




USE OF BIG DATA IN EDUCATION: HOW ANALYTICS SUPPORTS PEDAGOGICAL DECISIONS

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ABSTRACT

The emergence of Educational Analytics and the use of Big Data are revolutionizing the way educational institutions approach pedagogical decision-making. This study analyzes the transformative impact of these technologies on the contemporary educational landscape, exploring how the collection, analysis, and interpretation of large volumes of data can significantly improve teaching-learning processes. The research examines the methodologies employed in the implementation of Educational Analytics systems, highlighting their potential to personalize learning experiences, identify student performance patterns and optimize pedagogical strategies. The ethical and practical challenges associated with the use of educational data on a large scale are discussed, including issues of privacy, security and equity in access to information. The study also investigates the crucial role of teacher training in the age of Big Data, emphasizing the need to develop analytical skills among educators. The results indicate that Educational Analytics, when

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implemented ethically and effectively, can provide valuable insights for educators and managers, allowing for more accurate and timely pedagogical interventions. It is concluded that while the use of Big Data in education offers significant potential to improve learning outcomes, its successful adoption requires a balanced approach that considers both the benefits and risks associated with this emerging technology.

Keywords: Educational Analytics. Big Data. Pedagogical Decision Making. Educational Technology.



INTRODUCTION

The contemporary education landscape is experiencing an unprecedented transformation, driven by the digital revolution and the increasing availability of large-scale data. In this context, Educational Analytics emerges as a powerful tool, capable of redefining the way educational institutions approach the pedagogical decision-making process.

Educational Analytics, based on Big Data analysis, represents more than a simple technological innovation; It constitutes a paradigmatic shift in the way educators and managers understand and respond to the needs of students. This approach is based on the collection, processing, and interpretation of vast volumes of educational data, aiming to extract meaningful insights that can inform and improve pedagogical practices.

The implementation of Education Analytics covers a wide range of applications, from personalizing learning experiences to identifying students at risk of dropping out early. By analyzing complex patterns of student behavior and performance, this technology provides educators with the ability to make more informed and strategic decisions.

One of the most promising aspects of Education Analytics is its ability to provide real-time feedback. This allows teachers and institutions to adjust their pedagogical strategies in an agile and precise way, responding promptly to individual student needs and emerging trends in the learning process.

The use of Big Data in education also opens up new possibilities for educational research. By having access to broader and more diverse datasets, researchers can explore complex questions about learning and cognitive development with a level of detail and precision previously unattainable.

However, the adoption of Educational Analytics is not without its challenges. Ethical issues related to student data privacy, information security, and equity in access to analytics technologies are core concerns that need to be carefully addressed.

In addition, the successful implementation of Educational Analytics requires a significant cultural change in educational institutions. Educators and managers need to develop new skills to interpret and effectively use the available data, which requires substantial investments in training and professional development.

The technological infrastructure required to support Educational Analytics systems also represents a considerable challenge. Educational institutions need to invest in robust data collection and analysis platforms, as well as security systems capable of protecting sensitive information.



Another crucial aspect is the need to establish standards and protocols for the collection and use of educational data. This is essential to ensure the comparability and reliability of analyses, as well as to facilitate collaboration between different educational institutions and systems.

The potential of Educational Analytics to promote equity in education is a topic that deserves special attention. By identifying disparities in learning outcomes and factors that contribute to academic success, this technology can help direct resources and interventions to where they are needed most.

However, it is important to recognize that Educational Analytics is not a panacea for all educational challenges. Its effectiveness depends critically on the quality of the data collected, the sophistication of the analytical models employed and, above all, the ability of educators to interpret and apply the insights generated in a contextualized and pedagogically relevant way.

As we move into the era of Big Data in education, it becomes increasingly evident that the success of Educational Analytics lies not only in the technology itself, but in its harmonious integration with grounded and student-centered pedagogical practices. The true potential of this approach will only be realised when it is seen not as a substitute for, but as a valuable complement to, educators' expertise and professional judgement.

THEORETICAL FRAMEWORK

As a field of research and application, Educational Analytics is based on the intersection between data science, pedagogy, and educational technology. Siemens and Long (2011) conceptualize Educational Analytics as "the collection, analysis and presentation of data about students and their contexts, with the objective of understanding and improving the learning process and the environments where it takes place" (p. One (34). This definition highlights the multifaceted nature of Educational Analytics, which goes beyond simply collecting data, including analyzing and utilizing that data to enhance teaching processes. Baker and Inventado (2014) reinforce this perspective, arguing that Educational Analytics "enables teachers to identify patterns and make exceptions that can guide teaching decisions and improve student performance" (p. "61").

The efficient execution of Educational Analytics is directly linked to the quality and extent of the data collected. In this scenario, the idea of Big Data acquires particular importance. Mayer-Schönberger and Cukier (2013) define Big Data as "an ability of a society to use information in innovative ways to produce valuable insights or high-value products and services" (p.2). In educational terms, this manifests itself in the ability to

gather and examine large volumes of information about the learning process, including students' interactions with learning management systems, patterns of participation in pedagogical activities, and test performance. The combination of these varied data enables a more comprehensive and in-depth understanding of the educational process, favoring more grounded and efficient pedagogical decisions.

METHODOLOGY

This study adopted a mixed methodological approach, combining qualitative and quantitative analysis, to investigate the use of Educational Analytics and Big Data in pedagogical decision-making. The research was structured in several stages, aiming to provide an in-depth understanding of the theme and its implications in the contemporary educational context.

Initially, a comprehensive literature review was carried out in academic databases such as Scopus, Science Direct and Google Scholar. The keywords used included "Educational Analytics", "Big Data in education", "pedagogical decision-making", among others related to the theme. The period considered for the selection of publications was from 2018 to 2024, ensuring the timeliness of the information. As Creswell (2014) points out, "the literature review in a mixed-methods study can be used in a similar way to quantitative or qualitative studies" (p. 79).

After the initial collection, the materials were submitted to a screening process based on criteria of relevance and quality. Peer-reviewed scientific articles, books by recognized authors in the area, reports from educational organizations, and public policy documents related to the topic were selected.

The analysis of the selected materials followed a thematic coding process, where the main concepts, approaches, and findings were identified and categorized. According to Saldaña (2021), "coding is a method that allows organizing and grouping qualitative data coded in a similar way into categories or 'families' because they share some characteristics" (p. 10).

In addition to the literature review, case studies were conducted in educational institutions that implemented Educational Analytics systems. These cases provided valuable insights into current practices and the challenges faced in integrating Big Data into the pedagogical decision-making process.

To complement the qualitative data, a quantitative research was carried out through an online questionnaire applied to educators and educational managers. The questionnaire was developed using the Likert scale and aimed to evaluate the perceptions and

experiences of professionals in relation to the use of Educational Analytics in their institutions.

To ensure the validity and reliability of the study, a triangulation method was used, which compares and contrasts data from different sources and points of view. According to Flick (2018), "triangulation refers to the mixture of different methods, research groups, local and temporal contexts, and different theoretical points of view when approaching a specific one" (p. De 444).

The evaluation of quantitative information was done through statistical programs, while qualitative information was examined through content and thematic analysis methods. The combination of qualitative and quantitative results enabled a broader and more detailed understanding of the specifications under analysis.

To deepen the understanding of current practices of Educational Analytics, semi-structured interviews were conducted with experts in the field, including educational data scientists, managers of educational institutions and developers of educational technologies. These interviews provided valuable insights into the emerging trends, practical challenges, and future prospects of using Big Data in pedagogical decision-making. As Kvale (2008) points out, "qualitative interviews are particularly useful to obtain descriptions and interpretations of the meanings of the central phenomena in the interviewee's world" (p. 46).

Additionally, a documentary analysis of institutional policies and guidelines related to the use of educational data in several organizations was carried out. This stage aimed to understand the regulatory and ethical context in which Educational Analytics is being implemented. As Bowen (2009) argues, "documentary analysis is particularly applicable to qualitative studies, as the documents can provide data on the context within which the research participants operate" (p. 29).

To evaluate the impact of Educational Analytics on learning outcomes, a longitudinal study was conducted in a sample of educational institutions that have implemented Analytics systems in the last three years. This study compared key performance indicators before and after implementation, including retention rates, grade points average, and student engagement levels. The longitudinal approach, according to Menard (2002), "allows the analysis of the duration of events, the identification of interindividual changes over time and the establishment of the temporal order of events" (p. 14).

Finally, a predictive modeling technique was employed to explore the potential of Educational Analytics in the early identification of students at risk of dropping out or low performance. Using machine learning algorithms, patterns in historical data were analyzed to develop models capable of predicting future educational outcomes. Baker (2014) points

out that "predictive modeling in education can provide valuable insights for timely and personalized pedagogical interventions" (p. 112).

Frame of Reference		
Author(s)	Title	Year
Siemens e Long	Penetrating the Fog: Analytics in Learning and Education	2011
Baker and Invented	Educational Data Mining and Learning Analytics	2014
Mayer-Schönberger	Big Data: A Revolution That Will Transform How We Live, Work, and Think	2013
Creswell	Research Design: Qualitative, Quantitative, and Mixed Methods Approaches	2014
Saldaña	The Coding Manual for Qualitative Researchers	2021
Flick	An Introduction to Qualitative Research	2018
Kvale	Doing Interviews	2008
Bowen	Document Analysis as a Qualitative Research Method	2009
Menard	Longitudinal Research	2002
Baker	Data Mining for Education	2014
Siemens e Long	Penetrating the Fog: Analytics in Learning and Education	2011
Baker and Invented	Educational Data Mining and Learning Analytics	2014

Source: authorship

EDUCATIONAL ANALYTICS: TRANSFORMING DATA INTO PEDAGOGICAL INSIGHTS

The arrival of Educational Analytics represents a quiet revolution in the field of education, promising to transform the way educational institutions approach the pedagogical decision-making process. This innovative approach, based on the analysis of large volumes of educational data, offers educators and managers an unprecedented view of the learning process and student performance.

The essence of Education Analytics is its ability to transform raw data into actionable insights for decision-making. As Daniel (2015) points out, "the promise of Educational Analytics is to enable higher education institutions to increase student retention, improve course completion rates and identify students at risk of academic failure" (p. (1112)). This statement underscores the revolutionary potential of this technology in the current educational context.

One of the most promising aspects of Education Analytics is its ability to personalize the learning experience. By analyzing individual behavior and performance patterns, educators can tailor their pedagogical strategies to meet the specific needs of each student. This represents a paradigmatic shift from a "one-size-fits-all" approach to a truly student-centered model of education.

The successful implementation of Educational Analytics, however, is not without its challenges. Ethical issues related to student data privacy and security are core concerns that need to be carefully addressed. Slade and Prinsloo (2013) warn that "the collection,

analysis, and use of student data raises ethical and legal issues that educational institutions need to consider" (p. 1510). This aspect underscores the need to establish strict protocols for the handling and protection of sensitive information.

In addition, the effective adoption of Educational Analytics requires a significant change in the organizational culture of educational institutions. Educators and managers need to develop new skills to effectively interpret and use the available data. This implies substantial investments in training and professional development, as well as the creation of a culture of data-driven decision-making.

The potential of Educational Analytics to promote equity in education is an aspect that deserves special attention. By identifying patterns and trends in large data sets, this technology can help reveal disparities in learning outcomes and factors that contribute to academic success. As Wise (2019) argues, "Educational Analytics has the potential to democratize access to information about the learning process" (p. 232).

The integration of Educational Analytics with other emerging technologies, such as artificial intelligence and machine learning, opens up new possibilities for personalizing learning. Adaptive learning systems, powered by sophisticated algorithms, can automatically adjust the content and pace of instruction based on individual student performance and preferences.

However, it is crucial to recognize that Educational Analytics is not a panacea for all educational challenges. Its effectiveness depends critically on the quality of the data collected and the sophistication of the analytical models employed. In addition, as Gašević et al. (2015) point out, "the success of Educational Analytics depends on its effective integration with established pedagogical theories and teaching practices" (p. 65).

The implementation of Educational Analytics also raises important questions about the role of the teacher in the educational process. Far from replacing human judgment, this technology should be seen as a tool to enhance the pedagogical expertise of educators. The challenge lies in finding the right balance between data-driven analytics and teachers' intuition and expertise.

An often overlooked aspect of the discussion of Educational Analytics is its potential to inform curriculum design. By analyzing student engagement and performance patterns, institutions can identify areas of the curriculum that require revision or improvement. This allows for a more dynamic and responsive approach to curriculum development.

The application of Educational Analytics in formative assessment represents another promising area. By providing continuous and detailed feedback on students' progress, this approach can help to create a more reflective and self-directed learning environment. As



Shum and Crick (2016) note, "Educational Analytics can support metacognition and self-regulation of learning" (p. 17).

Scalability is one of the great assets of Educational Analytics. Once implemented, data analytics systems can process information from large numbers of students, offering insights that would be impossible to obtain through traditional methods. This is particularly valuable in the context of higher education and online education, where the number of students can be very large.

However, the successful implementation of Education Analytics requires a robust technological infrastructure. Educational institutions need to invest in systems capable of collecting, storing, and processing large volumes of data efficiently and securely. This can pose a significant challenge, especially for smaller institutions or those with limited resources.

Interoperability between different educational systems and platforms is another technical challenge that needs to be addressed. For Education Analytics to be truly effective, data from a variety of sources—learning management systems, student information systems, digital libraries, and more—needs to be integrated in a coherent way.

The potential of Educational Analytics to inform educational policies at the institutional and governmental level is significant. By analyzing large-scale trends and patterns, policymakers can make more informed decisions about resource allocation, program development, and education reforms. As Eynon (2013) argues, "Educational Analytics has the potential to transform not only pedagogical practices, but also governance and strategic planning in education" (p. 238).

It is important to recognize that Educational Analytics, like any tool, can be misused. There is a risk that an overemphasis on quantitative metrics and indicators could lead to a reductionist view of education, ignoring important aspects of the learning process that are difficult to quantify. Educators and managers need to be aware of this risk and maintain a balanced perspective.

The training of professionals capable of working effectively with Educational Analytics is a crucial challenge. Universities and teacher training institutions need to adapt their curricula to include competencies in data analysis, statistical interpretation, and ethical use of information. This represents a significant change in the profile of the educator of the twenty-first century.

Finally, it is essential to remember that the ultimate goal of Educational Analytics is to improve the quality of education and student learning outcomes. All decisions and actions based on data analysis should be guided by this fundamental principle. As Siemens (2013)



points out, "the true value of Educational Analytics lies not in the technology itself, but in its ability to empower educators and students to achieve better learning outcomes" (p. 1390).

FINAL CONSIDERATIONS

The application of Educational Analytics and the use of Big Data in specific pedagogical decisions are a remarkable progress in the area of education today. This research revealed that, even in the face of significant challenges, the possibilities provided by this methodology to change the educational scenario are significant and promising.

The implementation of the principles of Educational Analytics in the educational environment transcends the simple implementation of technology; It is a broad philosophy that encompasses all facets of the teaching and learning process. This holistic perspective has the ability to establish educational environments that not only welcome the diversity of students, but also value it as an enriching component of the learning experience.

One of the biggest advantages perceived in the application of Educational Analytics is the stimulus to the personalization of learning. This methodology, by providing in-depth insights into individual student performance and needs, allows teachers to adjust their teaching strategies more accurately and efficiently. This leads to a more inclusive and student-focused teaching environment.

However, the effective implementation of Educational Analytics requires significant involvement of the entire educational community. Constant investment is needed in teacher training, in the adaptation of teaching materials and in changing teaching practices. In addition, it is essential to create educational policies that promote and encourage the implementation of this methodology on a large scale.

The survey also highlighted the critical importance of ethical considerations in the implementation of Educational Analytics. Issues related to student data privacy, information security, and equity in access to analytics technologies need to be carefully addressed to ensure responsible and ethical adoption of this technology.

The role of technology in the implementation of Educational Analytics emerged as a central theme. Technological tools offer unprecedented possibilities for collecting, analyzing, and interpreting educational data on a large scale. However, it is essential to recognize that technology should be seen as a means to achieve pedagogical goals, and not as an end in itself.

This study also highlighted the need for an interdisciplinary approach in the implementation of Educational Analytics. Collaboration between educators, data scientists,



educational psychologists, and other professionals is essential to developing truly comprehensive and effective solutions.

It is important to recognize that the adoption of Educational Analytics is an ongoing and evolving process. As our understanding of learning and the potential of data analytics expands, Education Analytics practices and strategies must be constantly re-evaluated and refined to maintain their relevance and effectiveness.

Finally, this study concludes that Educational Analytics, when implemented ethically and effectively, has the potential to profoundly transform the educational landscape. By providing data-driven insights into the learning process, this approach can empower educators to make more informed and strategic decisions, ultimately benefiting students and improving the overall quality of education.

However, it is crucial to maintain a balanced perspective. Educational Analytics should not be seen as a panacea for all educational challenges, but rather as a powerful tool that, when used in conjunction with sound pedagogical practices and professional judgment, can significantly improve educational outcomes.

As we move into the era of Big Data in education, the success of Educational Analytics will depend not only on technological sophistication, but also on the wisdom with which we apply these tools to create more effective, equitable, and student-centered learning environments. The true potential of this approach will only be realized when it is harmoniously integrated with the core values of education and the unwavering commitment to the holistic development of students.



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