LEARNING ANALYTICS BASED INTERVENTIONS: A SYSTEMATIC REVIEW OF EXPERIMENTAL STUDIES

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ABSTRACT

Learning analytics includes interventions that will support learning and improve learning environments. Despite the fact that learning analytics is a promising field of study, the lack of empirical evidence on the effects of learning analytics-based interventions has been widely addressed in recent years. In this context, insights validated by experimental studies may play a crucial role. Therefore, there is a need for a report describing the methodological aspects and effects of current experimental interventions based on learning analytics. This systematic review provides an in-depth examination of learning analytics research that reports experimental findings to evaluate learning analytics-based interventions. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 protocol provided the basis for the work of this systematic review. This review contained 52 papers that met the inclusion and exclusion criteria. The results show that student-facing dashboards are the most common learning analytics-based intervention. Evidence from how user data is handled for interventions demonstrates that the most common method is the distillation of data for human judgment. This study confirms that a significant proportion of experimental studies employing learning analytics interventions have demonstrated significant effects on learning outcomes. The effectiveness of learning analytics-based interventions is also addressed in this review in terms of motivation, engagement, and system usage behaviors. The findings of this study will contribute to the literature in terms of describing the experimentally validated findings of learning analytics-based interventions in depth.

KEYWORDS

Learning Analytics, Intervention, Educational Data Mining, Experimental Studies, Systematic Literature Review

1. INTRODUCTION

Online learning environments have become increasingly prominent over the past years. However, these environments work in favor of autonomous learners, in other words, self-directed learners (Schumacher and Ifenthaler 2021). Even if online courses in which includes are based on a well-structured instructional design, these environments are disadvantageous for learners who do not take responsibility for their own learning (Toro-Troconis, Alexander, and Frutos-Perez 2019). Therefore, such learners need guidance in online learning environments. Studies emphasizing guidance in these environments form the basis of learning analytics conceptualized for the first time in the previous decade.

A considerable number of systematic reviews on learning analytics have been conducted because it is a relatively new but promising field of study. Some of these reviews were broader in scope, focusing on learning analytics or learning analytics dashboards in general (Bodily and Verbert 2017; Viberg et al. 2018). These studies have demonstrated the current state of the methods, trends, or challenges in learning analytics research. It's also quite frequent for reviews to concentrate on a particular issue or aspect of learning analytics rather than presenting a general overview. For example, while some reviews focus on ethical and privacy issues (Bassani and Cazella 2021; Tzimas and Demetriadis 2021), some reviews focus on the study success factor (Ifenthaler and Yau 2020; Namoun and Alshanqiti 2020). In addition, literature reviews on studies emphasizing self-regulation—one of the key constructs of learning analytics research—were carried out (Matcha, Gašević, and Pardo 2019; Viberg, Khalil, and Baars 2020). Many reviews have also been published on predictive modeling, which is the widely studied methodological aspect of learning analytics research (Namoun and Alshanqiti 2020). Similarly, the number of reviews is increasing in parallel with the number of studies on multimodal learning analytics, which focuses on obtaining data from different sources in addition

to online learning environments (Crescenzi-Lanna 2020; Namoun and Alshanqiti 2020). Furthermore, some reviews have concentrated on studies including the application of learning analytics in the context of educational games (Alonso-Fernández et al. 2019; Daoudi 2022).

In summary, even as some reviews provide a broad overview of learning analytics or specifically learning analytics dashboards, some reviews focused on specific issues such as methodological aspects, data gathering sources, or pedagogical constructs. These reviews made significant contributions to our knowledge of learning analytics research. To the best of our knowledge, no published reviews in the broader sense have only focused on the experimentally controlled effects of learning analytics interventions. Analyzing research using experimental designs may be the most effective way to determine the validity of the effects of learning analytics applications on learning outcomes. Therefore, the goal of this systematic review is to do an in-depth examination of experimental studies that include interventions based on learning analytics. The following research questions were formulated to guide the systematic review:

1. What learning analytics-based interventions are employed in research on learning analytics?
2. What are the (methodological) features of learning analytics-based interventions?
3. What are the outcome variables associated with learning analytics-based interventions?

2. METHOD

The PRISMA 2020 protocol outlined by Page et al. (2021) provided the basis for the work of this systematic review. Due to its widespread endorsement and adoption, this study was conducted based on this protocol. Considering the wide variety of fields in which LA might be developed and/or applied (e.g., psychology, education, computer science, and business), a diverse range of journals was examined. Thus, four well-known databases were selected without filtering for specific journals and/or research categories: ACM Digital Library, ERIC, ISI Web of Science, and Scopus. Hereby, a total of 375 papers (after removing duplicates) were obtained by running the following query: "learning analytics" AND experiment*. A literature search was conducted in each database on the first week of July 2022.

The following inclusion criteria were used: Studies had to (1) employ one of the experimental study designs, (2) utilize learning analytics as a part of the intervention, (3) be written in English, (4) be full-text available. Consequently, 52 studies were considered for further analysis within the scope of this review.

Following the screening process, the relevant information from the papers was extracted and organized in a spreadsheet. Two phases were involved in the coding procedure. Phase 1 concentrated on gathering descriptive data for each paper such as authors, year of publication, country, and sample size. In the second phase, details regarding learning analytics-based experimental interventions such as data analysis techniques and affected output variables were extracted in order to answer research questions.

3. FINDINGS

3.1 Descriptive Findings

The results of this study show that more than half of the experimental studies based on learning analytics interventions (n=30) have been published as of 2020 (Search date: July 2022). On the other hand, there are only two published studies before 2016. Computers & Education (n=4) is the journal that publishes the most studies. This is followed by the Journal of Computer-Assisted Learning and the Educational Technology & Society with 3 studies. International Conference on Learning Analytics Knowledge (LAK) (n=6) is the conference series that publishes the most proceedings. This is followed by IEEE International Conference on Advanced Learning Technologies (ICALT) with 4 studies.

3.2 Main Findings

RQ1: What learning analytics-based interventions are employed in research on learning analytics?

Among the learning analytics-based interventions, the most used one is student-facing dashboards (n=18). This is followed by instructor dashboard (n=14), automated learning analytics-based feedback (n=11), personalized feedback/recommendations (n=11), personalized static reports or visualizations (n=7), personalization of learning materials (n=6), real-time progress information (n=3), personalization of assessment (n=1).

RQ2: What are the (methodological) features of learning analytics-based interventions?

This study reports both the study group of the research and the user group of the learning analytics-based intervention. According to the study group findings, 75% of studies were conducted with undergraduate students. This is followed by K-12 students with %13,5, and teacher/lecturer group with %11.5.

Although nearly 90% of studies involving learning analytics-based interventions consider their impact on students, some of the interventions are presented via teachers. Thus, this study concludes that half of learning analytics-based interventions are provided directly to the learner. In addition, the findings show that 36.5% of interventions are provided to teachers and 11.5% are provided to both user groups.

The results of the study show that more than half of the studies (n=30) have less than 100 participants. The proportion of studies with sample sizes of 100-300 is 25%, while the proportion of studies with sample sizes of 300-1000 is 15%. There is only one study was conducted with over 1000 participants.

The findings on how user data is processed for interventions demonstrate that the distillation of data for human judgment (n=36) is the most used approach. This is followed by prediction (n=13), relationship mining (n=6), clustering (n=5), discovery with models (n=5).

RQ3: What are the outcome variables associated with learning analytics-based interventions?

This review reveals that learning outcomes (n=32) are the variable for which the effects of experimental studies based on learning analytics interventions are most studied. User reflections, in which learners express their views on the proposed system, take second place with 12 studies. This is followed by motivation (n=8), engagement (n=7), system usage behaviors (n=6), and teachers' performance monitoring (n=5).

Experimental results prove that learning analytics-based interventions significantly increased teachers' performance monitoring in all studies. Engagement is the second variable significantly affected by the interventions with %86, and system usage behavior is the third variable with %83. This study also reveals that motivation and learning outcomes are variables that are significantly affected by interventions in 3 out of 4 studies.

4. DISCUSSION AND CONCLUSION

This systematic review provides an in-depth examination of learning analytics research that reports experimental findings. Despite the fact that learning analytics is a promising field of study, the lack of empirical evidence on the effects of learning analytics applications has been widely addressed in recent years (Larrabee Sønderlund, Hughes, and Smith 2019). In this context, insights validated by experimental studies may play a crucial role. Therefore, there is a need for a report describing the effects of current experimental studies based on learning analytics interventions.

This review concludes that a very limited number of experimental studies were conducted in the first 5 years of learning analytics, which was first conceptualized in 2010. On the other hand, the fact that a significant part of the studies has been published in the last 2.5 years implies that the use of experimental designs in learning analytics research has gained momentum. However, until just a few years ago, it was frequently emphasized in many studies (e.g., Mah, Yau, and Ifenthaler 2019; Matcha, Gašević, and Pardo 2019) that learning analytics applications lack experimentally validated findings. On the contrary, the results of this review have been a confirmation of the increasing momentum in experimental studies in learning analytics research.

Meso-level and micro-level analytics are applications that provide information to students and instructors, whereas macro-level and mega-level analytics are large-scale and provide information to institutional or policymakers (Ifenthaler and Widanapathirana 2014). Therefore, it can be induced from this review that the existing experimental studies based on learning analytics interventions are meso-level and micro-level analytics applications.

This review validates that a significant proportion of experimental studies employing learning analytics interventions have shown significant effects on learning outcomes. The effectiveness of learning analytics-based interventions in terms of motivation, engagement, and system usage behaviors is also highlighted in this review. Therefore, it can be concluded that learning analytics are quite effective for intervening in the learning experience, without considering the quality of the reviewed experimental studies. The outcomes of this review will add to the body of literature by thoroughly describing the experimentally validated findings of interventions based on learning analytics.

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