Chapter 22: Global Perspectives on Learning Analytics in K12 Education

Cecilia Aguerrebere[1], Hao He[2], Michael Kwet[3,4], Mikko-Jussi Laakso[5], Charles Lang[6], Cecilia Marconi[7] Detra Price-Dennis[6], He Zhang[8]

[1] Fundación Ceibal, Montevideo, Uruguay
[2] School of Information Science and Learning Technologies, University of Missouri, Columbia, USA
[3] Information Society Project, Yale Law School, New Haven, USA
[4] University of Johannesburg, Johannesburg, South Africa
[5] Centre for Learning Analytics, University of Turku, Turku, Finland
[6] Department of Math, Science & Technology, Teachers College, Columbia University, New York City, USA
[7] Plan Ceibal, Montevideo, Uruguay
[8] New Oriental Education & Technology Group Inc., Beijing, China

DOI: 10.18608/hla22.022

ABSTRACT

Learning analytics within schools has been a rising interest both with K12 education practitioners and within the research community. Although LA has its roots in higher education, the spread of technology-enabled data collection has been a phenomena across all sectors of the education system. Analytics are routinely offered as part of education technology software offerings [23] and the LA research community has dedicated workshops at the Learning Analytics & Knowledge Conference in 2018 and 2019 and a forthcoming special issue of the Journal of Learning Analytics on the topic of LA in schools. Although this work is in its infancy, what is clear is that the adoption of LA within K12 education represents a complex endeavor. School systems are highly heterogeneous in their cultures, practices and attitudes toward technology and data and they occupy a politically charged position within society. Due to this heterogeneity, rather than attempt to summarize what LA in K12 education is in its totality, the following chapter provides a snapshot of the opportunities and issues associated with LA from the perspective of six researchers who are currently working in the space in different geographies: China, Finland, South Africa, Uruguay and the United States of America.

Keywords: K12 education, school, policy, international education

Learning analytics within schools has been a rising interest both with K12 education practitioners and within the research community. Although LA has its roots in higher education, the spread of technology-enabled data collection has been a phenomena across all sectors of the education system. Analytics are routinely offered as part of education technology software offerings [23] and the LA research community has dedicated workshops at the Learning Analytics & Knowledge Conference in 2018 and 2019 and a forthcoming special issue of the Journal of Learning Analytics specifically to the topic of LA in schools. Although this work is in its infancy, what is clear is that the adoption of LA within K12 education represents a substantially more complex endeavor than has been observed in individual universities or even university systems . School systems are highly heterogeneous in their cultures, practices and attitudes toward technology and data and they occupy a politically charged position within society. Due to this heterogeneity, rather than attempt to summarize what LA in K12 education is in its totality, the following chapter provides a snapshot of the benefits and issues associated with LA from the perspective of six researchers who are currently working in the space in different geographies: China, Finland, South Africa, Uruguay and the United States of America.

1 CHINA: GROWTH IN BIG DATA OUTPACES REGULATION & TRAINING

As the country with the largest population in the world, China could also "be the largest personal data pool and the biggest application market for big data" [60, p. 783]. By 2018, China had more than 230 million K-12 students [13]. Moreover, Chinese households pay great attention to their children's education and are willing to make significant investments. Therefore, K-12 education in China generates an enormous amount of educational data.

In the Chinese educational context, the term "big data analysis" (BDA) is more commonly used than "educational data mining" (EDM) or "learning analytics" (LA). An analysis of 546 studies from China National Knowledge Infrastructure (CNKI) revealed that Chinese researchers had an increasing interest in BDA in K-12 education since 2014 (Figure 1).

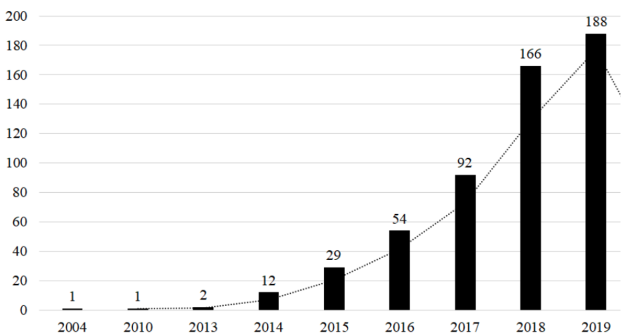

Figure 1: Published articles on BDA, EDM and LA in Chinese K-12 education (by year) .

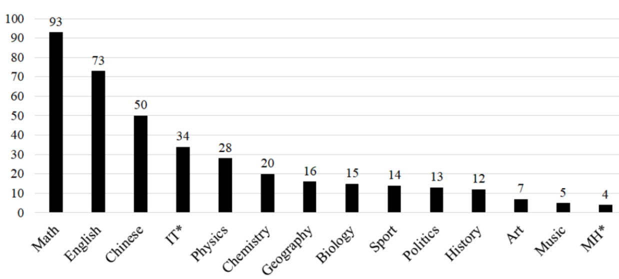

Figure 2: The frequency of subjects mentioned based on 546 studies. IT = Information Technology, MH = Mental Health

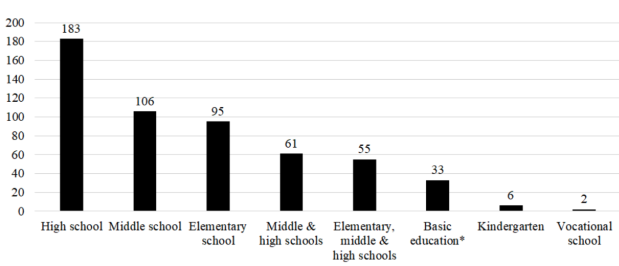

Figure 3: The number of schools that adopted BDA based on 546 studies. In China, "basic education" refers to the education across the stages of kindergarten, elementary school, middle school, and high school.

BDA techniques are most commonly utilized across three subject areas: Chinese, English, and math, but documented use exists in other subjects including chemistry, physics, biology, geography, politics, history, information technology, art, music, sport, and mental health (Figure 2). BDA techniques are used for learning behavior analysis, learners' weakness analysis, learning prediction and evaluation, instructional design, the configuration of educational resources, the management of teacher resources, and teachers' professional training [29]. These research studies and application practices are widely conducted across elementary schools, middle schools, and high schools in different areas of China (Figure 3).

Additionally, researchers have classified five types of educational big data applications in the basic education in China: question pool, homework support, language learning, classroom teaching, and adaptive learning [37]. With the development of artificial intelligence (AI) newer techniques are also being applied. For example, question pools are built using image recognition, optical character recognition (OCR), and natural language processing (NLP) to grab question items from paper-based resources, analyze these items, and generate knowledge graphs.

Homework support includes several types of applications such as photo answering and intelligent marking-up, which enable a student to take a photo of the question or her answer to the question, upload it to the internet, learn how the question should be answered or whether her answer is correct. This application is supported upon question pools. Successful examples are Homework Gang and Ape Counseling. In language learning, oral language evaluation and situational dialogues are major applications. Automatic speech recognition (ASR) and NLP are two major AI techniques that are being widely used. Successful products include Liulishuo and Microsoft Xiaoying. Classroom teaching, either online or face-to-face, generates substantial amounts of data through systematic teaching and learning evaluation systems. For example, by using the speech emotion recognition, ASR and NLP, the teaching quality is evaluated and the interaction between teachers and students is analyzed. By using the knowledge graph, teaching resources are integrated into classes. Adaptive learning depicts the learning path, analyzes the students' learning weaknesses, and pushes appropriate learning content and materials. It considers multidimensional learning elements (emotional factors, interest, motivation, etc.), and adopts the knowledge graph and deep learning techniques. A representative company in China is Squirrel AI, which offers intelligent adaptive learning.

Several issues or challenges exist in the application of BDA in Chinese K-12 education. On a macro level, firstly, China still needs a safe and unified mode to apply big data technologies in K-12 education [61], a national guideline of how to wisely and ethically develop and apply big data technologies in K-12 education. Secondly, data security, privacy, and ethics are important challenges [61]. Thirdly, more educational big data talents are needed [26].

On a micro level, the application of big data technologies in Chinese K-12 schools might be challenged for various reasons. For example, teachers and administrators may fear using new technology, or may not want to burden themselves with big data technologies by learning these new technologies and adjusting or changing their teaching methods [38].

In conclusion, the application and research of big data technology in K-12 education in China are increasing. However, challenges and issues co-exist. For example, the

COVID-19 pandemic and the "Double-Reduction" policy released by the Chinese Ministry of Education in July 2021 may significantly affect EDM and LA applications in K-12 education in China. Future researchers may explore or investigate the long-term impact caused by these changes. Additional attention should be paid to the development and release of a national guideline or norm of how to use big data in K-12 education wisely, safely, and ethically. Meanwhile, more talents with appropriate knowledge and skills of EDM or LA should be cultivated and hired. Moreover, teachers and administrators at schools may need to adapt their instruction and educational management to big data technology.

2 FINLAND: TOWARDS A NATIONWIDE TEACHING AND LEARNING ECOSYSTEM

In Finland, the Digivision 2030 program [48] emphasises the enhancement of the Higher Education sector with learning analytics being one of the key focal points. The goal of this program is to utilise learners' data in order to provide personalised educational experiences with the ultimate goal of improving society as a whole. In view of this effort, a learning analytics special interest group has been formed — under the supervision of the Ministry of Culture and Education — with the responsibility to develop frameworks and guidelines for the evolution and integration of learning analytics practices in K12 education in Finland as well.

The Finnish National Agency (EDUFI) is a key stakeholder in the field of education. The main responsibilities of EDUFI range from the formation of the curricula to providing resources for the adoption of new teaching methods and the integration of novel educational technologies in the school context (K12) as well as funding professional development programs for in service teachers. One of the latest focus areas of the currently funded programs concerns the utilisation of educational data. EDUFI is also responsible for developing the KOSKI-system [15]; a national data warehouse in which individuals' educational data (e.g., study records, study rights) will be stored. KOSKI serves many governing bodies including the Social Insurance Institution (Kela) and the Statistics Finland (StatFin). EDUFI is also responsible for maintaining the mPassId-solution [16]; a national identification system that provides individuals with a unique identifier, which can be utilized to access different web services (e.g., student registry system, learning management and e-assessment systems). To date, many content providers have integrated their eLearning solutions with the mPassId. Nevertheless, in K12 education the information is still scattered across various systems. Although learners can access the different services with the same (unique) identifier, each system is storing and maintaining its own data, and this data is not shared between the systems.

Each city and municipality has the freedom to choose the web services (eLearning solutions) that will be integrated in the school context whereas, teachers maintain the autonomy to adopt solutions as per their learners' needs. However, the above make the collection of learning data a challenging task; an issue, which is currently highlighted, also in the international literature. Typical questions that govern this problem range from "How can we collect data systematically (i.e., on a weekly basis)?", "How can we unleash the promise of Learning Analytics to identify and prevent learning losses due to a pandemic?", or "How can we create research-based interventions to overcome such losses on a nation-wide level?".

The Centre for Learning Analytics (University of Turku), in cooperation with national authorities, has been investigating and dealing with such issues since the early 2000s. Over the course of this time, a unique teaching and learning ecosystem for Finland has been developed; ViLLE – the collaborative education environment [34]. The platform has received various awards with the latest one being from UNESCO [58]. In addition, the "From Teachers to Teachers" initiative has led to the adoption of the platform by 60% of Finnish schools with hundreds-of-millions of completed tasks with immediate assessment and feedback being performed on an annual basis. This ecosystem enables data decision support systems from the classroom to the national level and further enables researchers to conduct mass scale multidisciplinary studies, while also offering the opportunity for teachers to take immediate actions based on the learners' performance behavior.

3 SOUTH AFRICA: THE SHADOW OF DIGITAL COLONIALISM

In 2015, the Presidency in South Africa, headed by Jacob Zuma, announced Operation Phakisa in Education (OPE) – a project to fast-track the delivery of computer devices to all 23,000 public school learners[21] based on a methodology first developed in Malaysia. The initiative is designed to transform – rather than reform – the basic education sector (Grades R-12) through the digitization of education. OPE also has a second core aim: to bridge the digital divide through the delivery of digital tech to the poor black majority [32, pp. 69–70].

The policy was announced against the backdrop of deep inequality and educational crisis. Despite twenty-five years of formal democratic governance, neoliberal policies have perpetuated poverty, inequality, and unemployment throughout the country [42, 41]. Public schools are failing despite high rates of government spending: as of 2016, 78% of Grade 4 learners could not read for meaning, an outcome heavily concentrated in poor black communities [47]. The failure to deliver basic levels of literacy imperils educational development and compounds inequality, as students who cannot read cannot acquire an understanding of more advanced concepts essential to democratic citizenship and high-paying skilled labor.

To help fix the educational crisis, OPE intends to upgrade the education system using computers and the internet. A computer-based solution for education is nothing new, however. In 2004, the Department of Education[1] pub-

[1] The Department of Education has since split into the Department of

lished the first e-education policy, the White Paper on e-Education [17]. As with OPE, the paper envisioned the delivery of information and communication technologies (ICTs) to public schools as a way to improve educational outcomes and bridge the digital divide. Yet the White Paper on e-Education failed to deliver at scale, as few schools ever received equipment.

The government has stated that OPE is based on the White Paper on e-Education, and they have advertised that a four-week Lab, held at the Birchwood Hotel in Johannesburg, focused on five "work streams": connectivity, devices, teacher professional development, digital content development and distribution, and e-Administration [14]. Statements made by government officials, tech corporations, and non-profits in attendance revealed that the government is planning a one device per child roll-out based on technologies and concepts developed in the Global North. In particular, the government would like to deploy blended learning, flipped classrooms, and adaptive learning techniques in the classroom, as well as US-based technology products and Big Data surveillance for pedagogical and administrative activity [31, pp. 148–178].

The e-education program violates official commitments to democratic governance. The DBE subscribes to the Batho Pele principles, which require governments to consult with citizens on matters to do with their needs, provide them with accurate information, and be open and transparent decisions made by government [50]. Additionally, the Phakisa methodology mandates the sharing of Lab findings with the public to incorporate their feedback and the production of a roadmap to inform citizens of a plan of action. DBE officials have yet to publish a report following the 2015 Lab but they [31, pp. 259–264]. Moreover, in 2007, the Department of Public Service and Administration passed a Free and Open Source Software (FOSS) policy preference which stipulated that FOSS would be given preference for use in the public sector [51]. Based on several documents commissioned in the early 2000s, the government was concerned that Big Tech transnationals like Microsoft would colonize the tech ecosystem, making South Africa dependent upon foreign corporations that would use proprietary software to dictate how computer experiences work while extracting rent from intellectual property monopolies. FOSS was to replace proprietary software in the public sector, including schools, to prevent neo-colonial domination [31, 33].

Eight of the nine provinces have discarded the FOSS policy preference, without providing a motivation, in favor of proprietary software solutions from Microsoft and Google. This is despite the government's own concerns that a mass deployment of US-based corporate infrastructure threatens to lock South Africa into subservience and monopoly rents through the process of digital colonialism – the political, economic, and social domination of another territory achieved principally through the ownership and control of the digital ecosystem [32].

While adoption of ICTs in schools has been slow to date, the South African government's choice to deploy Silicon Valley tech in schools reflects their self-imposed commitments to the so-called Fourth Industrial Revolution agenda coined by Klaus Schwab of the World Economic Forum. Ultimately, the African National Congress (ANC) is preparing South Africa to "restructure the economy" for the North's system of digital capitalism. To prepare for the tech-driven "future of jobs and skills", the ANC seeks to shape the education system according to a technocratic imperative that would "[produce] skills that are required at the correct time and in correct numbers" [12].

The government has yet to deploy OPE on the national scale, and it is not too late to change direction through democratic engagement and debate. An alternative vision for education technology, People's Tech for People's Power [31] – a nod to the People's Education for People's Power movement launched in the 1980s – could mandate the use of Free and Open Source Software, strong privacy protections for education participants, and internet decentralization technologies like FreedomBox and the Fediverse in all public schools [33, 31]. The use of such technologies and policies fulfills government policy and is consistent with human rights and equality in education and society.

4 URUGUAY: STATE FUNDED, STAKEHOLDER INCLUSIVE RESEARCH

Uruguay stands out in Latin America for its high income per capita[2], low level of inequality, and low level of poverty. Despite recent progress, several structural constraints to growth remain, in particular in the area of education, which may obstruct the progress towards sustainable development [55]. Uruguayan education is free and compulsory from pre-primary to upper secondary. Primary education is universal. Secondary education, however, faces serious challenges of student enrollment and retention. Only 40% of Uruguayans between 20 and 24 years completed secondary education, way below the average for Latin American countries (60%) [28].

Learning analytics (LA) is not a silver bullet to solve education problems but, because of the high level of digitized education in Uruguay, it can become an effective tool to better understand and tackle fundamental problems in the Uruguayan education system. Since 2007, Plan Ceibal[3](a government agency) has provided a laptop or tablet for every student in public primary (covering 85% of Uruguayan children) and lower secondary school in Uruguay. It also provides Internet access in schools and a wide variety of digital tools (e.g., LMS, math ITS, online library). These platforms are a great source of educational data which, given the nearly universal implementation of the program within the country, offers an excellent opportunity to conduct LA research in the K12 system. During the first two years of the COVID-19 pandemic, Plan Ceibal's infrastructure allowed to assess students'

Basic Education (covering grades R-12) and the Department of Higher Education.

[2]Uruguay GDP per capita for 2018 was $17.278, https://www.macrotrends.net/countries/URY/uruguay/gdp-per-capita

[3]https://www.ceibal.edu.uy/en/institucional

learning processes and to track their outcomes, supporting learning continuity at a national scale during school closures and beyond. This way, the Uruguayan education system was able to make decisions in real time and to provide suitable assistance to students that were offline.

Plan Ceibal is in advanced stages of the deployment of a Big Data platform for LA [6, 2], an initiative focused on data collection and integration to enable advanced analytics to support the education system. It is therefore responsible for the crucial and challenging tasks of protecting user privacy, guaranteeing quality and an ethical use of the data generated by 85% of the children in the country. A privacy committee is responsible for ensuring user privacy whereas an inter-institutional ethics committee is in charge of establishing the ethical guidelines that govern educational research. Moreover, it created an educational behavioral laboratory in 2022. This unit has a strong emphasis on carrying out experiments, using user-centered data analytics and applying behavioral science principles from a multidisciplinary perspective.

In 2015, Plan Ceibal created the Center for Research Ceibal Foundation[4] to support and promote research in education and technology. Both institutions have conducted numerous LA research projects [53, 1, 3, 43, 4, 49]. For instance, analyzing how should online teachers of English as a foreign language write feedback to secondary school students to encourage participation in discussion forums. How complex should teachers' feedback be? Results suggest that students participate more when feedback is adapted to their English proficiency level, neither too simple nor too complex [1]. In [4], a quasi-experimental study analyzes how learners' engagement with online educational resources is affected by receiving a new computer, an important question when implementing a large-scale educational computing initiative such as Plan Ceibal.

What can LA tell a primary school teacher, who spends long hours with her students and gets to know them very well, about her students that she doesn't know already? High quality research on topics that are relevant to stakeholders, is crucial for LA to have an impact on learning. This requires a strong collaboration between educators, policy makers and academia so as to understand the problems that are noteworthy, to include the stakeholders' know-how and to develop tools that they are willing and capable of using in their daily practice.

In the last few years the local LA research community has seen its capacities and its relationship with education stakeholders strengthened, resulting in the successful development of various national K12 LA initiatives [40, 19, 46]. For instance, high student dropout and grade retention problems motivated the development of a national LA initiative focused on tracking the trajectories of Uruguayan students during upper secondary education [40, 39]. Results show how students' performance at specific timepoints, as well as in specific subjects, predict student promotion or failure. Positive feedback was received from policy makers, as these results are useful to help at-risk students and to define new countrywide policies, such as implementing summer programs focused on the most problematic subjects [40]. This is a clear example of a fruitful collaboration between local institutions, national and foreign universities, where the joint work has generated concrete results and strategic recommendations for policy makers and educators.

Uruguay is giving its first steps towards realizing the benefits of LA in K12, but there is still a long way to go. In addition to deepening the paths already started, it is necessary to address crucial points, such as to promote data literacy among stakeholders and to be able to make pertinent interventions based on LA findings. Uruguay has made a permanent effort to build a high quality infrastructure and solid institutions capable of addressing the use and protection of students' data in a rigorous way, and the first LA developments have already yielded useful results. This, together with the fact that Uruguay is a small country with high enrollment in public education, puts it in a privileged position to conduct research in K12 supporting the national education system and contributing to the international LA research community.

5 USA: PERSISTENT INEQUITIES DESPITE THRIVING ED TECH

There has been no comprehensive empirical assessment of the use of learning analytics in schools within the United States and so it is difficult to say with any precision how many schools and to what extent they are utilizing new forms of data to impact learning. Yet, there are some claims that we can make with a high degree of confidence. Namely, that a) the study of learning analytics within K12 education in the US lags behind the study of LA within higher education and b) that, much like other aspects of the US education system, utilization of learning analytics is mediated by access to resources which vary considerably between schools across the country.

The study of learning analytics in schools has not had the same proliferation of reports and articles that have occurred within higher education [35, 57]. For many reasons, universities provide more fertile ground for the study of LA, they are closed data systems with defined populations and the expertise on staff to implement data intensive research. Conducting research within schools in the US is often more logistically complex, especially within public school systems that typically involve negotiating several layers of bureaucracy [20]. This is not to say that LA research has not occurred in schools in the United States, there are many examples (I.E. through better understanding of student learning pathways utilizing learning management systems and learning platforms [45, 8, 7]), but there is certainly less in comparison to higher education.

Despite the lack of empirical work, there have been multiple attempts to impress upon schools nationally the value of data and specific practices that purport to facilitate LA. Most recently, the work of Digital Promise lays out a detailed framework for embedding sound data processes and LA research into teaching practice [30]. It should be noted that such global frameworks for data informed in-

[4] https://fundacionceibal.edu.uy/en/

struction have been proposed before with limited success [52, 54]. The failure for such frameworks to be utilized at scale is likely related to the previous point, the decentralization of the United States school system and its vast heterogeneity with respect to teaching cultures, practices, bureaucracies and particularly resources.

Resource access can differ along many dimensions within the United States school system, including private vs. public schools, by school district, or demographic make-up of the school. These differences can be pronounced even within the same geographic area due to the decentralized nature of the US educational system and the dominant public school funding model, where schools are funded from local taxes [44]. The technological infrastructure that provides the raw material for analytic interventions such as dashboards and automation is subject to these funding discrepancies. So even before data can be utilized, there is substantial variability in which schools generate that data. It is unlikely that learning analytics in and of itself will provide the means to disrupt this pattern. When success has been attained, such as 99% of schools now having access to broadband internet on campus, it has been through long term political and policy negotiations with many stumbling blocks on the way [36].

In the United States, LA currently has limited ascertainable impact in K12 education. As such, LA is an emerging field in K12 schools that is prime for new research opportunities.. Two positive trends that support such opportunities are the growth of supra-district technology and data sharing organizations, and direct partnerships between schools and technology companies. Boards of Cooperative Educational Services (BOCES) or Educational Cooperatives in several states including New York, California, Kentucky and Colorado have a 70 year history in spreading capacity and access to technology across districts and have recently made progress in expanding the use of analytics in their associated schools through Regional Information Centers (RICs) [10, 56]. These centers have a mandate to spread the capacity to utilize data from technological sources across districts including sharing training and the development of data infrastructure.

At the same time, there is little doubt that the United States has one of the most active education technology sectors in the world [11]. Many companies offer learning analytics services to schools such as dashboards and prediction algorithms, and post-pandemic uptake of these tools is at record highs [5]. At the same time, startups are working with schools to conduct learning analytics research through government funding mechanisms such as the Small Business Innovation Research Program, a program designed to aid product development [22]. There are also well documented studies of specific platforms within schools including [27, 59, 18]. In the previous decade these tended to be correlational studies only though, concluding that students who performed better on state tests tend to also perform better within platforms. There is currently a renewed push however to move toward understanding the causal mechanisms between platforms and learning. Strategies involve pooling data across platforms and opening up platforms to researchers [24, 62]

There has also been growth in partnerships by the ed tech sector and school districts. Such partnerships have had mixed success from both a learning and political sense though. The Summit Learning Program, a personalization platform that has been funded by philanthropic monies from the Chan-Zuckerberg and the Gates Foundations, has been widely criticised for its attempt to automate learning using big data [9]. However, the partnership between Khan Academy and the Long Beach Unified School District, which has produced some interesting though small effects in research trials [25], has experienced more success. These partnerships tend to be treated with suspicion for several reasons: 1) key questions about conflict of interest and the ethics of utilizing student data to improve products have not reached consensus and 2) the school districts are under-resourced. These types of partnerships offer a double-edged sword in which districts gain access to technology, but at the expense of their students becoming research subjects.

Overall, learning analytics in the United States faces similar issues that all educational practice within the country faces. Large, multi-factor discrepancies between schools with respect to resources and practices hamper all systematic change efforts. Learning analytics could theoretically identify discrepancies in order to help ameliorate issues but requires substantial resources to be implemented before that vision can be realized.

6 CONCLUSION

The following descriptions of the state of learning analytics in five countries paints a picture of both substantial differences but also different approaches to similar problems. Two key concerns appear to be a) that data utilization is a task of far greater complexity than data collection and that b) that governments are playing catch up with respect to understanding how analytics are being used in K12 education. There are a range of approaches to both these problems. With respect to the first problem, Uruguay and South Africa have attempted to partner with non-governmental organizations, while Finland is keeping a lot of the work within national government entities and the United States and China have substantial private sector involvement. The second issue is a central problem for the learning analytics enterprise - the ability to understand how LA is being utilized is a central concern for the field as a whole. There is little debate across these country descriptions that LA is happening, but the concern remains that it is happening in a way that research will be unable to characterize. We see centrally controlled approaches to LA in Uruguay and Finland that may allow for a more complete picture of the state of LA in the future for those countries while South Africa, the United States and China have heterogeneous systems and implementation and, in the case of China, the sheer size of the educational system, may make the comprehensive characterization of LA difficult.

In this chapter the authors are cautiously optimistic that analytics can serve a useful purpose in the advancement of education and positive change in their respective societies. They argue for reasonable goals in harnessing LA, that take into account issues technical, ethical and pedagogical that can arise and are specific to the school context. All authors call for the need to coordinate efforts to better understand the consequences and opportunities that LA presents so that we are better placed globally to create more robust and equitable school systems.

REFERENCES

[1] Cecilia Aguerrebere, Monica Bulger, Cristóbal Cobo, Sofía García, Gabriela Kaplan, and Jacob Whitehill. "How should online teachers of English as a foreign language (EFL) write feedback to students?" In: *Proceedings of the 12th International Conference on Educational Data Mining* (2019), pp. 462–467.

[2] Cecilia Aguerrebere, Cristóbal Cobo, Marcela Gomez, and Matías Mateu. "Strategies for data and learning analytics informed national education policies: the case of Uruguay". In: *Proceedings of the 7th International Learning Analytics & Knowledge Conference*. 2017, pp. 449–453.

[3] Cecilia Aguerrebere, Cristóbal Cobo, and Jacob Whitehill. "Estimating the Treatment Effect of New Device Deployment on Uruguayan Students' Online Learning Activity". In: *Proceedings of the 11th International Conference on Educational Data Mining*. 2018, pp. 305–309.

[4] Cecilia Aguerrebere, Sofıa García, Gabriela Kaplan, Cecilia Marconi, Cristóbal Cobo, and Monica Bulger. "Exploring feedback interactions in online learning environments for secondary education". In: *Proceedings of the 2nd Latin American Conference on Learning Analytics*. 2018, pp. 128–137.

[5] Thomas Arnett. "Breaking the mold: How a global pandemic unlocks innovation in K-12 instruction." In: *Clayton Christensen Institute for Disruptive Innovation* (2021).

[6] Martina Bailón, Mauro Carballo, Cristóbal Cobo, Soledad Magnone, Cecilia Marconi, Matías Mateu, and Hernán Susunday. "How can Plan Ceibal land into the age of big data?" In: *Data Analytics 2015: The 4th International Conference on Data Analytics*. IARIA, 2015.

[7] Ryan S. Baker and Kenneth R. Koedinger. "Towards demonstrating the value of learning analytics for K-12 education". In: *Learning analytics in education* (2018), pp. 49–62.

[8] Andrea L. Beerwinkle. "The use of learning analytics and the potential risk of harm for K-12 students participating in digital learning environments". In: *Educational Technology Research and Development* 69.1 (2021), pp. 327–330.

[9] Faith Boninger, Alex Molnar, and Christopher Saldaña. "Big claims, little evidence, lots of money: The reality behind the Summit Learning Program and the push to adopt digital personalized learning platforms". In: *Boulder, CO: National Education Policy Center* (2020).

[10] Alex J. Bowers. "Data visualization, dashboards, and evidence use in schools: Data collaborative workshop perspectives of educators, researchers, and data scientists". In: *Education Data Analytics Collaborative Workshop* (2021).

[11] IBIS Capital and Cairneagle Associates. *EdTechX Global Report*. London, UK: IBIS Capital, 2020. URL: `https://uk.rs-online.com/web/generalDisplay.html?id=did-you-know/the-edtech-report` (visited on 12/09/2021).

[12] African National Congress. *5th National Policy Conference: Communications and the Battle of Ideas: Discussion Document*. 2017. URL: `https://pdf4pro.com/amp/view/communications-and-the-battle-of-ideas-2ec77f.html`.

[13] Ministry of Education of the People's Republic of China Department of Development Planning. *Number of Students of Formal Education by Type and Level*. Ministry of Education of the People's Republic of China. Aug. 12, 2019. URL: `http://en.moe.gov.cn/about_MOE/departments/`.

[14] Monitoring Department of Planning and Evaluation (DPME). *DPME Monitors Operation Phakisa Education Lab progress*. Hatfield, Pretoria, South Africa: Department of Planning, Monitoring and Evaluation (DPME). URL: `https://www.dpme.gov.za/news/Pages/DPME-monitors-Operation-Phakisa-Education-Lab-progress.aspx`.

[15] Finnish National Agency for Education. *Koskitietovaranto*. L568. Helsinki, Finland: Finnish National Agency for Education, 2019. URL: `https://www.oph.fi/en/node/1553`.

[16] Finnish National Agency for Education. *MPASSid*. Opetushallitus Utbildningsstyrelsen. 2021. URL: `https://www.oph.fi/fi/palvelut/tietopalvelut/mpassid`.

[17] South Africa. Department of Education. *White Paper on E-education: Transforming Learning and Teaching Through Information and Communication Technologies (ICTs).* Department of Education, 2004.

[18] Ann-Marie Faria, Ariela Greenberg, John Meakin, Krystal Bichay, and Jessica Heppen. "Replicating the relationship between teachers' data use and Student Achievement: The urban data Study and the data dashboard usage study." In: *Society for Research on Educational Effectiveness* (2014).

[19] Tomás Ferrero, Constanza Rodríguez, Belén Techera, and Regina Motz. "Analitica del aprendizaje orientada a los profesores". In: *VI Congresso Brasileiro de Informática na Educação (CBIE)*. 2017.

[20] Robert J. Franciosi. *The Rise and Fall of American Public Schools: The Political Economy of Public Education in the Twentieth Century*. Greenwood Publishing Group, 2004.

[21] Laura J. Grant and Alastair Otter. *How Big are South Africa's Schools?* 2016. URL: https://web.archive.org/web/20211122222933/http://passmark.org.za/howbig/.

[22] Kelsey Gross and Aubrey Francisco. *Using research in Ed-Tech: What does research-based product development mean?* Tech. rep. Digital Promise, 2016.

[23] Ananda Gunawardena. "Brief survey of analytics in K12 and higher education". In: *International Journal on Innovations in Online Education* 1.1 (2017).

[24] Neil T. Heffernan and Cristina Lindquist Heffernan. "The ASSISTments ecosystem: Building a platform that brings scientists and teachers together for minimally invasive research on human learning and teaching". In: *International Journal of Artificial Intelligence in Education* 24.4 (2014), pp. 470–497.

[25] Kelli Millwood Hill, Kodi Weatherholtz, and Rajendra Chattergoon. "Use of Khan Academy and Mathematics Achievement: A Correlational Study With Long Beach Unified School District". In: *Early Warning Systems and Targeted Interventions for Student Success in Online Courses*. IGI Global, 2020, pp. 37–63.

[26] Bicheng Hu and Zulin Wang. "The influence, challenges, and revolutionary trends on education brought by "Big Data"–A review of latest research findings of education revolution in a big data era". In: *Modern University Education* 04 (2015), pp. 98–104. URL: http://kns.cnki.net/kcms/detail/detail.aspx?filename=YSJG201504015%5C&dbcode=CJFQ%5C&dbname=CJFD2015&v=.

[27] Rodney Hughs. *DREAMBOX Learning Achievement Growth in the Howard County Public School System and Rocketship Education*. Cambridge, MA: Harvard Center for Education Policy Research, 2016. URL: https://cepr.harvard.edu/files/cepr/files/dreambox-key-findings.pdf.

[28] INEEd. *Informe sobre el estado de la educación en Uruguay 2017-2018*. Instituto Nacional de Evaluación Educativa (INEEd), 2019.

[29] Du Jingmin, Fang Haiguang, and Li Weiyang. "A review of research on educational big data". In: *The Chinese Journal of ICT in Education* 19 (2016), pp. 1–4.

[30] Andrew Krumm, Barbara Means, and Marie Bienkowski. *Learning analytics goes to school: A collaborative approach to improving education*. Routledge, 2018.

[31] Michael Kwet. "Digital colonialism: South Africa's education transformation in the shadow of Silicon Valley". PhD thesis. Rhodes University, 2019. DOI: 10.2139/ssrn.3496049.

[32] Michael Kwet. "Digital colonialism: US Empire and the new imperialism in the Global South". In: *Race & Class* 60 (2019), pp. 3–26. DOI: 10.2139/ssrn.3232297.

[33] Michael Kwet. "Operation Phakisa Education: Why a secret? Mass surveillance, inequality, and race in South Africa's emerging national e-education system". In: *First Monday* (20 Dec. 2017). DOI: 10.5210/fm.v22i12.8054. URL: https://journals.uic.edu/ojs/index.php/fm/article/view/8054/6585.

[34] Mikko-Jussi Laakso, Erkki Kaila, and Teemu Rajala. "ViLLE – collaborative education tool: Designing and utilizing an exercise-based learning environment". In: *Education and Information Technologies* 23.4 (July 1, 2018), pp. 1655–1676. ISSN: 1573-7608. DOI: 10.1007/s10639-017-9659-1. URL: https://doi.org/10.1007/s10639-017-9659-1.

[35] Philipp Leitner, Mohammad Khalil, and Martin Ebner. "Learning analytics in higher education—a literature review". In: *Learning analytics: Fundaments, applications, and trends* (2017), pp. 1–23.

[36] Sean Li and Erin Li. "The impact of digital divide on education in USA amid COVID-19 pandemic". In: *International Conference on Human-Computer Interaction*. Springer. 2021, pp. 571–576.

[37] Zhen Li, Donghai Zhou, Xiaoxiao Dong, and Xuejiao Huang. "The research status, problems and countermeasures of educational big data in China — Content analysis based on CNKI academic journals". In: *Modern Distance Education* 1 (2019), pp. 46–55. DOI: 10.13927/j.cnki.yuan.2019.0006.

[38] Jiangang Ma and Wencai Tan. "The opportunities and challenges in high school education and instruction in the background of a big data era". In: *China New Telecommunications* 15 (2019), pp. 188–189.

[39] Luiz Antonio Macarini, Cristian Cechinel, Henrique Lemos dos Santos, Xavier Ochoa, Virgínia Rodés, Guillermo Ettlin Alonso, Alén Pérez Casas, and Patricia Díaz. "Challenges on implementing Learning Analytics over countrywide K-12 data". In: *Proceedings of the 9th International Learning Analytics & Knowledge Conference*. 2019, pp. 441–445.

[40] Luiz Antonio Macarini, Henrique Lemos dos Santos, Cristian Cechinel, Xavier Ochoa, Virgínia Rodés, Alén Pérez Casas, Pedro Pablo Lucas, Ricardo Maya, Guillermo Ettlin Alonso, and Patricia Díaz. "Towards the implementation of a countrywide K-12 learning analytics initiative in Uruguay". In: *Interactive Learning Environments* (2019), pp. 1–25.

[41] Tshepo Madlingozi. "Social justice in a time of neo-apartheid constitutionalism: critiquing the anti-black economy of recognition, incorporation and distribution". In: *Stellenbosch Law Review* 28.1 (2017), pp. 123–147.

[42] Hein Marais. *South Africa Pushed to the Limit: The Political Economy of Change*. Bloomsbury Publishing, 2011.

[43] Cecilia Marconi, Juan José Goyeneche, and Cristóbal Cobo. "When teachers and machines achieve the best combination: A national comparative study of face-to-face and blended teaching and learning". In: (2017).

[44] Therese McGuire and Leslie Papke. "Local funding of schools: The property tax and its alternatives". In: *Handbook of research in education finance and policy* (2008), pp. 357–372.

[45] Carlos Monroy, Virginia Snodgrass Rangel, and Reid Whitaker. "A strategy for incorporating learning analytics into the design and evaluation of a K-12 science curriculum." In: *Journal of Learning Analytics* 1.2 (2014), pp. 94–125.

[46] Regina Motz, Ofelia Cervantes, and Blanca Viera. "Detection of Interactions that Impact Learning". In: *Proceedings of the Learning and Student Analytics Conference (LSAC)*. 2017, pp. 38–41.

[47] Ina V.S. Mullis, Michael O. Martin, Pierre Foy, and Martin Hopper. "TPIRLS 2016: International Results in Reading". In: *TIMSS & PIRLS International Study Center* (2017).

[48] Hanna Nordlund. *Korkeakoulujen yhteinen digivisio 2030 - Suomesta joustavan opiskelun mallimaa*. Digivision 2030. 2021. URL: https://digivisio2030.fi/.

[49] Marcelo Perera and Diego Aboal. *Evaluación del Impacto de la Plataforma Adaptativa de Matemática en los resultados de los aprendizajes*. Centro de Investigaciones Económicas (CINVE), 2017.

[50] Department of Public Service & Administration (DPSA). *Batho Pele – "People First": White Paper on Transforming Public Service Delivery. Department of Public Service and Administration.* Hatfield, Pretoria, South Africa: Department of Public Service & Administration (DPSA), 1997. URL: http://www.dpsa.gov.za/dpsa2g/documents/acts&regulations/frameworks/white-papers/transform.pdf.

[51] Department of Public Service & Administration (DPSA). *Policy on Free and Open Source Software Use for South African Government*. Hatfield, Pretoria, South Africa: Department of Public Service & Administration (DPSA), 2006. URL: https://www.gov.za/sites/default/files/gcis_document/201409/fosspolicy0.pdf.

[52] Marian A. Robinson, Claire Passantino, Marsha Acerra, Lauren Bae, Katie Tiehen, Eric Pido, Patricia Kannapel, Mark Duffy, and Connie Langland. "School perspectives on collaborative inquiry: Lessons learned from New York City, 2009-2010". In: (2010).

[53] Adolfo Ruiz-Calleja, Sofıa Garcıa, Kairit Tammets, Cecilia Aguerrebere, and Tobias Ley. "Scaling learning analytics up to the national level: The experience from Estonia and Uruguay". In: *Proceedings of the 2nd Latin American Conference on Learning Analytics*. 2019, pp. 1–10.

[54] Joan E. Talbert. "Collaborative inquiry to expand student success in New York City schools". In: *Education reform in New York City: Ambitious change in the nation's most complex school system* (2011), pp. 131–156.

[55] *The World Bank In Uruguay*. 2019. URL: https://www.worldbank.org/en/country/uruguay/overview#1.

[56] Susan Thomas. "Future ready learning: Reimagining the role of technology in education. 2016 National Education Technology Plan." In: *Office of Educational Technology, US Department of Education* (2016).

[57] Yi-Shan Tsai and Dragan Gasevic. "Learning analytics in higher education—challenges and policies: A review of eight learning analytics policies". In: *Proceedings of the seventh international learning analytics & knowledge conference*. 2017, pp. 233–242.

[58] UNESCO. *UNESCO Prize awarded to a collaborative learning platform ViLLE from Finland*. UNESCO. Apr. 6, 2021. URL: https://en.unesco.org/news/unesco-prize-awarded-collaborative-learning-platform-ville-finland.

[59] Haiwen Wang and Katrina Woodworth. "Evaluation of Rocketship Education's use of DreamBox Learning's online mathematics program". In: *Center for Education Policy* (2011).

[60] Zhong Wang and Qian Yu. "Privacy trust crisis of personal data in China in the era of Big Data: The survey and countermeasures". In: *Computer Law & Security Review* 31.6 (Dec. 2015), pp. 782–792. ISSN: 02673649. DOI: 10.1016/j.clsr.2015.08.006. URL: https://linkinghub.elsevier.com/retrieve/pii/S0267364915001296.

[61] Xianmin Yang, Sisi Tang, and Jihong Li. "The definition, potential value and challenges of big data in education". In: *Modern Distance Education Research* 1 (2016), pp. 50–61. DOI: 10.3969/j.issn.1009-5195.2016.01.007.

[62] Marta Zorrilla and Diego García-Saiz. "Meta-learning: Can it be suitable to automatise the kdd process for the educational domain?" In: *Rough Sets and Intelligent Systems Paradigms*. Springer, 2014, pp. 285–292.