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Exploring E-Learning Through the Lens of Learning Analytics*

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Abstract. Through the past couple of years E-Learning has been one of the most active educational technology fields gaining a growing attention after showing an entirely new level of possibilities for knowledge transfer. Certainly, using such technology comes with its own challenges, and treating the massive amount of learner's data is on the top of the list, giving room for the emergence of Learning Analytics as a novel set of approaches to latch and process educational data. Learning analytics techniques came as a specific manifestation of a larger leap toward an algorithmically dominated world, and their ramifications for education and especially in an E-Learning context must be carefully considered.

A general summary of Learning Analytics techniques, the innovations they brought and how they can be exploited to enhance pedagogical practices in educational systems, as well as some of their concerns and challenges, will be the major topic discussed in this paper, with a heavy emphasis on their applications in E-Learning environments. In addition to that, we marked off some of the core motives behind the integration of Learning Analytics techniques in the E-Learning domain, core limitations leading to new perspectives and assumptions built into E-learning powered by Learning Analytics' environments. In this perspective, recommender systems, customized feedback, and real-time interventions are significant issues in E-Learning systems and potential research fields, and we may handle present challenges while also paving the way for future growth by employing Learning Analytics approaches.

Keywords: E-learning · Learning Analytics · Big Data · Data Mining · Educational Data Mining.

1 Introduction

While dealing with learners' data is nothing challenging for tutors especially if they are relying on some sort of data systems, the explosive amount of data

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generated daily due to the wide spread of E-Learning programs and their applications. For higher education only in the United states, the number of students taking online courses reached 6.7 million students [1], which raised the bar for conventional methods and exposed an unseen gap in how to collect, organize, measure and analyze educational data that aims to advise and optimize teaching and learning experience. Moreover, to assist instructors in determining students' learning requirements and improving pedagogical techniques [2].

Providing and advising on learning, as well as assisting teachers in assessing students' learning requirements and improving pedagogical practices, these main incentives were what pushed the development of Learning Analytics researches as a set of data analysis techniques used to inform decisions made at all levels of the educational system [3]. In fact, the Learning Managements Systems (LMS) present the pillar of these learning analytics researches.

LMS usually capture a large quantity of user data when learners complete E-Learning programs [4]. To find patterns and insights to solve issues, this data may be sorted, filtered, and examined. In other words, Learning Analytics refers to the use of Big Data to improve online learning, as these metrics might be quite beneficial to learning institutions [5], especially after the growing pressure urging them to evaluate student experience using the data, they generate so that learning can be tailored to the requirements of individual students and student achievement may be forecasted for future planning efforts. Furthermore, retention and student support, particularly for at-risk students, are some of the earliest applications of learning analytics [6].

Unfortunately, according to [7], tutors in educational institutions are frequently dubious of the politics and efficacy of learning analytic techniques, and often reject their deployment via their academic E-Learning practice. [7] also stressed the need of looking at how Learning Analytics technologies alter activities outside of the classroom, as well as how they affect curriculum and pedagogy.

Regardless of the academic level, there are several educational difficulties that include all participants in the teaching and learning processes [8]. Several studies were conducted exposing the efficiency in which Learning Analytics could tackle these issues, from those we can mention: whittling down the massive amount of data on E-learning platforms [9], customizing support for students based on their generated data [10], challenges of collaborative learning among students on E-Learning platforms [11], support students going through learning difficulties performance [12]. The academic personnel will also gain several benefits such as understanding and interpreting students' behavior patterns [13], the creation of a better appropriate contents to accommodate learners [14], enhance the design of new effective interventions to deliver a precision education [15], provide access to information for monitoring and evaluating the activities and interactions of online students [16].

In light of these circumstances, and the fact that multiple research evaluations show the promise for learning analytics in other educational contexts, including higher education, professional and workplace learning, vocational education, and massive open online courses [17]. This paper gives a thorough overview of the

literature on Learning Analytics applications in various E-Learning contexts. furthermore, this study will be offering a general overview of the primary tutoring objectives, approaches, strategies, and issues associated with learning analytics and E-Learning.

The paper will be structured as follow: first we will be providing a brief background on Learning Analytics, tailed with some previous literature reviews discussing benefits and concerns resulting from the incorporation of Learning Analytics techniques into E-learning environments, the next section will be devoted to trending approaches of Learning Analytics and the way in which they can be utilized to improve E-Learning experience, from both teachers and students' standpoint, finally we conclude this study by discussing potential limitations and how they can be dealt with through future works.

2 Background knowledge

In order to understand how the educational system can be improved, this section presents the definition and the essential concepts of the E-learning domain.

2.1 The E-learning and the educational system

Nowadays, the evolution of the computer science, the psychology and the education fields as well as the phenomenal growth of the Information and Communication Technologies (ICT) and the Internet give the computational teaching environments an excellent choice for Distance Learning. In fact, there has been a significant increase in the number of tools and mechanisms available for the implementation and support of such category of education [18].

In this context, distant education and ICT technologies have altered the nature of student learning and perception in comparison to traditional educational teaching systems. Today, knowledge is viewed as something socially constructed via students' activities, conversation, and reflections. The traditional method dedicated for education on knowledge transfer has evolved into a model of practical experimentation and interaction that fosters changes in ideas and students' strategies until he achieves competency. Teachers, rather than providing knowledge, play the function of supporter in this setting. However, the evolution of the distance learning has showed a great capacity of integrating new technologies successfully for enhancing such classical learning methodologies. In a nutshell, the essential aspects that characterize the theories of Distance Education is physical separation between teachers and students.

Definition 1 (The E-learning): The E-learning is basically referred to *an online learning or electronic learning, is the acquisition of knowledge which takes place through electronic technologies and media. In simple language, e-learning is defined as "learning that is enabled electronically".* [19]

The E-learning as is defined in the first definition gains benefits from both distance educations as well as the use of innovative ways and instruments for organizing, communicating, and transmitting educational information to ensure a high level of student comprehension. In this case, five fundamental elements are required for a successful Online-Distance-Education program (E-learning) [20]:

- Contact between teacher and student,
- Active learning through student's answer,
- Fast feedback to the teacher about the student understands level,
- Fast feedback to the student about his performance,
- The student has the opportunity to review and learn through his own mistakes,

After establishing the position of online learning (E-learning), during the next section, we will go deeper into additional basic topics ranging from the types and technologies of E-learning towards its interactive tools.

2.2 The Types and the technologies of the E-learning

E-learning has evolved in a variety of ways during the last several years. The most common forms of e-learning alternatives accessible today may be divided into three categories [21]:

Web-Based Learning: In corporate training, technology is generally deployed to provide knowledge to the final user without any kind of engagement with training experts, peers, or management.

Supported online learning: The majority of a higher education course's content may be delivered through lectures or distance education textual material, but the course is classified as E-learning because the interaction with the instructor, dialogue with other students, and searching for resource materials are all done online.

Informal E-learning: Beyond these 'course-based' methods to E-learning, there are significant potential for technology to help informal learning in the workplace. In many knowledge-intensive institutions, it is related with knowledge management based on course material, interactive and cognitive engagement of students.

This variety of E-learning categories are principally related to a wide range of technologies and materials (e.g., blogs, collaborative software, text chat, virtual classroom. . . etc.) [22]. These technologies can be classified according to their distribution medium (text, audio, video, picture, links, etc.) or by their interaction tools, which will be discussed in the next part.

2.3 The E-learning interactive tools

There are 2 kinds of E-learning environments dominating the academic systems in today's world [23]: synchronous and asynchronous.

Synchronous E-learning: Synchronous e-learning entails online learning using chat and videoconferencing. This type of learning tool operates in real time. It is similar to a virtual classroom in that students may ask and teachers can respond questions quickly via instant messaging, which is why it is termed synchronous. Students that use synchronous E-learning software or online courses may readily communicate with their classmates and professors during the course, as opposed to taking classes alone.

Asynchronous E-learning: Asynchronous learning, on the other hand, can take place even when the learner is not connected to the internet. Asynchronous E-learning consists of coursework given over the web, email, and message boards, which is subsequently posted on online forums. In such instances, students should ideally finish the course at their own pace, utilizing the internet just as a resource rather than volunteering only for E-learning software or online interactive lectures.

Subsequently, knowing the behavior of the learners is a vital piece (and a huge challenge!) of E-Learning platform design. In this manner, we must create an E-Learning experience that offer the most benefits to learners and ensure that every component of the E-Learning course aids them in accomplishing their aims and goals. Learning analytics is one of the most efficient ways to make use of this priceless data. But why are learning analytics so crucial in E-Learning, and how can they help instructional designers become more effective? The next part delves deeply into the answer to these two questions.

3 The Learning Analytics crosses E-learning

The Learning Analytics are one of the pillars of an adaptive and customized E-learning platform, this section presents the importance and the pivotal role of such approaches in the E-learning.

3.1 The Basics of Learning Analytics:

Learning Analytics are, in essence, the gathering of data acquired when learners are interacting with E-Learning. Analytics also includes the analysis and reporting of this data. In the case of E-Learning, crucial bits of data are kept during the course, such as learners' score on a certain test/exam, how rapidly they are advancing through a module, how many times they have checked in, if they have contributed in a discussion board, and so on [24,25,26]. Simultaneously, Learning Analytics provide online facilitators and instructors with a full

view of how a student is performing, if he or she may want further assistance with a certain lesson or subject, and even whether the learner is likely to pass or fail an E-Learning course. Such data may then be utilized to do educational analysis and forecasts, assisting in determining whether learning resources are acceptable, valuable, or irrelevant for the learners. This is mostly determined by the learner's performance, skill level, and personal interests.

In depth, the growth of interconnected databases in data centers and on clouds is opening up new pathways for higher education policy and learning sciences. As previously explained, Learning Analytics was defined in different ways and the most outstanding of those is the one provided by the Society of Learning Analytics Research back in 2011 during the first Learning Analytics and Knowledge Conference putting the cornerstone for this new surging science research field [27], which was defined as *"the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs"* [28]. Learners leave digital imprints all over the system within learning management systems as they browse and engage with their peers and the digital space, and Learning Analytics systems capture these behaviors, which are commonly referred to as 'digital breadcrumbs' [29]. Data visualization techniques can be combined with Learning Analytics tools to create information dashboards from which instructors can infer how to intervene in a student's education [30], some other platforms take a different approach by enabling students to track their own development using dashboards similar to those used by teachers [31]. Learning analytics has far more potential than just being a tool for data-intensive educational research [32], as fascinating as this would be. The new prospect is that for the first time, educators and learners will be able to see their own activities and achievements previously only available to scholars outside the system, depicted in forms as they were within [33]. The researcher's role in data collection, analysis, interpretation, and even engagement has shifted to integrated sociotechnical educational infrastructure.

As a result, the capacity to gather knowledge in a timely manner that could improve outcomes is of interest to both educators and students [34]. Moreover, the system becomes reflexive when individuals are in the analytic cycle because it is almost instinctive for people to alter their behavior and act differently if they feel that they are under surveillance [35], which also shed light on a lot of ethical problems [36], that could hinder the growth of several aspects across the domain. Modeling closed, deterministic systems give way to complicated pre-defined limit as the design challenge evolves [37,38]. As the design of educational systems varies according to the requirements each have to fulfil and that is also linked to several factors such as institutions' policy [39], How well-defined are the desired learning outcomes [40], if the goal of analytical feedback loops is to influence learner cognition and interaction [41], and so on.

3.2 Learning analytics crosses E-learning

Several writers discuss various approaches that can be used in learning analytics. From those, the strategies based on modeling and captivating learners' behavior to build rich and informative profiles are regarded as fundamentals. For instance, user profiling, domain modeling, user experience modeling, user behavior modeling, instructional principal analysis learning component analysis and user knowledge modeling were mentioned by [42] as a recommendation to be relied on when dealing with learners on E-Learning platforms, which can be of a huge advantage especially for those dealing with massive quantities of data in need of filtering and analysis.

Since learning analytics covers such a broad variety of subjects, and different subjects implies various requirements leading also to the need for different types of techniques to treat them, which [42] divided to four main axes: domain analysis, social network analysis, pattern analysis and trend analysis. Designing a comprehensive, well-presented and easy to absorb content for learners is the main concern for domain Analysis and its importance is amplified in E-learning systems where all is about the contents and courses' design.

Student interactions are not a trivial matter either, and because the amount of information that we can gather on them is very limited Social Network Analysis can be of a great help as a tool for students' assessment and monitoring.

Pattern Analysis techniques are a well-known and exceedingly depended on for tasks such as: behavior prediction and behavior profile modeling. Behavior students' Models could be a useful material for Trend Analysis to broaden teachers understanding about the interests of learners in order to offer them the best fitting motivations in order to increase their academic performance.

To Conclude, the most compelling reasons why learning analytics may improve E-Learning experience and help to design more successful E-Learning environments are [43,44,45]:

- Helps to predict the future learners' performance throughout the duration of the E-Learning course,
- Provides learners with a personalized E-Learning experience,
- Increase learners' retention rates,
- Helps to improve the design of more efficient E-Learning courses,
- Boost in cost efficiency of the learners,

4 Review and Discussions

This part is devoted to the presentation of Learning analytics methodologies in the E-learning, as well as a general discussion highlighting the perspectives in this topic.

4.1 Related works: Advantages, Challenges and Concerns

According to the table 1 and despite the recent research on the application of Learning Analytics on different academic levels, Learning Analytics is still

a new subject of study. Leaders, administrators, teachers, course creators and other educational stakeholders must become familiar with Learning Analytics methodologies and their implementation in the field [46]. The problems are few publications have consolidated prior research or offered a comprehensive review of difficulties surrounding the use of Learning Analytics in E-Learning context [47], despite the ostensible benefits of employing it.

Although Learning Analytics might help E-Learning platforms and programs deal with a variety of issues (e.g., students feedback limitation [48], the lack of motivation [49] and information on learners' emotional state [50]), it wasn't implemented consistently across establishments. This might be due to a lack of study on the context and potential of Learning Analytics in E-Learning, as well as a lack of participation from a wide range of stakeholders in the deployment of Learning Analytics technologies. As a corollary, bridging the gap between technical capabilities and actual tutoring-learning skills will be essential [51]. Following this scenario, it's critical to find case studies that show the real-world repercussions of an E-learning environment founded upon Learning Analytics bases [52]. Since the inaugural edition of the LAK conference more than a decade ago, A number of reviews of the literature on learning analytics have been released. From those, a part was inclined to focus on exploring the advantages' [53,54,55] space that Learning Analytics opened for various educational domains, others went a step further conducting experiments by developing platforms and dashboards powered by Learning Analytics techniques [56, 57] and studying their impact on different holders for pedagogical contributes [58].

On the other hand, some of studies attempt to synthesize the major methods and strategies used to enable Learning Analytics approaches to be fused into educational systems generally and E-learning specifically [59]. By going through all of these studies and reviews, one of the authors' principal conclusions was that E-Learning is undeniably a promising research filed more than ready for Learning Analytics emergence.

Furthermore, due to the significant effects of visualization aspect in steering the expansion wheel of applications in the E-learning field. Learning Analytics development took the visualization tint and a notable set of platforms exposed that already [60]. The focus of these studies is to illustrate recent E-Learning developments and methodologies to instill visualization element as one of Learning Analytic underlying principles, as well as to confront difficulties and future research lines, and how learning analytic visualization powered dashboards in practice could assist scholars and teachers on E-learning platforms, as well as the hurdles and future research lines.

It's also worth noting that the E-Learning context differs dramatically from the educational settings examined in earlier literature reviews. When it comes to E-Learning, learners are usually under different constraints than the ones they may be accustomed to in face-to-face traditional tutoring systems. For instance, the ethical part is one of the most controversial aspect due to the fact that Learning Analytics is fueled by the data collected from students' interactions with the provided content. Generally, the data quality resulting from E-Learning systems

can be deceptive even for Learning Analytics techniques and lack precision in many factors with emotional ones as the main concern. These constraints were the motives behind many attempts to come with innovations to counter these issues [61].

4.2 Discussion: Drawbacks and Perspectives

This paper overviewed concepts and techniques encompassing Learning Analysis, advantages and solutions offered by this emerging field of research to give solution to hindrances obstructing the progress and the development of E-Learning environment by supplying the sufficient and the most efficient support for stakeholders across the overall hierarchy of educational system regardless of their levels or motives. While there are various obstacles in the way of completely applying this notion, it has several significant implications for E-Learning that might revolutionize the online teaching-learning experience and disclose new opportunities for further developments in the field. The imminent wave of Learning Analytics will lead to tutors equipped with a data analyst' skills which will enhance their performance and assist them to get a deeper understanding of students and introduce more appropriate interventions.

All the prior advantageous points will not refute the fact that Learning Analytics in general and in E-Learning context specifically came with its own set of challenges and concerns, with ethical ones on the top of the list. In the edges of data collection and the rising privacy concerns, as a set of tools and techniques developed solely to be powered by collected data and reaching the purpose they were developed for by processing and analyzing hidden patterns in it, it was obvious since the beginning that Learning Analytics had to deal with ethical problems and experts of the domain are already working on putting in place standards and policies to limit potential malicious exploits of such data.

Commercial firms without doubts, have more sophisticated Learning Analytics tool sets than most educational institutions. Companies can build innovative and functional tools due to their short development cycles. This approach could work for E-Learning systems in higher education as well, but in the realm of Learning Analytics, excluding commercial data analytics companies is practically impossible. As a result, we should expect university research offices and other institutions to form major partnerships with commercial businesses in the near future, allowing them to adapt some of their strategies and employ them in an educational context. In this perspective, Recommender systems, personalized feedback, and real-time interventions are key themes in E-Learning systems and promising research sectors, and by employing Learning Analytics methodologies, we can address existing difficulties while also paving the way for future advancement.

Table 1. Researches of Learning Analytics: Advantages and Concerns

	Authors	Year	Research Type	Discussed Topics
Advantages	Bienkowski.al [42]	2012	research	Learning Analytics and educational data mining to improve teaching and learning
	Freitas.al [54]	2014	research	Increase retention by Learning Analytics means
	Park, Yo [12]	2015	research	support student utilizing Learning Analytics dashboard
	Colthorpe.al [62]	2015	research	Learning Analytics interventions efficiency
	Vigentini [9]	2017	research	overcoming data deluge with Learning Analytics
	Liu [10]	2017	research	Customize students support using data Analytics
	Pardo.al [41]	2017	research	Learning Analytics to spread customized feed
	Alhadad [33]	2018	review	Data visualization and Learning Analytics
	el Alfy.al [17]	2019	review	Learning Analytics in higher education institutions
	Zhang.al [11]	2019	research	Learning Analytics in Collaborative Learning
	Wang, lin [14]	2019	research	developing Systems for Children using Learning Analytics
	Ifenthaler [46]	2020	review	Assist study success by relying on Learning Analytics indicators
	Herodotou.al [49]	2020	research	enhance distance education through Predictive Learning Analytics
	Brown [7]	2020	research	exploiting Learning Analytics powered dashboards
	Tempelaar.al [15]	2021	review	employ Learning Analytics to rise education precision
Tempelaar.al [48]	2021	research	Support Individualized feedback by Dispositional Learning Analytics	
Concerns	Ifenthaler.al [35]	2016	research	Learning Analytics privacy principles from a student standpoint
	Rubel, Jones [36]	2016	review	Learning Analytics and student privacy
	Sclater [37]	2016	research	Learning Analytics practice rules
	Lawson.al [55]	2016	research	Ethical perspectives about learning Analytics in higher Education
	Ifenthaler [39]	2016	research	Higher educational institutions readiness for Learning Analytics
	Selwyn [38]	2019	review	Learning Analytics general issues

5 Conclusion

When compared to previous decades, Learning Analytics research is advancing at a rapid pace. The E-Learning community should think about possible approaches to develop it and how to harness the advantages it offers. The procedure, on the other hand, is neither easy or straightforward. It's not only about student data when it comes to Learning Analytics. A deeper and contextualized knowledge, as well as attention to all ethical problems surrounding student data, should be created in order to accomplish a meaningful transformation in the E-learning domain through learning institutions. Learning Analytics provides several opportunities and issues for E-learning and educational society as a whole, and it should be exploited to achieve meaningful progress in educational operations. In this perspective, recommender systems, customized feedback, and real-time interventions are significant issues in E-Learning systems and potential research fields, and we may handle present challenges while also paving the way for future growth by employing Learning Analytics approaches.

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