

Doctoral Dissertation

Personalized Learning Analytics Intervention  
for Enhancing E-Book-Based Learning

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## Abstract

The application of big data in education has been recognized as a promising research field, and used to facilitate other research fields such as learning analytics (LA) and educational data mining (EDM). Accordingly, approaches based on the application of LA and EDM have been widely used to analyze interaction between the students and online learning systems and provide intervention for certain educational contexts. With the increasing popularity of digital technologies and LA techniques, researchers have applied various LA intervention approaches in online learning environments to target at-risk students and to provide effective and timely learning support for students to achieve the desired learning goals, improve course participation, and enhance academic outcomes. However, most of the existing intervention models focused on instructional feedback and lacked of providing actionable and interpretable feedback. Moreover, in addition to academic performances, indicative measures of student engagement of online learning are needed to examine the pedagogical impacts of such intervention models on students' academic success in an online learning environment. These measures should be adaptable to the unique challenges to learning in a specified context, such as an online learning environment.

To address the issues mentioned above, in this thesis, we first conducted two exploratory studies for identifying e-book learning indicators that positively affect the students' learning achievements. In the first exploratory study, we applied data analytic methods using the LA and EDM approaches to identify subgroups of students with various learning patterns utilizing an e-book. The aim of the study was to analyze 113 students' behavioral data while using an e-book for learning support. A clustering approach was employed to identify subgroups of students with different patterns of e-book learning behavior. Moreover, a statistical analysis was performed to investigate the associations between the identified subgroups of students and their learning outcomes from the course. The findings of this study provide educators opportunities to predict students' learning outcomes by analyzing their online learning behaviors and providing timely intervention for improving their learning experience, which achieves one of the goals of learning analytics as part of precision education. Next, in the second exploratory study, to further understand learners' interactions with the note-taking systems (e.g., e-books), lag sequential analysis (LSA) was applied to analyze 88 learners' e-book behavioral data collected in an online learning environment. Moreover, the difference between higher-

and lower-achievement learners in terms of their sequential behaviors of e-book note-taking was revealed and discussed. This study can help educators provide evidence-based educational feedback to learners regarding the identified sequential patterns of e-book note-taking that can be applied as effective strategies in online learning.

The identified indicators were then used to design and provide actionable and interpretable feedback through personalized LA intervention that integrates the features of an e-book and a recommendation system. The proposed intervention model applied association rule mining to explore the associative connection between the students' levels of behavioral engagements of each knowledge component (built by the teacher) and their learning achievements in the online learning course. Accordingly, the proposed approach aims at providing students with personalized recommendations of remedial actions as a way of intervention for them to take and strategically engage more in using the e-book and avoid failing the online learning course. To examine the pedagogical impacts of the proposed intervention, a quasi-experimental designed was conducted in an Accounting Information System graduate course that implemented an e-book as the tool for teaching and in-, out-of-class learning in the online learning environment. 45 students from one class were regarded as the experimental group and learned with the proposed personalized LA intervention approach, in which they used the e-book and the recommendation system to view online learning materials and receive personalized recommendation of remedial actions to take and strategically engage more in using the e-book, respectively. On the other hand, 42 students from another class were regarded as the control group and learned without the proposed LA intervention approach in the online learning environment, in which they only used the e-book for viewing the given online learning materials. Students' behavioral engagements of online learning measured by e-book learning logs and their learning achievements in the course were analyzed to better understand the significance of the proposed approach. The experimental results offer pedagogical insights into the formulation of LA intervention approaches in the online learning environments for those higher education institutions which are aiming at practicing LA intervention approaches to support teaching and learning experiences in similar contexts.