Chapter 1: What is Learning Analytics?

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ABSTRACT

Over the last ten years learning analytics (LA) has grown from a hypothetical future into a concrete field of inquiry and a global community of researchers and practitioners. Although the LA space may appear sprawling and complex, there are some clear through-lines that the new student or interested practitioner can use as entry points. Four of these are presented in this chapter, 1. LA as a concern or problem to be solved, 2. LA as an opportunity, 3. LA as field of inquiry and 4. the researchers and practitioners that make up the LA community. These four ways of understanding LA and its associated constructs, technologies, domains and history can hopefully provide a launch pad not only for the other chapters in this handbook but the world of LA in general. A world that, although large, is open to all who hold an interest in data and learning and the complexities that follow from the combination of the two.

Keywords: Learning, analytics, data, technology, education, field, domain

Pinning down the precise nature of "learning analytics" (LA) is a non-trivial task and although attempts at standard definitions abound, there remains a wide variety of interpretations. A literal definition such as, "learning analytics is the analytics of learning", simply shifts focus onto the two terms separately, both of which are contested. "Learning" carries the baggage of being a universal experience and therefore open to interpretation by anyone, including a range of academic fields that claim the definitive meaning (Anyone pursuing an interest in LA will quickly become an expert in parsing LA research from machine learning research for example). Even within the domain of human learning, vast differences arise when it is considered to be an individual cognitive process or a participatory one in which people come to take part in particular cultural practices [15]. Perhaps less obviously, "analytics", a term that conjures up the precision and concreteness of quantitative analysis, is also somewhat fuzzy, its meaning being older and more changeable than these concepts belie. Even among professionals in the LA space, the distinction between "analytics" and "analysis" remains muddied [65]. This is not surprising since well into the 20th century the term "analytics" was more often associated with the nature of prime numbers than any area of applied data analysis [23].

Rather than provide a dictionary definition of LA, the following chapter seeks to explain LA across four dimensions: 1) As a concern, 2) as an opportunity, 3) as a field of inquiry and 4) as a community. Through these four lenses we hope to give a more holistic picture of the field and its subtleties and to provide a launching point for the other chapters in this book. While this chapter deals with the question "What is learning analytics?" in an epistemological sense, subsequent chapters answer the question, "What are learning analytics?" in terms of specific methods, applications, systems and problems that make up the field.

1 A CONCERN

From its conception LA has been concerned with solving the problems associated with the growth in the availability, quantity, speed and type of data in learning environments. The first International Learning and Knowledge Conference in Banff in 2011 posed LA as a problem in need of a solution:

> The growth of data surpasses the ability of organizations to make sense of it. This concern is particularly pronounced in relation to knowledge, teaching, and learning. [13]

Initially these problems were largely technical issues and to be sure this remains a strong concern within LA, but substantial progress has been made on how to effectively deal with standards, technical architectures, and the edtech landscape, particularly within institutions of higher education [51, Chapter 23]. In 2022, LA is at a place where, through the joint efforts of research and industry, the technical problems are at least tractable, MOOCs and the shift to remote instruction during the COVID-19 pandemic have demonstrated that large scale acquisition and analysis of its data trails about learner interactions with educational content and each other are at least possible [50, Chapter 18]. What remains less certain though are whether educational systems can meet the adaptive challenges such as changes to behavior, attitudes and processes that arise in response to these technical changes [28]. As argued by Macfadyen in Chapter 17 of this handbook, the challenges of institutional adoption pose a substantial hurdle to the widespread use of LA, and successful large-scale implementations in which LA has become a key tool to solve educational problems remain elusive [34, Chapter 17]. At the same time, although comprehensive, systematic adoption is in its infancy, the breadth of concerns that the field now considers has grown substantially.

A decade since that initial conference in Banff, LA continues to be framed as a concern, but the scope of that concern has expanded substantially. Although the wider range of problems may emanate from the proliferation of data, they now also include the contexts and purposes for which data is collected. The list of concerns has grown each year to include areas such as privacy [42], ethics [47], data ownership [30], equity [57, Chapter 20], usability [35], and the state and direction of learning analytics itself [21] to name a few. The growth in the breadth of concerns has also been accompanied by a greater sense of clarity around specific problems adjacent to data. In particular, this includes the idea that data cannot be divorced from the modes of technology that facilitate its collection, and that the relationship between humans and machines raises myriad issues in need of exploration [55, 35]. For example, questions have been raised about the introduction of technology into the classroom through sensor technology [40, 63, Chapter 6], what can be lost through mechanization [26], and the tension between learning as a creative and social endeavor and analytics as a reductionist process that is removed from human relationships [44]. Within all of this, attention has expanded beyond questions of how to deal with existing data to also examine means for collecting better, more useful, and extensible kinds. This also necessitates acknowledgment of the kinds of data that have not traditionally been collected and the dynamics of power in who makes these decisions [62, 14].

At its most fundamental level then, when considering what LA is we can point to an ever growing list of concerns that emanate from educational data and the technologies that facilitate their collection. Indeed, the problems of making sense of accumulated data that Long et al.[12] identified as important concerns back in 2011 remain as does the core hypothesis that education will experience consequences as a result of changes in the data landscape and that these consequences should be examined. However, LA is not only motivated by the existence of these issues and finding solutions to them. In addition, it arises from the premise that LA can help to solve long standing problems and create new opportunities in education.

2 AN OPPORTUNITY

The concerns thrown up by the acceleration of computing speed and storage in education are only one side of the LA coin. As well as identifying issues, LA has also been framed as a wide array of opportunities. To some extent these mirror the promises of technology more generally, from efficiency and reducing work [32, 22, 20, Chapter 16] to more sweeping claims that LA could remake education systems and ameliorate ills such as inequality and access [57, 2, 39, 37, Chapter 20, Chapter 22].

To some extent the evolution of LA as opportunity has flowed from that of the eponymous business analytics (BA). In the 1970s, some businesses saw competitive advantage in replacing intuition with insights derived from data in the decision making process [27]. This approach, although by no means universal nor having a universal implementation, has grown to be advocated for by many of the most profitable businesses in the world [7]. BA has had many and varied influences on LA, through the adoption of ideas, practices and tools within universities, schools and Human Resources (HR) departments. The logical question that is asked is, "What might translate between the management of resources and the management of learning?" Over the 1980s and 1990s, finance and administrative offices within universities began to utilize data and computational methods to make decisions and identify "actionable insights". These methods and platforms soon made their way out of budget and finance and into other administrative units such as registrars' offices where the data available involved the basic administrative operations that were much more specific to education. By the first decade of the 21st Century, "academic analytics", the application of analytics to educational administrative functions, had grown to include sophisticated modeling of enrollment and retention, as well as tentative steps to model student outcomes such as risk of dropout [9]. This was mirrored in K12 schools with the growth of data-centric improvement strategies and the development of data skills among teaching staff [36, Chapter 19].

The promise of BA is often construed not as a specific method but rather in terms of missed opportunities - there are important insights and therefore revenue left behind when data goes uncollected or unanalyzed. This sense of undiscovered wealth has been imported into LA, with data management and analytics software companies emphasizing that analytics is necessary to prevent institutions from missing important opportunities for learning, supporting students or revenue generation. In addition, in the US fifteen years of the "No Child Left Behind" legislation has emphasized the connection between student progress and robust data systems. It is important to note that whether analytic systems produce improvements in student learning remains an open question in LA, but if there was one driver of the opportunity for impact that has demonstrated enduring presence and remains the backbone of the analytics enterprise, it is the rise of use in the Learning Management System (LMS).

For the development of LA, it is difficult to overstate the opportunity that the marriage of utility (delivery of educational materials) to data (student activity) through LMSs has meant. LMSs expanded the extant data pool beyond administrative activities to actions directly taken by students in relation to their learning. At the same time this is accomplished in a centralized way that can overcome institutional barriers that might have otherwise prevented the data collection and combination [51, Chapter 23]. Such systems took some time to develop though and mirrored the development of Content Management Systems (CMS) and software as a service (SAAS) models generally [59]. MIT had experimented with a system, Project Athena, that predated the widespread uptake of personal computers in 1983 [10], but the advent of offerings in the 1990s such as FirstClass, NKI Distance Education Network and NB Learning Network, and then the creation of the open source Moodle platform in 2000 [18] opened the door to extensive, organized and centralized data streams that could be utilized to investigate learning. As these systems became integrated into the everyday operations early adopters such as the Open University in the UK began to see the possibilities of observing patterns in student data almost immediately [49]. It is no surprise that LA took root first within institutions of higher education that often have more centralized data and technology infrastructure than K-12 education.

Dominant within the rationale for much of the work motivated by the availability of LMS data was the opportunity to better understand learning, what Macfadyen calls the "LA imperative" [34, Chapter 17]. The idea that within these new data sources, either through their scale, type, or temporal characteristics, lies uncovered insight into learning - the corollary of the promise of uncovering sources of profit in BA. But learning is an altogether different phenomena from profit. As we began this chapter noting, learning is a far more slippery construct than a dollar. The potential opportunity of LA was therefore always posed as a research endeavor (the "knowledge" in the naming of the Learning Analytics and Knowledge conference is not an accident). The consequences of the availability of data about learning is a key aspect of the opportunity but what will be found within the data is far more uncertain. Nevertheless, this framing of the value learning analytics, to deepen our knowledge about learning, is a call that has been reaffirmed many times over the last decade [16].

Growth of knowledge about learning has only ever been half the imperative of LA though. Rather, LA also represents the opportunity for, "new routes for teachers to understand their students and, hence, to make effective use of their limited resources" [11]. In addition to informing teachers' learning designs and pedagogical actions, LA has also been seen as a route to offer insight directly to students that can inform their studying, collaboration or other learning activities [van Leeuwen et al. Chapter 15]. LA is applied in nature, the insight provided by data has always been for the purpose of application to educational experiences in their varied forms. Rather than limiting inquiry though, this has spawned questions around: What constitutes improvement [24, Chapter 2]. How can the application of LA be done responsibly? What should the relationship between data and instructor [36, Chapter 19]? How can the implementation of LA be done responsibly [48]? What role does the student play in the system [60, Chapter 8]? And in what way will analytics aid in the development of Artificial Intelligence and vice versa [8, Chapter 3]?

3 A FIELD OF INQUIRY

The concerns and opportunities listed above provide a clear motivation for research within LA, but these motivations are not unique to LA. Rather they are major lines of inquiry across education research in the early 21st century. It is therefore important to ask, "What makes LA a field of inquiry in its own right?", both in terms of the ideas that hold the field together and the boundaries that distinguish it from other fields and education research writ large.

What constitutes the internal connective tissue of LA, the shared concepts that hold the field together, is dependent on how we define the field. We might argue that LA holds some weight in the Khunian sense of paradigms, that there are model problems and answers that lead to a shared understanding of scientific advancement [31]. As far as such a majority view exists within LA, it is in the form of the "human in the loop" argument. The core of the human in the loop concept is that, although automation is powerful, education as a social enterprise requires human decision making [56, 19, 11]. To some extent, this is a working assumption within the field, a paradigm, and it has spawned inquiry into where and how humans and machines should interact in the processing and consumption of educational data - through data collection, algorithms, dashboards, alerts, simulations, and/or policies . More so than other concepts within LA the human in the loop acts as a North Star for the field and creates a level of internal consistency, to the extent that it provides a set of values upon which research goals are based. A successful line of inquiry within LA can be defined as one in which data is utilized to investigate the partnership of machines and humans (or the partnership of humans mediated by machines for that matter) in the learning process. Progress is made when a greater understanding of these interactions is uncovered, or applied in ways that facilitate the process. Moreover, this paradigm stands in opposition to research that seeks to supplant humans in the educational process, for example, to replace teachers with machines [52, 29].

Another approach to characterizing the scope of the field has been through bibliometrics. As of writing, there are no fewer than 14 studies that seek to characterize LA according to the relationships between published material. Universally these studies point to the substantial growth of the field from almost nothing in 2011 to thousands of published articles and book chapters ten years later. To understand how these studies might help us define LA the ten that have attempted thematic analysis are listed in Table 1 Common themes are clearly associated with

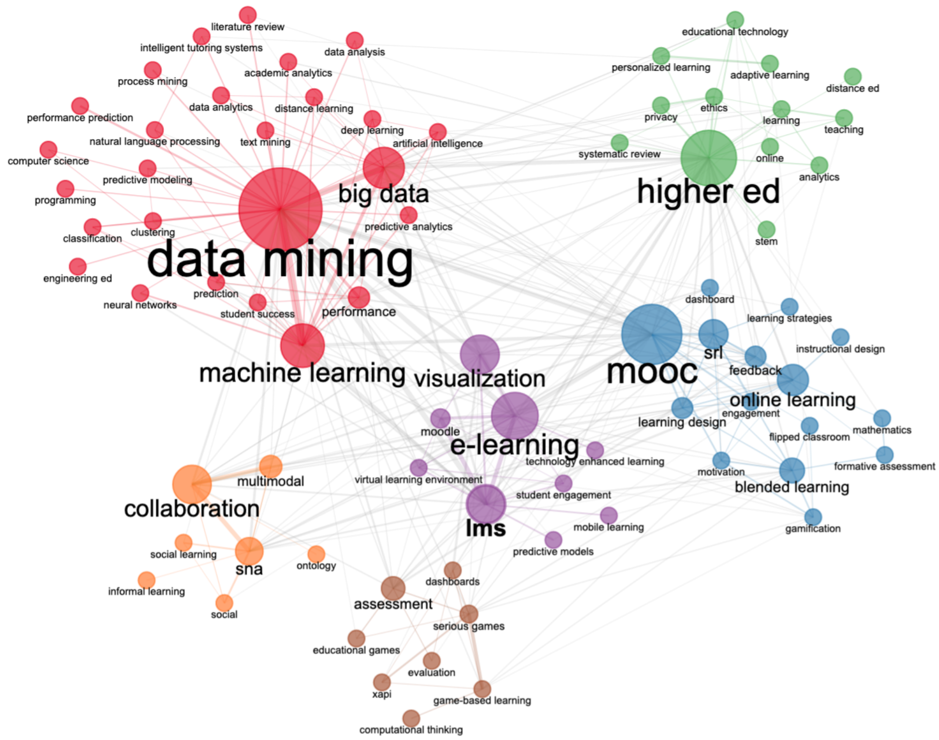

Figure 1: Keyword co-occurrence network of author assigned keywords from documents that mention "learning analytics".

technology, data, and education. Beyond these big three though there are multiple mentions of higher education, big data, data mining, and prediction. An intrepid researcher with an interest can replicate this pattern for themselves using the Web of Science Core Collection and the code appended to this chapter to produce Figure 1 - a co-occurrence network of author-supplied keywords across 4,293 articles within the topic of “learning analytics”, using leading Eigenvalues-based clustering. This confirms the outsize presence of data mining and higher education but also points to the influence of MOOCs and learning management systems as well as important practices such as visualization, collaboration, and assessment.

Whether these themes are enough to distinguish LA from other fields though is an open question though. There are several closely related fields that would likely claim to share the same concerns and see the same opportunities in the growth of technology-mediated data in education [6]. These related fields include educational data mining, artificial intelligence in education, the learning sciences, computer supported collaborative learning, and the more recent educational data and learning engineering. The exact divisions between these areas are fuzzy with many researchers and their work belonging to two or more. Several attempts have been made to draw divisions empirically, Baek and Dolek [5] argue that LA and EDM continue to be used interchangeably while Dormetzil et al. [17] go as far as arguing that EDM is a sub-field of LA. More often though the two distinguishing dimensions that are most commonly appealed to as differentiating factors are methodology and the historical origins of the separate fields.

Siemens [56], Baek and Dolek [5] and Gray & Bergner [3, Chapter 2] have identified that a defining feature of LA is an expansive approach to methodology. Methodology within LA is far ranging and there is no truly common language or processes across the field by which researchers demonstrate evidence. In the Popperian sense of a research field, one that is based on shared logic and doctrines of falsification, LA may well fall short due to this methodological agnosticism [46]. However, this has not necessarily been detrimental, if anything, methodological openness has contributed to an inclusive community and may well have assisted membership growth. But there is a trade off: methodology, and specifically how arguments are made and evidence is demonstrated, are key factors in differentiating one field from another and a lack of standard methods hinders both communication between members and their ability to make convincing arguments to each other [53]. It also makes it difficult to differentiate LA from the broader world of education research, though one can contrast the short-cycle, direct and local impact of LA on the learning populations from which data is collected with the relatively extended time scale, indirect and generalized impact of educational research writ large [61].

Historical differentiation is a clearer argument to make for LA. Clow [11] ties the emergence of the field directly to the growth of the learning management system, others

Table 1: Keyword themes across bibliometric studies of learning analytics.

Paper	Education/EdTech	Data & Computing	Other
[4]	Education	Computer science, artificial intelligence, software engineering, information systems, telecommunications, electrical engineering	Scientific disciplines
[17]	Education computing, computer-aided instruction, mobile learning, ubiquitous learning, students' behaviors, assessment, curricula, design, knowledge building, learning dispositions	Computational linguistics, natural language processing, information systems, mobile applications, information science	Statistics, conceptual frameworks, linguistics, ontology
[25]	Educational theories	Methods and data analysis, data governance	Stakeholders, ethical issues, structural factors, research results
[43]	Learning design, learning performance prediction, learning theories, learning environment, learning interaction analytics, collaborative learning	Multimodal dataset, sensor, multimodal processing, machine learning related learning	
[45]	Prediction of student success or failure, analytics to inform instructional design		Policy implementation concerns
[54]	Performance, education, student, higher education, MOOC, knowledge, motivation, pattern, online learning, design	Big data, analytics, environment, educational data mining, model, online, system, technology	Framework
[58]	Student, performance, activity, learner, teacher, intelligent tutoring system	Analytics, data, environment, development, big data, application, tool, computer, outcome, system	Challenge, approach, review, case study, game, framework, use, impact
[64]	Computer-based science inquiry, multiliteracies assessment, educational curriculum, visually-enabled active deep learning, instructional sensitivity	Big data, educational data mining, spatio-temporal data	Recent work
[1]	Accuracy, correlation, predictor, higher ed institution, multimodal, semester, frequency, student, policy, collaborative learning, discussion forum, Educational-Data Mining, interoperability, expertise, lecture	Workshop, conference, privacy, risk, emergence, study	
[41]	Students, learning, activity, education	Data analytics	Use

have similarly claimed that other fields have been driven by the prevalence of new technologies. Each field is preceded by the growth of different technologies and their educational impacts: AIEd with early computerized systems such as CAROL in 1970s and 1980s, EDM with the growth of intelligent tutors in the 1990s such as AutoTutor and Cognitive Tutor and LA with the growth of Learning Management Systems such as Moodle and Blackboard in the 2000s. To some extent the field is thus culturally defined as an association between technologies, those who pioneer them and the research agendas that stems from them.

4 A COMMUNITY

LA does not exist independent from the people who utilize and participate in the label. It is therefore worth considering who these communities are and how they approach LA. Since 2011 a very sizable community has coalesced around the problems and opportunities of LA through the Society for LA Research (SOLAR). SOLAR boasts a membership just south of 1000, predominantly from the United States (46%) but located across the globe. The flagship conference (LAK) regularly boasts more than 500 attendees, with further auxiliary events supported by the Society including the annual LA Summer Institute (LASI), podcasts and webinars. Complementing these events, SoLAR also publishes the Journal of LA (which has released 24 issues to date and is indexed in Scopus and Clarivate Web of Science), this Handbook (now in its second edition) as well as position papers, a blog and a periodic newsletter to communicate with its membership.

As influential as SOLAR has been in the development of LA globally, a great deal of activity within LA also occurs outside the organization. Other LA organizations exist such as the Learning Analytics Learning Network (LALN), the Bay Area Learning Analytics Network (BayLAN) and even the Learning Analytics in European Dental Education special interest group (LAEDE). Online communities have also arisen including the popular, colorful discussions on the @learninganalytics Google Group. These less formal organizations tend to be of similar make up, largely comprising academic audiences with a smaller number of people representing commercial interests.

An important source of codification of LA practices are the various formal educational programs ranging from micro-credentials, through advanced certificates, on to Master's degrees and PhD programs. These programs reflect the diversity in approaches to the question of what LA is, and can vary widely in content. Even within a class of qualifications such as graduate certificates there is a wide range of interpretations on what the necessary skills and competencies that a graduate from a LA program should have. The University of North Dakota program is strongly technical and methodological, Monash University focuses on problem solving and practical application, Northeastern focuses more on administration and institutional decision making, while North Florida has a strong focus on psychology.

A more concrete picture of what constitutes LA is provided by the current job market. Table 2 is a summary of job advertisements from February, 2022, collected across a range of regions from the job sites: Indeed, Glassdoor, LinkedIn, Monster, PNet, Wuzzuf and Yingjiesheng. Countries were included that had at least ten advertisements that included the term "learning analytics" (roles that involved no explicit educational component were excluded, IE - "machine learning analytics"). As a snapshot from a limited number of job sites the generalizability of this data is limited, but it affirms trends that have been identified by other findings about what the practicing LA community looks like outside of research institutions [33, 38].

Overall, the job market is clear about the venues that are considered to be LA and these can be categorized quite precisely into: corporate training, education technology, government/non-profit and education providers such as schools and universities. The dominant category is corporate training, supporting the conclusions of Littlejohn [32, Chapter 16], hat a key economic driver for the field appears to be around professional LA. These jobs tend to be located within the Human Resources departments of companies and relate to the measurement of training and staff development. The range of companies that require these services span a huge diversity of areas from financial services, construction, health and sports, but tend to be focussed on analytics of the behavior of knowledge workers. It is worth noting that some also extend analytics to include customer behavior though. Similarly, within government and NGOs there appears to be a need to provide quantitative measures of human behavior as it relates to the administration of educational programs, especially those utilizing technology. In this sample there appear to be fewer opportunities with education technology providers and these roles are largely dominated by established companies such as Pearson and Wiley rather than startups. Universities are also well represented with a smaller number of positions within K12 private institutions.

With respect to skills there appears to be some diversity in expectations but not as wide as that presented by LA degrees and certificates. Educational providers themselves have clear demands of their prospective employees, largely looking for people who can manage data systems and processes or be an instructor on these topics. Within companies there is a split between roles looking for data visualization and analyses with tools such as Tableau, and roles that are more process oriented and involve data management. Roles tend to be focused on report generation, insight identification and improving decision making rather than automation though. This may indicate that automation remains the purview of engineers rather than data analysts or scientists. Whether that will change over the coming years is one of the key open questions for the field. Within government and NGO profiles there also appears to be demands for data visualization and knowledge and experience in data stewardship.

Table 2: Number learning analytics targeted jobs per region and sector.

Region		Corporate Training	Education Technology	Government/ NGO	K12/Higher Ed
Africa & Middle East					
	Egypt	8			2
	Nigeria	5	2	6	
	Saudi Arabia	10		1	
	South Africa	17		2	
Americas					
	Canada	5		2	3
	Chile	2		7	2
	Mexico	3		6	4
	USA	8	3	1	2
Asia & Pacific					
	Australia	5		1	4
	China	5	8		1
	India	7	1		2
	Singapore	13		1	4
Europe					
	Germany	3	6		4
	Ireland	7	3	1	
	Spain	3	2	4	2
	UK	15	1	2	
Total		**116**	**27**	**33**	**30**

5 CONCLUSION

There is clearly more than one answer to the question, "What is learning analytics?" Over the last decade a community has coalesced around a common set of problems stemming from the proliferation of digital data within education, made possible by advances in computing. It was not the only community to do so, but there was an early acknowledgement that the acceleration was particularly acute within higher education, where data was generated in closed systems that also had people with the necessary expertise to make use of it readily available. From this starting point the field has grown in both its membership and the expansiveness of its areas of interest. If there is a common thread though it may well lie in the etymology of the word "analytics". The word analytics comes from the Greek "to set free" or "loosen" and in a sense that remains a key part of the promise of LA. The opportunity to set free learning with new knowledge and the promise of this new knowledge leading to a sense of improvement. While the promise remains attractive, there is a need to clarify the kinds of improvement we seek to make, the most productive paths towards them, and to start to generate compelling evidence of the positive changes possible through learning analytics.

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