Data Analytics in Education: Global Practices

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[Abstract] Data Analytics is an emerging area of study in the digital age and knowledge-based society. Data provides a base for informed decision making for quality improvement and policy making. Educational data has got its prominence in the educational sector planning and administration. Several countries have started capturing educational data at all levels and using them in developing educational policies and programs. In this paper the authors have highlighted the nature of educational data and its importance for quality educational planning and administration. The article also presents the various initiatives of different countries across the world by highlighting the challenges of collecting educational data and integrating with educational policies and practice.

[keywords] big data, data mining, educational planning and administration, educational policy and Practice.

Introduction

Education is one of the most powerful tools for reducing poverty, improving health outcomes, promoting equal opportunity, maintaining peace and stability, and driving development (World Bank, 2023). It is also a key contributor to a country's economic, intellectual, and political health, enabling individuals to reach their highest potential, effectively contribute to society, and compete successfully in an evolving global marketplace (Woolf et al., n.d.).

Education has no excuse to produce critical thinkers capable of solving real-world problems and ensure these abilities are nurtured and sustained to fulfill its overarching vision. To achieve this, the strategic use of data is essential in transforming and empowering education systems. As data increasingly governs the modern world, it has become the driving force behind decision-making and policy development (Analytics Insight, 2022b). Data powers everything we do, shaping the foundation of informed decisions and developmental strategies (Yeboah-boateng & Nwolley, 2018; Weiner, 2015).

Data refers to raw facts such as text, numbers, or symbols in an unorganized form, which, when processed, become meaningful information that enables organizations to implement and drive developmental policies (Cambridge International Examinations, 2015). Like finance, media, security, transportation, health, and government, education is data-driven, relying on systematically organized textual or numerical information to inform practice and policies (AISNSW, 2022).

According to AISNSW (2022) and Custer et al. (2018), educational data is diverse and encompasses the following:

- **Student Data**: Includes enrolment rates, attendance and absenteeism rates, repetition and dropout rates, assessment scores, and personal characteristics such as socioeconomic status, parents' education levels, gender, ethnicity, language, and disability status. Academic and well-being outcomes are also critical components.
- **Human Resource Data**: Covers information about teaching and non-teaching staff, such as the number of personnel, qualifications, and attendance rates.
- **School Data**: Includes the type of school (e.g., public, private, religious), available facilities (e.g., classrooms, electricity, bathrooms, computers, furniture), and resources (e.g., textbooks, paper).
- **Financial Data**: Tracks sources of funding, including government funding, tuition fees, grants, and allocations, as well as expenditures.

Educational data serves as a fundamental cornerstone and critical input in the formulation and implementation of effective education policies. It plays a central role throughout the policymaking process, enabling policymakers to navigate the complexities of decision- making, budget planning, policy design, resource allocation, and monitoring and evaluation in a structured and evidence-based manner. Without data, policies lack the necessary foundation to support informed decisions and risk falling short of addressing the multifaceted challenges within the education sector (UIS, 2023, p.7). At the national level, the Ministry of Education (MoE) and its sub-ministries rely on educational data for policy design, strategic planning, and decision-making. It enables the MoE to identify the strengths and weaknesses of the education system, monitor equity, ensure the equitable distribution of resources, and hold the system accountable for progress toward established standards and objectives. At the school level, educational leaders utilize data to track progress toward system-wide targets, develop school action plans, guide school-level practices, and evaluate and support teachers and staff (Custer et al., 2018).

Educational data can be collected in both qualitative and quantitative formats, utilizing various methods such as surveys, observations, portfolios, work samples, previous records, and class records (AISNSW, 2022). For education policies to be effectively monitored, the data collected must be relevant, comparable, and accessible, ensuring it provides meaningful insights and drives actionable outcome (UIS, 2023, p.7).

Research and expert analysis have highlighted the importance of data analytics in improving the quality of educational management. Data analytics enhances administrative decision- making and ensures optimal resource allocation (Analytics Insight, 2022a). Further, it promotes the effective use of data, strengthening mechanisms for monitoring progress and driving responsiveness within the system (Custer et al., 2018; World Bank, 2018; Jacob, 2017 Best et al., 2013; UNESCO, 2013; Kellaghan et al., 2009). Therefore, educational data and analytics are indispensable tools for advancing effective policy-making, fostering accountability, and driving improvements in education systems.

Educational administrators, educators, policymakers, researchers, and stakeholders must recognize and address the volume, variety, and velocity of educational data being collected. Ignoring the availability and potential utilization of this data risks undermining efforts to set a

strategic direction for education. The Sustainable Development Goal 4 (SDG 4) emphasizes the critical need to leverage data to drive system-level improvements in learning outcomes and equity (Crouch, 2019). Government compliance bodies further advocate for educational institutions to adopt streamlined data management practices that enhance accessibility and promote transparency. Embracing the growing power of technology in managing educational data represents a significant step forward. The implementation of a robust Management Information System (MIS) can transform data management, ensuring that every piece of data generated is recognized and utilized effectively to guide institutions toward achieving their goals and advancing the broader vision of education (Vidyalaya, 2023).

The next logical step in this evolution is leveraging Artificial Intelligence (AI) and big data technologies (Briggs, 2014). Big data provides state-of-the-art tools to collect, allocate, analyse, and discover patterns within massive datasets. It goes beyond merely accessing specific aspects of data; it unlocks the possibility of utilizing every type of available data to make informed decisions (Yeboah-boateng & Nwolley, 2018). By identifying patterns and predicting outcomes, big data transforms the way educational systems approach problem- solving and decision-making (Sharma, 2022). Adopting these technologies empowers educational institutions to maximize the value of their data, paving the way for data-driven strategies that promote transparency, equity, and progress in education.

Big data in education has the potential to significantly enhance the quality of educational policies and decision-making across various levels (Wang, 2019). At the micro level, big data serves as a valuable tool for schools and teachers. It can provide insights for improving teaching practices, accurately assess students' academic progress, and identify potential challenges they may face. Additionally, it aids in predicting students' future academic performance, enabling proactive interventions to support their success (Li et al., 2018). At the meso level, educational institutions can use big data to optimize and enhance their management processes. This includes improvements in teaching and research management, personnel management, enrolment processes, employment tracking, and other key decision- making areas (Wang, 2019). At the macro level, big data has the capacity to analyze the overall state of the education system, providing actionable insights to elevate its quality and effectiveness (Denisova et al., 2021). By leveraging these capabilities, big data applications can monitor, warn, and predict educational progress, driving better outcomes for students and institutions alike.

Illustrative applications of big data in education include forecasting student academic performance, supporting employment opportunities, and offering financial aid to low-income students. Big data also facilitates teaching innovation, improves educational administration, and strengthens research management. Research has shown that student performance can be predicted in the courses they undertake in subsequent terms, further highlighting the transformative potential of big data in education (Sharma, 2022). Recognizing its far- reaching impact, educational institutions at all levels must embrace big data as a strategic resource. By doing so, they can better prepare current and future learners for national and global development, ensuring education serves as a catalyst for progress and innovation.

Accordingly, an increasing number of countries have adopted Education Management Information Systems (EMIS) to manage big data in education (UNESCO, 2003). EMIS represents a comprehensive system encompassing people, technology, models, methods, processes,

procedures, rules, and regulations that work together to provide education leaders, decision-makers, and managers at all levels with relevant, reliable, unambiguous, and timely data to support their responsibilities (Macdonald, 2020; UNESCO, 2008). EMIS systems are designed to go beyond administrative and student data, integrating financial information, human resources data, and learning outcomes, as well as tracking both graduates and non- graduates post-completion of their studies. This data is critical at both the individual and aggregate levels and is utilized for policy analysis and formulation, planning, monitoring, and management across all levels of the education system (Abdul- Hamid, 2014; Macdonald, 2020). Looking ahead, EMIS must expand its scope to collect a broader range of actionable data. This would not only enhance teaching and learning outcomes but also provide insights into how education can be interconnected with other sectors to support a wider array of development objectives (UNESCO, 2018).

Despite efforts to strengthen Education Management Information Systems (EMIS), many countries face significant challenges in their implementation. A report by UNESCO (2003) emphasizes that several nations failed after adopting new EMIS names, securing funds for technology, organizing study visits, and acquiring project vehicles without achieving meaningful outcomes. One major issue is the lack of an overarching EMIS framework or comprehensive data policy, which has resulted in poorly coordinated data collection, fragmented datasets, and duplication of efforts (UNESCO, 2020). According to a global study by the Global Partnership for Education (GPE) (2019), most EMIS systems only track aggregate-level data, focusing on the "average child." This approach makes it difficult to determine whether education systems are addressing the needs of the most vulnerable students or implementing effective interventions to support them.

Research on EMIS capacity in countries such as the Philippines, Ghana, and Mozambique found that these systems failed to produce adequate information to monitor learning outcomes, address inequalities, and assess cost-effectiveness (Custer et al., 2018; DeStefano, 2011). Similarly, in Senegal, EMIS remains synonymous with the annual school census, which reports aggregate-level data on indicators such as disability status but excludes individual student data. This lack of granular data complicates educational planning and the ability to design targeted interventions (Kaindaneh et al., 2024). These findings underscore the need for countries to prioritize comprehensive frameworks, policies, and child-level data systems to ensure EMIS effectively supports educational equity and evidence-based decision-making.

UNESCO (2021a) highlights that individual learner data is becoming an emerging component for the future development of EMIS. The inclusion of learning assessment data within EMIS is particularly critical in countries where communication between different education units is weak, and alternative information-sharing methods are unavailable (Raudonytė & Foimapafisi, 2022). Moreover, the process of collecting individual student data inherently serves as a data quality assurance mechanism (UNICEF, 2019). Integrating learning assessment data into EMIS allows for a comprehensive analysis of various factors influencing education, including learning outcomes, school characteristics, the geographical location of schools, and the socioeconomic profiles of households—all within a unified analytical framework (UNESCO, 2021b).

This study emphasizes the importance of leveraging big data analytics within EMIS processes, with a particular focus on the collection, integration, sharing, and effective utilization of learning assessment data. Its primary objective is to explore how countries have promoted and

implemented the integration of learning assessment data into their EMIS, ensuring a more holistic approach to educational planning and decision-making.

Educational Data Analytics: Global Practices

The implementation and use of Education Management Information Systems (EMIS) across countries highlight common goals in improving education systems through data collection, analysis, and utilization. However, the specific features, strengths, and challenges of EMIS vary significantly by country, offering valuable lessons for global educational planning. Authors have reviewed the educational data analytics practices of selected countries and explained with a view to understanding the diversified country specific models.

Croatia

In Croatia, the Education Management Information Systems (EMIS) serves as the agency responsible for collecting data from schools. The data collected includes school data (infrastructure, materials, internet connection, etc.), teacher data (teacher contracts, qualifications, etc.), and student data (students' personal and academic details). A digital EMIS platform facilitates the real-time collection of data from schools, conducted weekly for primary and secondary education and annually for pre-primary education. The gathered data is analyzed and utilized in educational planning and management, focusing on understanding the relationship between schools, teachers, and students and their impact on educational achievements. However, data collection in pre-primary education is limited to basic information about teachers and students. Additionally, the results of analyses on learning portfolios are not made accessible to individual students (UNICEF, 2023).

India

In India, the EMIS plays a key role in collecting data from schools. The data gathered encompasses school data (factors related to schools and their resources), teacher data (teacher contracts, qualifications, etc.), and student data (personal details, examination results, etc.). The Unified District Information System for Education Plus (UDISE+) is the primary tool for collecting this information from schools (UNESCO Institute of Statistics, 2017). The collected data is analysed and utilized for educational planning and management, optimized resource allocation, the implementation of various education programs, and progress assessment (Ministry of Education, Government of India.). Reports based on data analysis are made publicly accessible under the Right to Information (RTI) Act 2005, Section 6(3). However, challenges persist, including issues with data entry in certain schools (Shala Saral, 2023).

Jordan

Jordan's EMIS plays a vital role in collecting and managing school-related data. The data collected includes school data (school profiles, infrastructure, etc.), teacher data (teacher qualifications, transfers, professional development tracking, and quality assurance for early childhood education) and student data (personal and academic details) (Altai Consulting, 2017). The OpenEMIS platform is employed to facilitate real-time, online data collection, providing comprehensive and detailed information (Adam et al., 2021; Altai Consulting, 2017). However, the Ministry of

Education faces challenges in effectively utilizing this data to inform policy decisions. Significant gaps persist in their capacity to manage and fully leverage the system's potential (Adam et al., 2021).

South Africa

South Africa's EMIS under the Department of Education, collects data on school infrastructure (buildings, sanitation, and other facilities) (Adam et al., 2021), school administrators and staff information (Adam et al., 2021; UNESCO, 2021) and student data (personal and academic details) (UNESCO, 2021a). The OpenEMIS platform is being introduced to replace the SA-SAMS (South Africa School Administration and Management System) (Adam et al., 2021). OpenEMIS facilitates real-time data collection both online and offline. This platform provides high-quality, timely data essential for identifying barriers, understanding needs, and addressing inequalities in education. It also enables better coordination for data sharing, contributing to effective assessment, planning, and monitoring (UNESCO, 2021a). Despite its potential, the development of OpenEMIS modules faces challenges due to limited budgetary support from the Ministry of Education (Adam et al., 2021).

Ghana

Ghana's EMIS, based on the Annual School Census (ASC), serves as the central tool of the Ministry of Education (MOE), which provides annual snapshot of students, teachers, and schools at the regional and district levels (Macdonald, 2020). In 2022, the system was enhanced to collect real-time data both online and offline using the mobile application KoboCollect, improving data accuracy and the timeliness of its release. Data collected spans across TVET, basic education, and second-cycle institutions, covering school data (school profiles, infrastructure, etc.), student data (basic information), and teacher data (qualifications, transfers, etc.) (Gustafsson-Wright et al., 2022). The EMIS primarily supports tracking and addressing student and teacher behaviour and performance, with the overarching goal of ensuring student learning progress. However, the system lacks critical data on National Education Assessment (NEA) and Early Grade Reading/Mathematics Assessments (EGRA/EGMA) (Raudonytė & Foimapafisi, 2022). Additionally, it does not include formative assessment data, end-of-term exam results for each class and subject, or national and international assessment statistics.

As a result, the analytical reports generated by Ghana's EMIS omit key insights into student learning achievements. While Ghana is making efforts to integrate learning assessment data into its new EMIS, this approach is only partially effective. The platform aims to include data from the Basic Education Certificate Examination (BECE) and the West African Secondary School Certificate Examination (WASSCE), but other critical assessment data remain excluded (Alberto, 2021). The system also faces significant challenges, including poor internet connectivity, data duplication, server errors causing crashes, and data entry issues in some schools due to headteachers' limited ICT knowledge.

Key Lessons from Global Practices in Educational Data Analytics

The global implementation of Education Management Information Systems (EMIS) offers critical insights into leveraging data analytics to enhance educational outcomes. The following key lessons

can be drawn from global practices:

The Importance of Comprehensive Data Collection: Countries such as India and Ghana demonstrate the value of collecting diverse types of data, including school infrastructure, student enrolment, teacher qualifications, and financial resources. A lack of comprehensive frameworks, as seen in Senegal, where EMIS is limited to aggregate-level data, hinders effective educational planning and targeted interventions.

The Role of Real-Time Data Collection and Technology Integration: Nations like Jordan, South Africa, and Ghana highlight the benefits of integrating digital platforms (e.g., OpenEMIS and KoboCollect) for real-time data collection. These systems ensure timely access to critical information, enabling more responsive decision-making. However, challenges such as limited internet connectivity and system errors, as seen in Ghana, must be addressed.

The Need for Policy Utilization of Data: Jordan provides a cautionary example of how a lack of institutional capacity to utilize collected data limits the effectiveness of EMIS in informing policy decisions. Conversely, India's RTI Act 2005 demonstrates the importance of transparency and public accessibility to data for fostering accountability and driving improvements.

The Integration of Learning Assessment Data: The inclusion of individual learner data, as highlighted by UNESCO, enhances the ability to analyse factors influencing education, including learning outcomes, school environments, and socioeconomic contexts. Countries like Ghana are beginning to integrate learning assessment data into EMIS, but limited inclusion of formative assessments and critical metrics still poses challenges.

Addressing Systemic Challenges: Some of the common challenges across countries include:

- Data Duplication: Observed in Ghana, leading to inefficiencies.
- Limited ICT Skills: Many schools, particularly in developing countries, struggle with data entry due to low levels of ICT knowledge among staff.
- Insufficient Funding: South Africa's EMIS development faces hurdles due to inadequate budgetary support.

Linking Education Data to Broader Development Goals: Big data in education, as emphasized by multiple countries, has the potential to connect education with broader societal goals, including poverty reduction, improved health, and economic development. For example, India uses its EMIS for resource allocation and enrolment tracking, linking educational outcomes to national development priorities.

Leveraging Big Data Analytics for Decision-Making: Across all case studies, the integration of big data analytics into EMIS has proven vital for enhancing decision-making processes at the micro, meso, and macro levels:

- At the micro level, schools and teachers use data to improve learning outcomes.
- At the meso level, institutions manage resources and track performance.
- At the macro level, governments design policies and evaluate the education system's overall state.

The need for local Adaptation of EMIS: EMIS must be tailored to local needs and conditions. For instance, Ghana's KoboCollerct application addresses connectivity challenges by enabling offline data collection, while South Africa's OpenEMIS supports integration across various administrative levels.

Conclusion

The global implementation of educational data analytics through systems like EMIS underscores the transformative potential of data in driving educational equity, efficiency, and effectiveness. By leveraging comprehensive, timely, and actionable data, nations can address systemic challenges, enhance decision-making processes, and align educational practices with broader developmental goals. Countries such as India, Ghana, Jordan, Croatia, and South Africa provide valuable lessons on the successes and challenges of integrating data analytics into education systems. The use of real-time data collection platforms, such as OpenEMIS and KoboCollect, illustrates the benefits of technology in ensuring timely and accurate information.

However, systemic issues like insufficient funding, poor ICT infrastructure, and limited capacity for data utilization persist, often hindering the full potential of these systems. A recurring theme across international experiences is the importance of tailoring EMIS to local contexts and ensuring the inclusion of critical data, such as individual learning assessments, to provide a comprehensive view of educational outcomes. Additionally, the integration of big data analytics into education systems has demonstrated the ability to enhance policy design, optimize resource allocation, and address inequalities.

To fully harness the power of educational data analytics, countries must invest in robust frameworks, capacity building, and technological infrastructure. By doing so, education systems can not only meet current challenges but also adapt to future demands, ensuring progress toward national and global educational goals, including Sustainable Development Goal 4. The effective use of educational data analytics holds the key to shaping inclusive, data-driven, and innovative education systems that prepare learners for success in an ever-evolving global landscape.

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