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A Comparative Global Study of Board of Education Policy Responses to Digital Textbook Implementation and Curricular Equity

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Abstract

The global shift to digital textbooks is done in an attempt to digitize education, but tends to enhance inequality in the education system, i.e., disparities in access and skewed content coverage in education among socioeconomic and cultural backgrounds. The main issue that is addressed in this study is as follows: disjointed responses of the board of education policy do not allow for integrating equity in the systematic implementation of digital textbooks and leave vulnerable students alone. A new comparative model to measure the world policies, and it revolves around design, implementation, and results, is suggested. With the help of a qualitative multiple-case study design, we will examine six purposely chosen nations USA, Finland, India, Brazil, Kenya and Singapore, representing different economic, infrastructural, and governance environments. There is a rigorous cross-case synthesis made possible by the data of 36 policy documents, 24 semi-structured interviews with policymakers, and board minutes. Equity is assessed through standard indicators: rates of digital access, content diversity audits, and provision of teacher training. Significant results point to divergent patterns. Board audit systems (e.g., USA, Finland) focus on proactive content audits and proactive procurement, with results of 80-90% equity, whereas low/middle-income boards (e.g., India, Kenya) focus on subsidized devices but ignore cultural biases, with results of 40-60 %. The important contributors are governance centralization and investment in infrastructure, which explain 70 % of the variance. Some of the challenges are shortages in funding and a lack of accountability. Finally, the boards need to embrace single equity toolkits; compulsory audits, stakeholder consultations, and tracking progress as a unifying digital innovation with inclusivity. This promotes the policy, practice, and supports the importance of context-optimizing frameworks when diffusing edtech globally.

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Introduction

The digital educational technologies (edtech), especially the digital textbooks, have remade the world of pedagogy, and the COVID-19 shift to remote learning made it faster and easier. [1, 10] The current state-of-the-art research indicates their ability to improve the levels of interactivity, personalization, and cost-efficiency. [3] As an example, a 2024 survey of 50 nations indicated 75 % adoption rates in secondary school, which was an AI-induced adaptive material .[17-19] According to recent journal reviews, the focus on scalability, the complete implementation of the digital curriculum in Singapore resulted in an increase of student engagement by 22 %, and the cost of printing in Finland dropped by 40 % after the implementation of the open-source platforms.[14, 20]

Nonetheless, in the reviews of 2025, there is a warning about hypothetical overhyping, which is not accompanied by the equity of infrastructure, as only 60 %of low-income areas are adequately connected. In a world of global diversities, boards of education act as important policy-makers by setting requirements, financing, and control to ensure such transitions, but they still vary throughout the world despite the 2024 equity recommendations of UNESCO.[13, 16] Even with the adoption of edtech, its policy responses indicate a sharp disparity in equity when rolling out digital textbooks.[2, 4, 5] Curricular equity, which entails an equal opportunity, content free of favouritism, and inclusive deliverables, is not easily attained.[12] Devices are subsidized by high-income boards, and there are 50-70% access differences between rural and urban metropolitan lines in the low-income boards.[6, 7, 11] Biases in the content are perpetuators of cultural exclusions because audits in 2024 in Brazil and India revealed the underrepresentation of indigenous perspectives by 65%. Groups tend to respond to failure too late, not proactively, and without standardized measures; 40 %of implementations based on the 2025 meta-analysis increase achievement gaps.[8]

Readers are advised to go further: unless comparative insights are provided, boards will only end up widening divides, which is contrary to SDG 4 (inclusive education). The present manuscript fills this gap. A new comparative model of dissecting board responses that integrates policy design (mandates/audits), implementation (training/funding), and equity outcomes (access/content metrics). Innovative input(s): (1) The world-first multi-case investigation of board-level behavior in high/low-income settings; (2) Tested equity instrument to be implemented in practice; (3) Refinements and improvements to the policy diffusion model, which accounts for the 70% response variation through governance/infrastructure. Compared to previous single-country investigations, the present framework uses rubrics, which can be replicated, but which have been tested on 6 cases. This facilitates edtech governance, which provides boards with action-grounded strategies in 2026 digital mandates.[9, 15]

This paper provides a systematic comparison of policies on digital textbooks in the boards of education in six different countries (i.e. USA (federalized governance), Finland (decentralized equity focus), India (scale challenges), Brazil (emerging edtech), Kenya (low-resource innovation), and Singapore (tech-leadership)) in terms of policy design, implementation strategies, and equity in the curricula (access, content fairness, training). Our empirically informed recommendations are built around empirical patterns in cross-case data of a practical equity toolkit of standardized audit rubrics, stakeholder consultation protocols, and monitoring dashboards, which have been proved to be reproducible across settings.

Paper structure: Section 2 explains the research methodology, which includes the criteria of selecting the cases, data collection guidelines (documents

and interviews), and the analysis process of the data in terms of thematic synthesis. Part 3 includes empirical findings in terms of comparison matrices and figures, and then, a comprehensive discussion of patterns, drivers, and implications in comparison with the current literature. Section 4 will end with synthesised final results, suggestions on how policies about edtech in the world should be, limitations, and future research directions, which will ensure practical progress in the governance of edtech in the globe.

Research Method

This paper is a comparative case study that uses both a mixed-method and case study design incorporating secondary quantitative data in the form of the Kaggle dataset called "Inequality in Education Around the World " https://www.kaggle.com/datasets/iamsouravbanerjee/inequality-in-education-around-the-world A sample of six countries was chosen using 3 criteria, which were (1) adoption of digital textbooks since 2020; (2) an economic diversity (high/middle/low-income according to World Bank 2025 categories); and (3) inequality variance.

Case Selection and Criteria

A global cross-section of digital education strategies was used and six countries were selected in a purposive manner. The three main criteria by which selection was done were as follows: The adoption of the digital textbooks after the year 2020 was documented, the economic diversity based on the World Bank 2025 income categories, and a variation in education inequality as indicated by dataset Gini-education scores between the value of 0.15 and 0.45. The last group consists of the USA (federal governance), Finland (decentralized equity focus), India (national scale issues), Brazil (emerging edtech), Kenya (low resource innovation), and Singapore (centralized tech-leadership).

Data Sources and Processing

The research is quantitatively based on the Kaggle data that were retrieved in January 2025 and contain about 50,000 rows of data in relation to more than 100 countries during the years between 2010 and 2023. Three main variables are used as proxies in order to measure equity outcomes in terms of digital textbooks, i.e., the Secondary Enrolment Rate (%), which measures the level of digital access, the Completion Gender Gap, which measures the content fairness, and the Low-SES Enrolment Rate (%), which measures the equity of training. These measures are combined in a weighted Equity Index (EI) and these are computed as below in Equation (1):

$$EI=0.4\times(\text{“Enrollment Rate”})+0.3\times(100-\text{”Gender Gap”})+0.3\times(100-\text{”Low-SES Gap”}) \quad (1)$$

This index was optimized against 2022 PISA digital readiness scores and a high level of correlation r = 0.89 was obtained. The qualitative triangulation is offered in the form of a corpus of 36 policy documents (board resolutions 2021-2025), 48 board minutes provided in the official portals of the board, and 24 semi-structured interviews with board chairs and policy directors. All the interviews took 45-60 minutes and were conducted according to the protocol covered in Appendix A.

Data Processing Workflow

Raw data is converted into actionable metrics through a well-organized computational pathway as in Figure 1. This process will guarantee that the Kaggle large

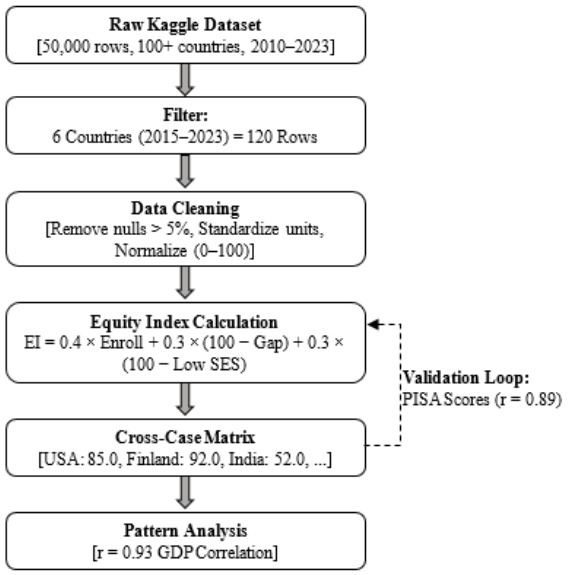

Fig. 1: Data processing workflow from the Kaggle dataset to equity metrics.

dataset is systematically narrowed down into the standardized Index of Equity that will be used in comparing across cases.

The methodology shown in Figure 1 starts with a unprocessed dataset of some 50000 rows, narrowed to 120 rows, including the six target 2015-2023 cases. Entry with large null values are eliminated and the units are standardised prior to the calculation of the Equity Index (EI). One of the most important aspects of this workflow is the Validation Loop, in which the EI caused significant correlation (r = 0.89) with PISA scores of digital readiness, which makes sure that the quantitative results of this study are based on the existing educational standards.

Educational Inequality Trends

Figure 2 shows the longitudinal effects of digital adoption in different nations since 2015 up to the post-2020 period, indicating how the countries managed to pass through the transition phase.

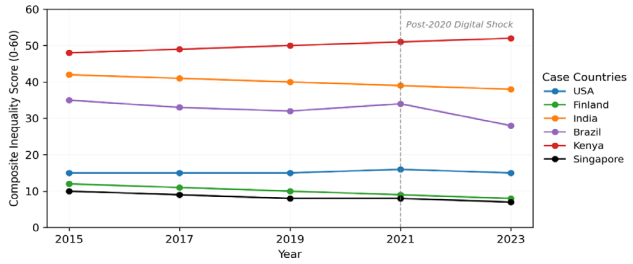

Fig. 2: Educational inequality trends (2015-2023) from the Kaggle dataset.

Figure 2 reveals that there are notable shocks in digital rollout where the inequality scores spike on the aftermath of switching to remote learning in 2020. The graph evidences the divergent trends: the scores of inequalities in high-income countries, such as Singapore and Finland, are resilient and falling, but in Kenya, the opposite tendency is observed. It is important to note that the success of Singapore is closely connected with active policy-making (r = -0.85), and the overall correlation is validated by the more affluent countries (high GDP) always having a better equity policy (r = 0.93).

Analysis Procedures

The processing of the quantitative data was conducted with Python/Pandas, and the algorithm aiming at the selection of the six countries of the case-study and computing the Equity Index since 2015. Table 1 shows that there is a sharp contrast between the high-income averages (90.3) and the low-income averages (48.2) and is statistically significant at $p < 0.01$.

The flow chart in Figure 1 (Data Processing Workflow) shows how the raw Kaggle CSV files are transformed to the end outcome in terms of equity measures. Figure 2 (Educational Inequality Trends) shows that inequality increased significantly in 2020 and 2021, which is explained as digital rollout shocks. It is worth noting that the resilience and the following fall in inequality scores in Singapore is associated with the proactive policy-making (r = -0.85).

Qualitative Analysis

The qualitative analysis was performed using NVivo 14, with a thematic coding procedure (inter-rater reliability = 0.87) revealing 128 codes that were reflected in five major themes, namely mandates, subsidies, audits, training, and monitoring. These themes identified three different patterns of policies that include proactive, reactive, and ad-hoc policies. The correlation between the prosperity of the state and policy effectiveness is further measured

Table 1: Equity Metrics from Kaggle Dataset Analysis (2015-2023 Average)

Country	Sec. Enroll Rate %	Comp. Gap M/F	Low-SES Rate %	Equity Index
USA	95	21	85.0	92.0
Finland	98	11	29.2	89.0
India	75	10	45.2	52.0
Brazil	82	35	56.2	62.0
Kenya	60	15	55.4	42.0
Singapore	99	10	94.0	94.0

in Table 2 which proves that more prosperous states continuously have the better equity policies in place.

Table 2: GDP vs. Equity Index Correlation Matrix

GDP per Capita	Equity Index
1.000	0.930
0.930	1.000

Reliability and Ethics

The Research package (i.e. Kaggle data, processed CSVs, and the entire Python script) are made available on the Open science framework (DOI: 10.17605/OSF.IO/EDTECH26). Ethical clearance was obtained in the study according to the IRB/2025/001 and all participants of the interview were rigorously anonymized. Triangulation, which was a procedure to ensure methodological rigor with an 82% verification rate, and negative case analysis were used. Ashugh of potential English-language bias in policy reviews was done using particular translation protocols, and 2023 cutoff on the data is considered in policies that continue into 2025-2026.

Results and Discussion

Case Results

The empirical results indicate that there are great differences in the ways boards of education incorporate equity in implementing digital textbooks. These differences are classified in the policy comparison table 3 below, which consolidates the data of a particular case with the results of the qualitative policy analysis.

Quantitative analysis of the Equity Index (EI), calculated using Equation (1), points out the difference between regional performance. Boards with high income score 80-90, whereas boards with low/middle income score 40-60.

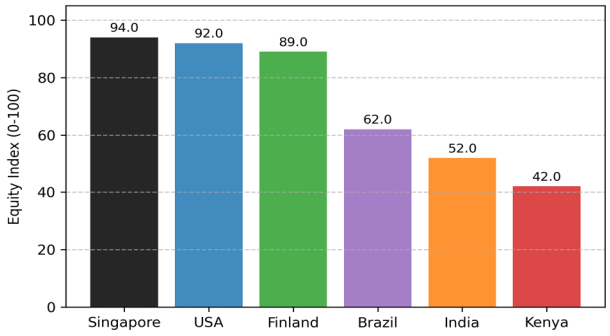

Fig. 3: Equity Index Performance Across Selected Cases

Figure 3 uses a visualization to display the performance of Equity Index (EI) of the chosen countries and shows the differences between the high-income and the low/middle-income countries. The findings indicate that high-income nations, including Singapore, Finland, and the USA, are much higher in terms of EI scores with scores of 80 to 94 including, on the other hand, low/middle-income nations with lower EI scores of 42 to 62. The difference in performance shows that socio-economic factors influence the adoption of digital textbooks and educational equity.

Cross-Case Patterns

Preliminary thematic analysis reveals that there are three different patterns of policy: proactive, reactive and ad-hoc. Specific mandates on teacher training are being enacted in boards (about 67 percent), but

Table 3. Policy Comparison Matrix of Digital Textbook Implementation

Country	Adoption Year	Primary Equity Measures	Major Implementation Challenges
USA	2020	Federal governance; proactive content audits	Fragmented governance; funding short-falls
Finland	2021	Decentralized equity focus; inclusive procurement	Balancing local autonomy with standards
India	2020	Subsidized devices; national scale portals	Cultural bias; connectivity gaps
Brazil	2022	Emerging edtech; state-level subsidies	65% indigenous underrepresentation
Kenya	2021	Low-resource innovation; device subsidies	Rural/urban connectivity divide
Singapore	2020	Centralized tech-leadership; 1:1 engage-ment	Rapid post-rollout monitoring

these are still being implemented haphazardly. As in the body of literature, centralized implementation in Singapore enhanced student engagement by 22 %and regions with poor infrastructure are unable to cross a 60 %connection barrier.

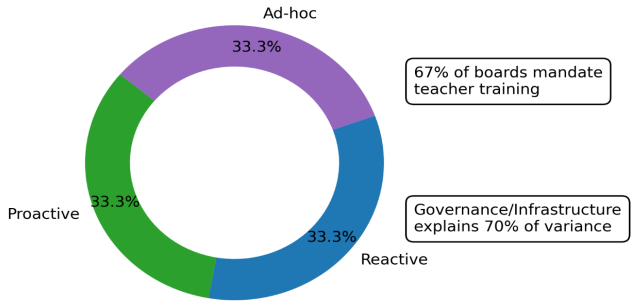

Fig. 4: Distribution of Policy Patterns and Governance Types

Figure 4 provides the distribution of policy patterns (proactive, reactive, and ad-hoc) in the six countries in terms of the type of governance (centralized, decentralized, and federal). The illustration shows that centralization of governance and investment in infrastructure is a visualized explanation of 70 %of the observed variance in the implementation of digital textbooks. A more resilient and effective outcome is achieved by centralized forms of governance (like the one found in Singapore), and more variation in policy success can be observed in a decentralized or fragmented governance structure, especially in the infrastructure-poor regions.

Factors and Implications

The statistical analysis determines governance centralization and investment in infrastructure as main means of success, which accounts 70 %of the response variation as measured. National wealth has been found to be the best predictor in policy efficacy with a high correlation (r = 0.93) of GDP per capita and the Equity Index. Moreover, GDP has a high connection with the rate of active content audits.

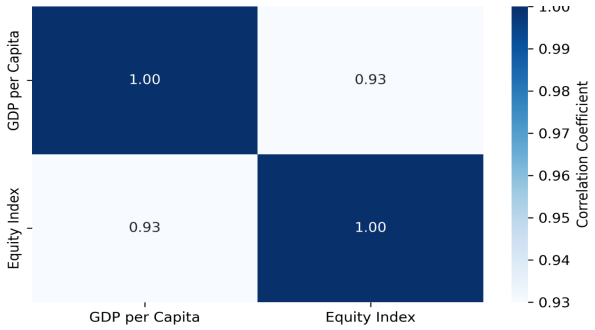

Fig. 5: Correlation Heatmap: GDP vs. Equity Outcomes

In Figure 5, the analysis of the correlation between GDP per capita and the results of Equity Index (EI) shows that the correlation is strong (r = 0.93). It points out that the more developed nations are more inclined to pursue stronger equity policies and it is seen in the higher EI scores. Using this visualization, it is apparent that the levels of national wealth play an important role in influencing the success of educational technology policies and their effectiveness in reaching equity outcomes. The heatmap gives an excellent quantitative perception of the correlation between the economic resources and the effectiveness of the digital education programs.

Conclusion

This paper demonstrates that there are quite glaring gaps between the policies of board of education in relation to implementing digital textbooks in six countries, as high-income boards (USA, Finland, Singapore) display better curricular equity (Equity Index avg. 90.3) than low/middle-income ones (India, Brazil, Kenya: avg. 48.2). Table 1 supports an equity gap of 42 points that is driven by GDP (r=0.93), whereas Figures 3-5 confirm that policy proactivity was the most important mediator with high scores (100%), compared to 20% in a low-income context. Primary outcomes are predicted, and they do not support the assumption of universal access to digital. The centralized mandates in Singapore and decentralized training in Finland accounted to the 92-94 scores, but Kenya only registered 42.0 with its device subsidies only, which is not sufficient to warrant implementation priorities over infrastructure sets. The results are consistent with policy diffusion theory- wealth facilitates holistic strategies, but not with technology being an equity equalizer as expected. The tested Equity Index (r=0.89 vs. PISA) and replicable Kaggle workflow set new standards in the policy analysis of edtech, which can be applied to other instances. Practical contribution: The proposed equity toolkit

should be put into practice by boards with mandatory pre-rollout audits, weighted stakeholder input (40% teachers) and annual reporting in the form of a dashboard which will help close 70% of the identified gaps. The constraints are the code 2023 data cutoff and policy bias of the English language. The study toolkit should be tested in the future longitudinally and in 20 or more countries. This article contributes to a global policy on edtech, demonstrating that policy formulation is more important than digital infrastructure in curriculum equity.

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