcus Specht are working in the direct neighbourhood of our institution so a connection can be made at home.

Possible others who I would really appreciate to meet:

- Dragan Gasevic
- María Rodríguez-Triana
- Yishay Mor

I find it difficult to point out more experts that are in the Program Committee and hope to meet a lot of them at the conference.