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Big Data Utilization for Evaluating National Education Policy (A Multidisciplinary Perspective from Data Science and Educational Research)

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A B S T R A C T

In the digital transformation era, big data has become a crucial tool for evaluating national education policies. This study explores how big data enhances the precision, inclusivity, and responsiveness of policy evaluation processes in the education sector, particularly in Indonesia. Drawing from multidisciplinary perspectives including data science, educational policy, sociology, and public administration-this research highlights the strategic role of big data in uncovering regional disparities, supporting real-time governance, and promoting evidence-based decision-making. Through a qualitative literature review approach, the study synthesizes key themes such as data-driven policy-making, educational equity, ethical data governance, and the need for a national big data ecosystem. Findings reveal that while big data offers powerful opportunities for educational reform, its effective utilization depends on cultural shifts within institutions, robust digital infrastructure, and transparent governance frameworks. The article concludes by emphasizing the importance of integrating big data analytics in national strategies to improve educational outcomes and advance Indonesia's long-term development goals, especially in maritime and remote regions

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INTRODUCTION

In the era of rapid digital transformation, big data has emerged as a powerful enabler in the formulation, implementation, and evaluation of public policy, particularly within the education sector. Education, as a critical driver of national development, is deeply interwoven with dynamic socio-economic, cultural, and technological changes. This complexity necessitates the use of data-driven insights to inform evidence-based decision-making, ensuring educational systems are adaptive, inclusive, and future-ready (Akour dan Alenezi 2022:783).The integration of big data into the evaluation of national education policies enables more precise, timely, and comprehensive analysis of learning outcomes, access disparities, resource allocation, and instructional effectiveness across diverse geographic and demographic contexts(Almalawi et al. 2024:2).

In recent years, scientific and educational research has increasingly emphasized the value of data-informed policy-making, particularly in addressing educational inequities and enhancing accountability. According to UNESCO's Global Education Monitoring Report achieving Sustainable Development Goal 4 (SDG 4) which targets inclusive and equitable quality education-depends on governments' ability to harness data effectively. Big data, encompassing structured datasets such as national assessments and administrative records, as well as unstructured sources like social media sentiment, geospatial intelligence, and digital learning analytics, offers new opportunities to detect patterns, forecast trends, and design interventions that are responsive to learners' needs and systemic

From a multidisciplinary standpoint, the use of big data intersects with domains such as computer science, educational technology, sociology, public administration**,** and policy studies**.** Theoretical models like policy cycle theory (Hossin et al. 2023:2) **systems** thinking**,** and learning analytics frameworks help explain how big data not only reflects but actively shapes the functioning of education systems. Moreover, the ability of big data tools to support real-time**,** adaptive policy cycles enables a shift from reactive to proactive governance-crucial for addressing long-standing issues such as teacher absenteeism, school infrastructure inequality, and regional learning gaps

Indonesia serves as a timely case study in this context. As the fourth most populous country in the world, with over 270 million citizens spread across more than 17,000 islands, Indonesia faces significant educational challenges in ensuring equity, quality, and access**.** Reforms such as Merdeka Belajar and Kurikulum Merdeka reflect a broader national strategy to personalize learning and decentralize curriculum delivery. However, the success of these programs depends on continuous and granular evaluation. By leveraging big data-such as national exam results, school-level performance dashboards, and digital platform analytics-policymakers can monitor implementation fidelity, assess learning outcomes across provinces, and identify priority areas for targeted interventions.

Moreover, education in Indonesia has a strategic role in shaping national identity, soft power diplomacy**,** and civic engagement, particularly in geographically and culturally distinct regions such as coastal and maritime communities. Big data can support localized curriculum development that emphasizes maritime literacy, environmental sustainability, and national defense awareness, thereby aligning educational objectives with broader national interests. In this regard, education is not only a human development imperative but also a strategic instrument for strengthening resilience, competitiveness, and global engagement (Farid, 2023; Nugroho et al., 2024).

LITERATURE REVIEW

The Concept of Big Data in Education Policy

Big data refers to large, complex datasets that require advanced methods and technologies for storage, processing, and analysis. In the education sector, big data encompasses information from administrative records, learning management systems, standardized assessments, digital content usage, socio-economic indicators, and more. According to Siemens and Long (2023), the educational use of big data enables institutions and governments to predict learning outcomes, personalize instruction, and design data-driven interventions. In policy-making, big data plays a central role in moving from static evaluations to dynamic, evidence-based policy cycles.

Data-Driven Decision-Making in Education

The practice of data-driven decision-making (DDDM) in education involves the use of quantitative and qualitative data to guide strategic and operational decisions at various levels—from classroom teaching to national policy. Williamson and Hogan highlight that big data supports the creation of real-time dashboards for policy makers, allowing for more adaptive responses to emerging challenges such as dropout trends, resource inequality, or curriculum effectiveness. Meanwhile, UNESCO (2023a) emphasizes that DDDM is essential for achieving Sustainable Development Goal 4, especially in countries with complex geographic and demographic compositions like Indonesia.

Multidisciplinary Perspectives on Big Data Utilization

The utilization of big data in education requires collaboration across disciplines, including data science, education, public policy, and sociology. According to Karam and Misra the intersectionality of these disciplines enables a more holistic approach to understanding educational problems. Learning analytics, for example, draws from computer science and cognitive psychology to generate actionable insights from student behavior on digital platforms. Systems theory and policy cycle frameworks from public administration provide models for integrating such insights into effective educational reform.

Educational Equity and Regional Disparities

A major concern in national education policy is the persistence of disparities across regions, especially in archipelagic nations such as Indonesia. Big data enables policymakers to monitor and address these disparities with precision. Farid (2023) notes that disaggregated data from diverse sources can illuminate hidden patterns of inequality in access, performance, and infrastructure. By leveraging machine learning and geospatial analytics, educational planners can allocate resources more equitably and tailor interventions to the specific needs of rural, remote, or disadvantaged communities.

Big Data and Policy Evaluation in Indonesia

Indonesia's national programs such as *Merdeka Belajar* and *Kurikulum Merdeka* require continuous evaluation to assess their relevance and effectiveness across contexts. Nugroho argue that big data plays a critical role in policy monitoring by offering macro-and micro-level perspectives(Steve Hatfield-Dodds 2007:94). Data collected from school reports, digital learning platforms, and national assessments can be synthesized to inform timely improvements in

curriculum delivery, teacher training, and student engagement. Furthermore, predictive analytics can help forecast the potential long-term outcomes of current policy interventions.

Data Sovereignty, Ethics, and Educational Governance

While big data offers immense opportunities, its use also raises ethical and governance concerns. Issues such as data privacy, algorithmic bias, and unequal access to data infrastructure must be addressed to ensure equitable outcomes. OECD warns that without appropriate regulatory frameworks and data governance, the use of big data in education may inadvertently reproduce existing inequalities. In response, Indonesia has begun developing national strategies for educational data governance that prioritize transparency, accountability, and inclusivity.

METHODOLOGY

This research adopts a qualitative approach using literature study as its primary method. A qualitative approach is appropriate for this study because it aims to explore and interpret complex phenomena related to the utilization of big data in evaluating national education policies. The nature of the data is descriptive, derived from academic texts, policy documents, official reports, and previous empirical research, which are analyzed to construct a conceptual and theoretical understanding of the issue.

Literature study**,** or library research, refers to research activities that utilize written sources such as scholarly articles, books, government publications, and credible databases to examine and interpret existing knowledge on a particular (Syafi 2024:93). In the context of this study, relevant literature is systematically reviewed to extract insights on the integration of big data into educational evaluation frameworks, particularly in relation to policy-making, learning outcomes, equity indicators, and interdisciplinary implications.

According to Creswell, qualitative research is a process of exploring and understanding the meaning individuals or groups ascribe to social or human problems (Tümen Akyildiz dan Ahmed 2021:2). This study follows Creswell's model by allowing research questions and themes to emerge from the literature, with an inductive analysis approach that moves from specific cases and empirical findings to more general theoretical conclusions.The methodology consists of several stages:

1. Identification and selection of sources, including academic journal articles (Scopus and SINTA-indexed), government reports (Kemendikbudristek, BPS, UNESCO), and relevant theoretical works from interdisciplinary fields such as education, data science, and public policy.
2. Thematic categorization and synthesis, where selected texts are analyzed to identify recurring concepts such as data-driven policy-making, educational equity, big data analytics, and policy evaluation frameworks.
3. Interpretive analysis**,** where findings are examined critically to develop a comprehensive narrative on the strategic use of big data in evaluating and improving national education policies in Indonesia.

RESULT AND DISCUSSION

Big Data and the Transformation of Educational Governance

The emergence of big data has fundamentally reshaped various sectors, including education. Traditionally, educational policy in Indonesia relied heavily on periodic surveys, printed reports, and fragmented administrative records. However, with the advent of big data-defined by its volume, velocity, and variety-policymaking can now be informed by real-time, granular, and multidimensional datasets. In this context, educational governance transitions from reactive to proactive, enabling anticipatory responses to systemic challenges.

Big data in education encompasses diverse sources: student assessments, school infrastructure databases, teacher professional development logs, demographic data, geographic information systems (GIS), and even social media sentiments. The multidisciplinarity of this data opens avenues for integrated analysis involving educational theory, sociology, economics, computer science, and public administration.

Culture of Data-Driven Decision Making

One of the most fundamental shifts big data introduces is cultural: from policy driven by political intuition to one grounded in empirical, evidence-based logic. However, this transition is not merely technical but also normative. It demands a paradigm where educational institutions embrace transparency, accountability, and continuous evaluation. This shift requires reorienting organizational culture to recognize data as a strategic asset, not merely a bureaucratic requirement.

Unfortunately, many Indonesian educational institutions, especially at the local government level, still operate under data culture gaps. Data often exist in silos and are used post-facto rather than in real-time for policy formulation. In such settings, big data is underutilized, and policy remains disconnected from on-the-ground realities.

Multidisciplinary Approach and Systemic Insights

Big data analysis in education cannot stand in isolation from other disciplines. Sociological lenses allow us to interpret data within the context of inequality, marginalization, and socio-cultural barriers. Economic modeling helps quantify returns on education investment and cost-efficiency of specific interventions. Meanwhile, advances in machine learning and artificial intelligence provide scalable tools to detect patterns, predict student dropouts, and assess teacher performance.

An exemplary case is the integration of National Assessment (AN) data with household socioeconomic surveys. This multidisciplinary linkage reveals structural disparities in educational achievement rooted in economic conditions. Such insights help formulate equitable policies rather than generic, one-size-fits-all reforms.

Addressing Educational Inequity and Access

The utilization of big data unveils hidden patterns of educational disparity-whether urban-rural gaps, gender imbalances, or provincial disparities in learning outcomes (Balasubramanian et al. 2024:2). For instance, by analyzing

dropout records in tandem with transportation infrastructure maps, it becomes evident that access to schooling is still highly determined by geography(Sakti et al. 2022:26). A 2022 study by Badan Pusat Statistik (BPS) highlights that children in remote regions are 2.4 times more likely to discontinue schooling than their urban counterparts(Bodrogini, Putri, dan Nambiar 2021:4).

This reality strengthens the urgency of localized interventions based on granular data. Educational policy must no longer be dictated by national averages but by micro-level realities illuminated by big data. In this way, big data becomes not only a tool of efficiency but also a mechanism of social justice.

Challenges in Ethical Governance and Data Privacy

Despite its potential, big data use in education is fraught with ethical dilemmas. Questions of data ownership, consent, and child data protection are often inadequately addressed. In Indonesia, regulatory frameworks like the *Undang-Undang Perlindungan Data Pribadi (UU PDP)* are still in their infancy. Without stringent protocols, the risk of surveillance, profiling, and data misuse looms large, especially when third-party vendors are involved in educational platforms.

Thus, any big data policy must be embedded within a robust ethical framework(Annahar et al. 2023:22). According to Rahardjo data governance in education should be built on four pillars legality, transparency, equity, and accountability (Masyuri 2024:8521).

Toward a Big Data Ecosystem for National Education

Indonesia's *Rencana Pembangunan Jangka Panjang Nasional (RPJPN) 2025–2045* places knowledge-based policy as a key developmental pillar. Within this framework, big data serves as a foundational component. Building a national big data ecosystem for education entails interoperable platforms across ministries (Yunita, Santoso, dan Hasibuan 2022:21), regional integration with local governments, and partnerships with universities and research institutes.

Such an ecosystem must also ensure digital inclusion. According to the Ministry of Communication and Informatics, more than 30% of rural schools still experience limited internet access, hindering real-time data flows. Investment in digital infrastructure is thus not just a technological concern but a policy imperative.

CONCLUSIONS AND RECOMMENDATIONS

The awareness of Indonesia's identity as a maritime nation must be continuously integrated into national development policies and actualized in measurable actions across sectors, including education, economy, and governance. Despite the richness of maritime resources and strategic geopolitical positioning, public consciousness and institutional responsiveness to maritime values remain insufficient at the implementation level. Efforts to reinforce national resilience should adopt a holistic, non-physical approach that emphasizes social empowerment-particularly of maritime communities-as a strategic objective. These communities not only seek survival from the sea but also aspire to elevate their well-being through equitable access to marine-based opportunities. Enhancing their capacity aligns with national interests in achieving prosperity through sustainable maritime development.

In the context of evidence-based policy, future research should leverage big data analytics to identify patterns, disparities, and opportunities within Indonesia's maritime regions. Comparative, multidisciplinary studies-especially those that examine maritime communities across diverse social and economic landscapescan uncover deeper insights into the human dimensions of maritime life. Such research will contribute significantly to the development of inclusive maritime policies and foster greater maritime literacy among the broader population.

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