Learning Analytics and Adaptive Instructional Design Strategies

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Abstract — Learning analytics is referred to the measurement, collection, analysis, and reporting of information about learners and their contexts for the purposes of understanding and optimizing learning. In recent years learning analytics has emerged as a promising area of research that traces the digital footprint of the learners and extracts useful knowledge from educational progress databases to understand students' and performance. As the amount of data available to the educators is increasing exponentially, the potential benefits of learning analytics can be far-reaching to all stakeholders in education, including students, teachers, leaders, and policymakers. Substantial numbers of investigations in learning analytics have been conducted and reported the strategies, techniques, and approaches on this topic in the literature. This paper examines the recent attempts to conduct systematic research highlighting the current trends, creative and unique approaches in learning analytics, and presents their findings and suggests improvement in instructional design.

Index Terms—Learning analytics; student performance; instructional design

I. INTRODUCTION

Instruction design is defined as a systematic procedure involved in development of teaching and training programs and materials with the focus on maximizing learning. A number of theoretical models for systematic design for learning have been developed in the past several years. The earlier model, such as ASSURE has been in use for teaching and training contexts for several years. The acronym ASSURE represents the steps involved in designing, developing and evaluating the instructional programs. The steps involve in this model are analyzing the learner characteristics, stating the objectives, selecting, modifying, and designing materials, utilizing the materials, requiring the learner response and evaluating the outcomes [1]

Another model employed in instructional design is ADDIE framework. The ADDIE stands for analyze, design, develop, implement, and evaluate. The educators and trainers find this model useful because the framework guides them to clearly follow the stages for effective implementation of teaching and training methods, tools and materials. In both models, it is evident that analyzing the learner characterizes is the key to successful learning [2], [3].

II. LEARNING ANALYTICS

The term Learning Analytics is referred to an educational application of web analytics to discover students' profiles, learning patterns, their activities, and interactions for the purposes of understanding and seeking ways for the improvement of learning. In recent years, the contributions of learning analytics have been discussed in the educational research community. Most educators agree that learning analytics can facilitate evaluation of the effectiveness of pedagogies and instructional practices. Some suggest that learning analytics has the potential to contribute to the quality of teaching and learning by designing innovative and adaptive lessons to suit the individual students' cognitive abilities. The Learning Management Systems (LMSs) that combine content delivery, discussion forums, and quiz and assessment allows to monitor students' learning activities, and from the analysis, the instructor can detect the students at risk and undesirable behaviors. Once the issues are identified, the instructor can provide remedial solutions to support the students and help increase the level of achievement.

III. SUPPORTING LEARNING

Six aspects that learning analytics can support to improve the education process have been classified [4]. These are (i) improving student retention, (ii) supporting informed decision making, (iii) increasing costeffectiveness, (iv) understanding students' learning behavior, (v) arranging personalized assistance to students, and (vi) providing timely feedback and intervention.

A. Student Retention

In educational settings detecting early warning signs for students who are coping with their study can be an advantage for the instructors. The issues and problems that students are facing may vary from social and emotional issues to academic matters or other factors that may lead to giving-up from the study. Those students can be provided with remedial instructions to overcome some of the problems. It was reported that knowing the

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circumstance and understanding the causes, an instructor can increase the interaction with the students to provide personal interventions [5]. As a result, the students showed better academic performance and significantly increase the retention rate. Similar study describes that increase interactions with students promote a sense of belonging to the learner community and learning motivations [6]. It was found that in the process, the students' attrition rate dropped from 18 to 12%.

B. Informed Decision Making

The results from learning analytics can also be used to support informed decision making. A study at the Open University in the UK involves analyzing the learning designs of 157 courses taken by over 60,000 students and identify the common pedagogical patterns among the courses. The authors suggest that educators should take note of activity types and workload when designing a course, and such information will be useful in the decision making of specific learning design. However, the authors conclude that further studies are needed to find out whether particular learning design decisions result in better student outcomes [7].

C. Cost-effectiveness

With the funding cut and raising expenditure, costeffective has become the key indicator of sustainability in the education sector. One of the effective ways is to take advantage of the learning management systems that not only deliver the course materials, also keep track of the learners' activities. Instructors can analyze the activities and report the progress to the students and other stakeholders in a cost-effective manner. After conducting the analysis, notifications were automatically generated and send to students and their parents on students' performance.

D. Students' Learning Behavior

To better understand the students' learning behavior, instructors can explore the data collected from the learning management systems and social media networks. Instructors can examine the relationships between students' utilization of resources, learning patterns and preferences, and learning outcomes. This approach has been adopted by [8] when attempted to examine the collaboration and social networking in a subject for education degree course. The study analyzes the intensity and relevance of the student's contribution to the collaborative framework by using social network analysis and information extraction. The authors concluded that findings from the study help to understand more clearly how students behave during the course.

E. Personalized Assistance to Students

Given the advantages of data mining techniques and algorithms that are used in business and manufacturing industry, learning analytics has emerged as educational data mining of students and the courses they study. An investigation into the application of such technique in education domain was conducted by [9] to discover the insightful information about the students and interaction with the course. They report that after analyzing the students' study results, demographics, and social data, instructors can identify who needs assistant most to provide individual counseling.

F. Timely Feedback and Intervention

Providing feedback to students is a central role of teachers in any educational settings. This process enables students to learn from their action and can have a significant impact on the motivation of the learners. The quality and timeliness of feedback are crucial in the learning process. From the learning analytics, teachers can identify students who are in need of assistance and provide appropriate intervention to the specific students. Interventions through emails to the students work best and found that such approach impact on student achievement [10].

Similar to business forecast, ability to predict students' success can be a powerful practice in all levels of education. There is such a possibility to predict student performance with the use of advanced learning analytics. In their study, a wide-ranging background and personal data that includes students' household family expenditure, family income, students' personal information such as gender, marital and employment status, and the family assets are collected. By using discriminative and generative classification models, the authors can predict whether a student will be able to complete the course [11].

IV. EMERGING TRENDS

Many investigations on learning analytics have been carried out and disseminated in the literature, and studies related to learning analytics are growing rapidly and cover wide range of disciplines. The emerging trends in learning analytics and leveraging the power of education were presented in the recently published book [12]. The following paragraphs describe synopsis of selected chapters included in the book.

It was noted that Learning Analytics (LA) in higher education is maturing, but the studies still tends to focus more on predictions than interventions [13]. The author argued that there is a need to use multiple ways to engage the students. Their chapter focuses on the findings of one institution's use of several "built and bought" learning analytics solutions. It was found that Learning Management System (LMS) activity can serve as an alternate for engagement throughout a term, providing direct feedback to students about their own LMS behavior. This raises their self-awareness and responsibility for learning as well as identifying at-risk students by the faculty members. By using the data from LMS, course designer can provide intervention with adaptive learning options.

Learning analytics tools and dashboards focus on user interaction data to support learning processes through visualizing learning traces and produce interventions in the context of teaching and learning [14]. In the past decade, researchers have developed a considerable number of learning analytics tools, and various studies examined these tools to evaluate their features. However there are limited studies that explore predictive and prescriptive learning dashboards in real-life settings. Their chapter focuses on the current state of the art of learning analytics tools within the scope of design and pedagogical features. The chapter is organized into three parts. The first part focuses on comprehensive concepts of learning analytics field as interaction data, learning dashboard, intervention, and actionable knowledge. In the second part, the authors introduce a prescriptive learning dashboard, which visualize interaction data and how to offer personalized support for learners in their learning journey. In the final part, the authors present their work developing and utilizing the learning analytics tools in terms of its design and pedagogical features. The chapter concludes with suggestions for research on developing and utilizing learning analytics tools in learning and teaching contexts for researchers, instructional designers, and course instructors.

Another chapter in the book describes that increasing numbers of students who have been vulnerable or disadvantaged in the past are accessing higher education in Australia [15]. The author notes that the increasing use of technology in learning, such as LMS has produced valuable data through learning platforms. Institutions are exploring to gain insights about individual students and their engagement with the learning materials. By analyzing the student learning data, institutions are able to predict academic risks and successes by using a range of measurements such as profile, background, barriers, expectations, use of online technology, use of resources, attendance, and performance. The data obtained from these measurements can be used for profiling and improving trends in student engagement and success, particularly for the vulnerable students.

The authors in "Discourse analysis visualization based on community of inquiry framework" noted that dialogue analysis is one of the important perspectives for the evaluation of collaborative learning online. It is necessary to conduct dialogue analysis based on collaborative learning theory to understand the complex interactions among learners [16]. Their research aims to investigate the effects of a dialogue visualization tool for collaborative learning, based on the "Community of Inquiry (CoI)" framework, which enhances online collaborative learning experiences. The CoI framework consists of three elements: social presence, cognitive presence, and teaching presence. The first element, social presence, is regarded as a necessary precursor for creating a secure environment for interpersonal communication in order to facilitate an open environment conducive for discussion. The second element cognitive presence is defined as "a vital element in critical thinking." The last element teaching presence is considered as the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful learning outcomes. The authors developed and evaluated a dialogue visualization tool using text mining technology, focusing on social presence and presented the results. It was found that this dialogue visualization tool affords learners and teachers to

understand the quality of the interactions in groups and indicate the level of the engagement of collaborative learning.

The authors in "A snapshot of research on learning analytics: A systematic review" repeat the importance and value of learning analytics in the e-learning settings by examining the studies conducted in recent past [17]. They argue that e-learning platforms can be improved through the application of learning analytics. They provide a detailed analysis of what e-learning analytics means, its scope, and benefits to online instructors, systems developers, and administrators. They also suggest ways to enhance the quality, effectiveness, and some practical hints on privacy and security issues in learning management systems and learning analytics. The authors made reference to the Moodle data from one of the universities and presents how such data can be used to provide better learning experience for the students. The chapter concluded with the remark that customization of online platforms can be done with analytics, and students can benefit from adaptive learning environment.

The research on learning support system based on cohesive learning analytics aims to develop and evaluate the effects of visualization tools for learning behaviors on online learning environment [18]. The authors argue the importance of analyzing students' learning activities in both in-class and out-of-class contexts. They suggest that recent learning analytics research tends to focus on development of learning analytics tools, and it is crucial to conduct cohesive learning analytics research based on well-defined educational and learning theories.

The authors conducted investigations about the relationships between learning behaviors data recorded on learning management systems, self-regulated learning theory, and learning patterns outside a class that promote learning student's academic achievement. The team developed the tools for supporting learning and teaching both inside and outside a class to enhance the learning awareness and performance. These consist of (i) a visualization tool to trace the overview of learning activities through a course; (ii) automatic summarization of learning materials to promote the preview; (iii) realtime analysis to understand students' behaviors during a class, and (iv) learning journal analysis to discover student's situation of learning and self-reflection after a class. The results showed that these visualization tools effects on the improvement of learning have environments and students' learning performance.

Jo [19] recognized that flipped learning is a recent educational innovation. According to Jo, instructors can take full advantage of self-paced, digitalized pre-study, and interactive face-to-face primary instruction. Flipped learning aims to achieve instructional objectives of higher-order thinking efficiently and effectively. The notion of flipped learning is to make sure learners master the prerequisites of face-to-face sessions during the online pre-study. By allowing more study time for individuals falling short of the requirements for the faceto-face meetings, learners can make themselves, at least theoretically, be equipped with enough skills and knowledge for the following interactive instructional phase such as project- or problem-based learning activities. However, it was noted that instructors often face the problem when they discover significant differences among learners in terms of the degree of readiness of the prerequisites. And without detailed information on individual learner's learning behaviors. instructors may not be able to construct collaborative teams with maximum diversity and productivity, which are critical success factors in highly interactive teambased learning such as PBL. In this chapter, the author argued that learning analytics could be a solution to the flipped learning in two ways, by providing online nudges to help at-risk learners to catch-up, and by giving individual learners' behaviors and psychological characteristics to inform the instructor of a face-to-face session. Related theories and case studies with ethical and technical issues are discussed in this chapter.

The chapter by Schumacher, Klasen, and Ifenthaler [20] focuses on the implementation process of a learning analytics system, LeAP (Learning Analytics Profile) into a higher education environment from a pedagogical and information technological perspective. The authors noted that implementing learning analytics in higher education is impacted by several factors. These include students' willingness to reveal personal data, instructors' tasks to prepare a variety of learning materials and their potential lack of knowledge about analyses and the suggesting appropriate interventions, the institutions' responsibility to make the resources available for integrating learning analytics into IT-infrastructure, as well as administrative challenges of institutional change. The authors argued that learning analytics should be linked to learning theory and support students' learning processes by offering automated and personalized interventions together with providing instructors with information about the potential difficulties that could be faced by their students. The chapter introduces the decision-making process for identifying relevant features based on empirical evidence and grounded on learning theory. It also suggested considering costs associated with information technology infrastructure and other organizational requirements. The chapter concluded with recommendations for further research and implications based on the case study.

V. CONCLUSIONS

From the above-mentioned studies, it is evident that findings from the learning analytics are valuable and information can be used to improve the instructional design in both face-to-face and online delivery modes. There is much to benefit from these data for teachers and students. For teachers by looking at the students' study patterns and achievement, improvements can be made in design of instruction to suit the characteristics and level of the students. For students by reflecting their activities, study habits can be adjusted to maximize the learning [21]. As the technology develops, more advance analytics can assist teachers, faculty member and trainers in design of learning in all disciplines [22].

CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHOR CONTRIBUTIONS

MSK conceived of the idea, conducted the literature search, performed analysis and synthesis and prepare the manuscript.

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