

OPTIMIZING RESOURCE ALLOCATION IN EBONYI STATE SCHOOLS USING BIG DATA ANALYTICS

By

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Abstract

This paper examines how big data analytics can be used to maximize resource utilization in schools in Ebonyi State, Nigeria, in solving the endemic problems of unequal and inefficient provision of education. Based on the primary data collection strategy in the form of surveys and interviews with school administrators, teachers, and students, the study focuses on the distribution of financial, human, and material resources on limited budgets and the increasing number of students under the value of comprehensive data-driven models. The background sheds light to the educational inequalities in Nigeria, especially in the Ebonyi State where the public secondary schools are underfunded and ill-equipped in terms of the infrastructure they utilize as developed by the budgetary allocation who is lesser than the UNESCO standards. The problem statement highlights the existence of inefficiencies in the use of resources that results to poor learning outcomes, high rates of dropout, and inequitable access. Extensive literature review combines outdated views of the 1980s and 1990s regarding the issues with resource constraints in the education of Nigeria and the recent research of predictive analytics and personalized learning by applying the concept of big data. The present study based on the Resource-Based Theory and Data-Driven Decision-Making framework was built as a mixed-methods research design, where 1,200 participants provided their demographic data and the results revealed a teacher-student ratio of 1:60 in most schools and the level of literacy as depending on the socioeconomic factors of the population. Results indicate that big data tools reduced the unequal distribution of resources by up to 40 percent to enhance performance metrics in students. Concluding, the paper proposes changes to the policy that can be undertaken to incorporate analytics in state education planning with the focus on scaleable digital infrastructure. The article can make contributions to the general research by filling the gap between technology and education policy in developing settings.

Keywords: big data analytics, resource allocation, Ebonyi State education, Nigeria, data-driven decision making, educational equity

Introduction

Education can be considered as one of the pillars of socioeconomic development within any country and especially in developing countries such as Nigeria, where the provision of quality education can mean a lot in the formation of human capital and alleviation of poverty. Within the education sector of the southeastern state of Nigeria, Ebonyi State, there are a number of complex issues that impede the ability to utilize resources optimally and to distribute them evenly. Ebonyi is a state that was founded in 1996 and today it has more than 3.2 million people,

many of whom are below the age of 15 years, which puts a huge strain on education systems. According to late 20th century historical studies, education system in Nigeria has been largely underinvested and mismanaged, with budget funds that are usually lower than global standards. An example is, economic recessions in the eighties and nineties have caused some delays in the supply of resources, which translate to full classes and incomplete teaching resources. All these problems are still present today, accelerated by the high rate of population growth and urbanization.

The context of this research is based on the wider Nigerian educational context, with basic school enrollment increasing by 18 percent in the period between 2014 and 2018 to more than 35 million students throughout the country. In Ebonyi State alone, the State has a youth literacy rate of 91.9% and that of adults stands at 69.8% with a total of almost 583 secondary schools, of which 240 are public secondary schools and 343 are private secondary schools. Nevertheless, such imbalances in resource distribution worsen inequalities, as in most cases, the public schools are not adequately funded. Ebonyi also spends 11.61% of its total budget, or 46.06 billion on education in 2024, which is 11.61 below the UNESCO-recommended 15-20. Such underinvestment causes waste of resources, ineffective strategies of administration and lost student numbers. This has been highlighted in early writings of the 1980s to focus on resource management to achieve sustainable development, with insufficient funds only being known to have a direct relationship with low enrollment and high dropout rates in sub-Saharan Africa.

The problem statement focuses on inefficiencies in the allocation of resources in the Ebonyi State schools that have been evidenced by the unequal distribution of teachers, facilities, and funds in the schools. In state-owned secondary schools, inadequate financial resources are noted, where most schools lack basic facilities such as laboratories, libraries among others. It leads to the poor learning outcomes which is reflected in the national statistics indicating that the rates of out-of-school children in the southeast region are around 1.15 million as of 2023. Furthermore, the absence of data-based strategies keeps these problems unresolved because the old-fashioned methods of allocations are based on old manual practices that cannot reflect the current demographic changes and performance indicators. The recent challenges such as the COVID-19 pandemic have underscored the necessity of digital transformation but the Ebonyi schools are behind in implementing big data analytics in predictive resource planning. These issues may increasingly create education gaps without measures to tackle them, preventing the state to achieve the Sustainable Development Goal 4 quality education.

The existing literature highlights the disruptive nature of big data analytics in relation to these issues. Research of the 2020s shows that resource allocation can be optimized through the application of data-driven models to affect disparities in teacher-student ratios and improve the efficiency of institutions. Such as the case of predictive analytics through big data approaches, inequities have been reduced by 44.8% in similar situations. The views holding that variations in resource distribution cause variations in enrollment and outcomes were represented in older literature in the 1990s, including the ones analyzing education spending in African nations which argued in favor of evidence-based policies. In Nigeria, post-independence reviews in the 1980s

criticised the remnants of colonialism in terms of unequal access to education, especially between the north and south, which is still playing its role in redistributing resources in the current society. Combining these views, current studies in Africa acknowledge the use of big data in curriculum development and efficiency of operations, where implementations in South African universities predict outcome-based funding. In addition, models such as the Grey Model (1,1) are used to predict school going age populations and this will help in resource planning. In sub-Saharan Africa, where education funding assessments show that the UNESCO standards are not met, data analytics can provide a solution to equity-oriented approaches, which in equity-driven resource allocation research decrease inequalities in student populations.

In the same vein, the literature indicates that the barriers to big data adoption in education, such as inadequate digital infrastructure and ducted skills among teachers, exist. Empirical research in Nigeria during the 2000s has associated socioeconomic factors with learning achievement, and specific interventions are required to be applied in such states as Ebonyi. Recent systematic reviews of big data on education emphasize its potential in the area of personalized instruction and optimization of resources, but its application in developing countries is associated with limitations such as data privacy and its integration with the current system. Resource-based theory theoretical influences assume that the strategic distribution of assets informed by analytics can achieve competitive benefits within the educational environment. In a similar manner, the data-driven decision-making frameworks give a well-organized way of converting the raw data into actionable information, as shown in models of teacher professional development. According to post-2020 research on digital evolution during pandemics in Africa, there are experiences of such transitions to online education, though it is important to note that big data is necessary to facilitate the use of hybrid models. In general, the overlapping of old and new literature indicates a critical gap in the underutilization of big data when it comes to the allocation of resources to Ebonyi State, which is addressed by the current study based on empirical research.

To enlarge on historical backgrounds, the education policy in Nigeria follows colonial times whereby missionary schools were the order of the day to post independence initiatives during the 1960s and 1970s to facilitate a universal approach. This led to economic structural adjustments in the 1980s that minimized the amount spent on the program creating poor facilities and shortages of teachers. In Ebonyi, which is a union of Enugu and Abia states, these legacies are reflected in the low literacy levels when compared to the national levels. In 1990-2000, literature indicated that government spending was correlated with human resource development and econometric models reflected that they had a positive effect on economic growth. Recent 2020-2026 research in Africa focuses on using artificial intelligence and big data to allocate resources in a smarter way, suggesting models through which predictive algorithms can be used to condense budgets and optimize the quality of teaching. As an example, digital transformations in Ghanaian universities during the COVID-19 included analytics-based decision-making, which may be implemented in Ebonyi. Furthermore, the obstacles like out of school children (more than 2 million in north-central Nigeria) make the necessity of data based policies urgent. The

combination of the main data and these insights in this research aims at offering a local solution; regarding the role of big data in the needs forecast and intervention assessment.

Going deeper into the issue, education sector in the state of Ebonyi is subject to certain demographic stress. The population density of 450 people per square kilometer and growth rate of 2.7% per annum puts the state at risk of increasing twofold in 25 years putting a strain to the school capacity. The national statistics show that primary students in the government schools have different socioeconomic backgrounds where such aspects as education level of parents determine performance of a learner. Young people aged below 15 are approximately 40 percent of the total population in Ebonyi, but only 74 percent of the adult population is literate, which presents generational problems. The old literature of the 1980s criticized the resource inefficiencies of universal basic education programs of the time because it also means that they have not been fairly distributed to even the differences among the regions. Modern studies suggest the use of big data in order to reduce them, with algorithms optimising the use of teachers and facilities. Lack of these systems within Ebonyi continues to promote wastage since administrators do not have the means of monitoring in real time. This research paper assumes that big data analytics will seal this gap, relying on international examples, where data has lowered the cost of operations and increased results.

When analyzing the literature, it is clear that resource allocation models started with simple budgetary models of the 1980s and went to complex analytics-based models in the present. Reviews of education funding in sub-Saharan Africa indicate that higher education spending has been associated with positive results only on the condition that allocation is efficient in developing countries. This is exemplified by the case of Nigeria where in 1990 studies pointed out enrollment increase despite the shortage of funds. The recent big data applications in education management focus on dynamic simulation algorithm in preschool and secondary levels to optimize resource based on predictive modeling. In Africa, post-2020 plans such as the Global Education Coalition will be used to reduce out-of-school by half by 2025 using data to make transformative policies. Nevertheless, there are still such issues as silos of data and ethical considerations regarding the use of AI. This research design solution posits these by suggesting a localized big data model of Ebonyi on the basis of the historical criticism and contemporary advances.

Methodology

The study also followed a mixed-method approach, where it examined how to optimize the distribution of resources in schools of the Ebonyi State through the application of big data analytics. To ensure that data can be triangulated to provide better validity the design incorporated both quantitative survey (statistic analysis) and the qualitative interviews (in depth insights). The research was carried out in three education zones of the Ebonyi State Abakaliki, Afikpo and Onueke education, which comprises urban and rural schools to ascertain representativeness. The inquiry was informed by a theoretical framework based on the Resource-Based Theory (RBT) and Data-Driven Decision-Making (DDDM) framework. According to

RBT, schools and other organizations can use strategic utilization of resources to gain competitive advantage, and data can be considered as one of strategic assets that guarantee sustainable performance. The conceptualization of DDM in the educational literature converts raw data into usable knowledge by repetitive data collection, analysis, and implementation in educational settings to predict resource planning.

The use of primary data collection was the main method, using semi-structured interviews and structured surveys. The sample included school administrators, teachers, students, and parents of the public secondary schools, approximately 222 schools with more than 10,000 teachers and 200,000 students according to the state data. The participants were selected using a stratified random sampling strategy to select 1,200 respondents who included 300 administrators, 500 teachers, 300 students and 100 parents. Demographic data indicated a neutral balance of the sex ratio (52: 48) with the ages of the population falling within the 15-60 years range. The socioeconomic status of the sample was 65% low-income household, which shows the rural-urban divide in Ebonyi. Ethnically, there were mainly Igbo (85%), and other minorities. Education levels were not homogenous with administrators possessing bachelors or post bachelors (90%), teachers had at least NCE degrees (75%), and students were in their junior secondary (40%), senior secondary (60%) stages.

The survey instruments were a 50-item respondent-rated questionnaire regarding resource availability, utilization, and big data perceptions on a 5-point Likert scale. The reliability was determined through Cronbach alpha (0.85). The qualitative elements (such as barriers to analytics adoption) were discussed based on 50 important informants interviewed. In 2025, data were collected over a period of 6 months and the ethical permissions of Ebonyi State Ministry of Education were taken. The analysis of quantitative data was performed with the methods of descriptive statistics, regression models, and predictive algorithms written in Python to model the optimization of resources. Thematic analysis on qualitative data was conducted. Limitations were possible bias of responses and inability to use digital tools in isolated locations, which were overcome by administering them in person.

To enlarge on the research design, a mixed-methods paradigm enabled an overview of the resource dynamics. Quantitative factors paid attention to quantifiable indicators like ratios of teachers to students (1:60 on average) and the rates of budget implementation (which are typically less than 70%), and qualitative stories offered a background of the administrative issues. The RBT and DDDM theoretical combination conceptualized big data as a strategic resource, with the analytics models such as the Gray Model of population forecasting as guidelines to allocation realities. The data used was primary data that made it relevant to the context of Ebonyi unlike secondary reliance in earlier studies.

Results

The result of this research provides important insights into resource distribution in schools in Ebonyi State and the possibility of utilizing big data analytics to optimize the resources in these schools. The participants were demographically analyzed with a diverse sample representative of the population of the state. The demography is presented in table 1.

Table 1*Demographic Characteristics of Participants*

Category	Sub-category	Frequency	Percentage (%)
Gender	Male	624	52
	Female	576	48
Age Group	15-25	350	29.2
	26-40	500	41.7
	41-60	350	29.2
Role	Administrators	300	25
	Teachers	500	41.7
	Students	300	25
	Parents	100	8.3
Socioeconomic Status	Low	780	65
	Middle	360	30
	High	60	5
Ethnicity	Igbo	1020	85
	Others	180	15

A proportional representation is presented in this table by putting the emphasis on teachers and low-income population groups which is relevant to the Ebonyi demographics of 74 percent of the population being child or adult with differing literacy levels.

Quantitative outcomes showed that there was inefficiency in the existing allocation: 68 percent of schools indicated that there were inadequate funds, average teacher-student ratio of 1:60 was above a recommended 1:40. Simulations with predictive models on big data streamlined projections disparities by forty percent, predicting optimal teacher utilisation based on the dynamics of enrolment. There are some pre- and post-analytics resource metrics in Table 2.

Table 2*Resource Allocation Metrics Before and After Big Data Optimization*

Resource Type	Pre-Analytics Level	Post-Analytics Level	Improvement (%)
Financial (₦ per student)	5,000	7,200	44
Human (Teacher-Student Ratio)	1:60	1:45	25
Material (Books per Class)	20	35	75
Infrastructure (Classrooms per School)	15	20	33

Themes were identified qualitatively: administrators reported the existence of silos of data that performance has impeded, whereas teachers expressed an enhancement of efficiency with the assistance of analytics. Generally, the effects of big data were more beneficial to equity, as 75% of respondents said that the results were improved in simulated conditions.

To extrapolate the findings, a regression analysis revealed that analytics use positively correlates to the performance of students ($r=0.72$) with demographics as a confounding factor. In rural, actually 60-percent, school areas, where 30 percent of the schools exist, big data suggested an increase in retention by thirty percent through redistribution of money towards infrastructure. These results confirm the theoretical model, as they prove the relevance of RBT in the educational scenario.

Discussion

The findings correspond with the current body of literature, and the claim that the big data analytics are capable of changing the operations of allocating resources in under-resourced environments such as Ebonyi State is proven. The 1980s and 1990s in history sources highlighted the lack of funds in Nigerian education, which reflects the present-day results of 11.61% budgetary allocation. Most recent studies agree with the reduction of 40 percent of disparity, considered similar to world patterns of lowering teacher-student ratio by 44.8 percent. Similar to the African reviews, demographical influences, including low socioeconomic status (65 percent of the participants), resonate between background and outcomes. The application of DDDM here would expand its application in predictive education, which covers gaps in the developing countries.

Infrastructure constraints are among the challenges, which were identified in the post-2020 African research on digital divides. Nevertheless, the whole data methodology consists of localized evidence, unlike older works that are based on secondary. Implications imply that policy incorporation of analytics in the pursuit of equity is possible based on RBT in acknowledging data as a core asset.

Conclusion and Recommendations.

To summarize, this paper has shown that big data analytics can provide a feasible opportunity of streamlining resource allocation within Ebonyi State schools and reducing all forms of inefficiencies and inequalities. Through the combination of primary data and theoretical framework, the study enacts on positive aspects of financial, human, and material distribution, which may positively influence learning outcomes when dealing with demographic pressures.

Suggestions are as follows: using state-wide platform of big data monitoring in real-time; educating teachers in analytic tools; allocating 20% of education budget to education; collaborating with NGOs on the digital infrastructure. Future studies need to cover longitudinal effects.

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