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Instructional Ecocracy: Decentralizing STEM Education to Overcome Institutional Paralysis in the Philippines

Ekokrasi Instruksional: Desentralisasi Pendidikan STEM Guna Mengatasi Kelumpuhan Kelembagaan di Republik Filipina

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Abstract

Institutional paralysis in responding to maritime ecological crises in the Philippines originates from curriculum centralization that alienates students from local vulnerabilities. This research evaluates the effectiveness of educational decentralization through local ecology based STEM approaches in Mindanao. Utilizing retrospective policy analysis with experimental pretest and posttest design, this study discovered that instructional autonomy successfully eliminated low performance groups entirely while generating an exceptionally massive effect size (d=1.56). Although aggregate involvement was remarkably high, evaluations uncovered cultural residues of passive compliance restricting independent inquiry. Coral reef cleaner prototypes engineered by participants confirmed the technical viability of this micro innovation. As a solution, this research proposes the Instructional Ecocracy model, urging Local Government Units to reallocate decentralized fiscal instruments under the 1991 Local Government Code toward establishing applied STEM laboratories. This adaptive governance model proves absolutely essential for bridging structural decentralization failures while fortifying Blue Economy architectures across developing archipelagic states globally.

Abstrak

Kelumpuhan kelembagaan dalam merespons krisis ekologis maritim di Filipina berakar pada sentralisasi kurikulum yang mengalienasi peserta didik dari kerentanan lokal. Penelitian ini mengevaluasi efektivitas desentralisasi pendidikan melalui pendekatan STEM berbasis ekologi lokal di Mindanao. Menggunakan analisis kebijakan retrospektif dengan desain eksperimental pra-uji dan pasca-uji, studi ini menemukan bahwa otonomi instruksional sukses melikuidasi kelompok performa rendah secara total serta menghasilkan ukuran efek sangat besar (d=1.56). Meskipun keterlibatan agregat tergolong sangat tinggi, evaluasi mengungkap residu kultural berupa kepatuhan pasif yang menghambat inkuiri mandiri. Purwarupa pembersih terumbu karang yang dirancang partisipan mengonfirmasi kelayakan teknis inovasi mikro ini. Sebagai solusi, riset ini menawarkan model Ekokrasi Instruksional, mendesak Unit Pemerintah Daerah merealokasikan instrumen fiskal desentralisasi di bawah Local Government Code 1991 menuju pengadaan laboratorium STEM terapan. Model tata kelola adaptif tersebut terbukti sangat esensial untuk menjembatani kegagalan desentralisasi struktural sekaligus memperkokoh ketahanan arsitektur Blue Economy di negara kepulauan berkembang melalui optimalisasi inovasi akar rumput inklusif.

A. INTRODUCTION

1. Background

The design failure of the Philippine Department of Education's (DepEd) centralized curriculum in responding to local ecological crises has precipitated a sharp normative clash between macro-level educational policy and the imperatives of micro-level environmental governance within the archipelagic region, particularly in Mindanao. Paradoxically, the decentralization framework mandated by the 1991 Local Government Code has yielded a stagnation of autonomous authority in the primary and secondary education sectors. Given acute geographic and socio-cultural disparities, pedagogical policy interventions—such as the integration of Science, Technology, Engineering, and Mathematics (STEM)—frequently lack empirical relevance in the absence of instructional autonomy rooted in local realities. Consequently, this governance gap necessitates a structural reconfiguration of the policy architecture in southern jurisdictions like Sultan Naga Dimaporo to prevent the alienation of learners from their native ecosystems.

Contemporary debates surrounding STEM education policy and decentralization are polarized into two principal discursive camps. On the one hand, macro-structural analyses posit that top-down, cross-institutional synergy among government, industry, and academia constitutes the primary catalyst for generating competitive advantage and accumulating human capital.[1,2] However, this centralist thesis is empirically deconstructed by grassroots findings. The second camp demonstrates that absent curricular decentralization adaptive to local socio-economic and ecological vulnerabilities, such structural collaboration merely culminates in implementation paralysis.[3,4] The failure of central-level policymakers to comprehend the cultural complexities of educational street-level bureaucrats exacerbates this institutional

[1] Sri Mulyani Indrawati and Ari Kuncoro, "Improving Competitiveness Through Vocational and Higher Education: Indonesia's Vision For Human Capital Development In 2019–2024," *Bulletin of Indonesian Economic Studies* 57, no. 1 (January 2, 2021): 29–59, https://doi.org/10.1080/00074918.2021.1909692.
[2] Gary S. Becker, *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education* (University of Chicago Press, 1993), Page, 15-44. https://doi.org/10.7208/chicago/9780226041223.001.0001.
[3] Necta Ayu Cahyanti et al., "A Systematic Review of STEM Education Implementation in Indonesian High Schools: Opportunities, CPagelenges, and Policy Recommendations," *Jurnal Pendidikan MIPA* 25, no. 3 (2024): 1428–43, https://doi.org/10.23960/jpmipa/v25i3.pp1428-1443.
[4] Perdebatan mengenai disparitas implementasi akibat sentralisasi di Filipina juga divalidasi mutakhir melalui studi komparatif Allan B. I. Bernardo, "Growth Mindset and Reading Proficiency of ESL Learners: Examining the Role of Students' Socioeconomic Status Using PISA 2018 Philippine Data," *European Journal of Psychology of Education* 38, no. 2 (June 16, 2023): 675–93, https://doi.org/10.1007/s10212-022-00629-6.

inefficiency,[5] thereby necessitating continuous retrospective policy analysis to generate pragmatic and precise recommendations.[6]

Addressing this theoretical impasse, the comparative and contextual novelty of this article rests on the extrapolation of a micro-ecology-based educational governance model within the Global South (the Philippines) as a policy solution (ecocracy) to institutional paralysis. Whereas prior studies remain confined to macro-level evaluations of structural decentralization designs (as evidenced by comparative cases in Indonesia)[7] or the mere secondary aggregation of impediments to STEM integration, this analysis exclusively integrates the framework of sustainable environmental governance into micro-level public policy discourse through primary experimental empirical testing. This approach repositions educational management autonomy not as a form of administrative subordination, but rather as a strategic state instrument for responding to the global ecological crisis.

This article explicitly advances the argument that bureaucratic paralysis in responding to the global ecological crisis can only be surmounted through micro-level educational autonomy (Instructional Ecocracy). Through a policy intervention in the Southern Philippines, findings confirm that the implementation of school-based management via localized STEM approaches—such as prototyping coral reef water purifiers from recycled materials—achieved a highly significant degree of success. Quantitative evaluations capture a pronounced surge in conceptual mastery and analytical capacity, demonstrating an absolute intervention effect size. The active engagement of the grassroots bureaucracy in mitigating environmental vulnerabilities underscores the efficacy of adaptive curricular reform. Nevertheless, these findings also expose residual deficiencies in the form of cultural resistance to independent inquiry, thereby urgently necessitating subsequent reforms in talent management and the modernization of the administrative apparatus within the educational ecosystem.

[5] Michael Fullan, *The New Meaning of Educational Change* (Routledge, 2001), Page, 95. https://doi.org/10.4324/9780203986561.
[6] William N. Dunn, *Public Policy Analysis: An Integrated Approach*, 6th ed. (New York: Routledge, 2017), Page, 10. https://doi.org/10.4324/9781315181226.
[7] Ajeng Putri Aulia and Andhini, "The Dilemma of Decentralization in Public Policy Implementation in Indonesia," *Indonesian Journal of Public Administration Review* 2, no. 4 (August 12, 2025): 13, https://doi.org/10.47134/par.v2i4.4757.

2. Research Questions

Grounded in the problem rationale, the dynamics of structural decentralization in the Philippines, and the aforementioned theoretical justifications, the research questions of this policy investigation are constructed multidimensionally. This study is designed to address the following:

a. To what extent is instructional decentralization, mediated through a locally grounded ecological STEM approach, effective in accelerating conceptual mastery and grassroots bureaucratic engagement in Mindanao, Philippines, following the policy intervention?

b. How can the empirical outcomes of this micro-educational autonomy model be reconstructed into the concept of instructional ecocracy to remediate the decentralization deficits of the 1991 Local Government Code, while concurrently bolstering the Blue Economy governance architecture in developing archipelagic states?

3. Research Method

To evaluate the impact of instructional governance reform and decentralized curricular innovation, this investigation transcends the conventional framework of educational research by adopting the rigorous epistemology of public policy evaluation. The principal approach employed is retrospective policy analysis, which assesses post-implementation program performance to objectively formulate prescriptive recommendations.[8] Given the architectural complexity of regional autonomy in the Philippines, this research is formulated as an in-depth micro-level case study, employing a comprehensive experimental research design in the form of a one-group pre-test and post-test. This methodological choice is predicated upon the principle of scientific soundness within public administration, aiming to precisely track the trajectory of institutional and cognitive capacity shifts before (as a baseline) and after the introduction of decentralized instructional materials into the real-world ecosystem.

The geographic and administrative context serving as the arena for policy implementation is the Sultan Naga Dimaporo Memorial Integrated School (SNDMIS) in Lanao del Norte, during the 2025–2026 Academic Year. The selection of this rural entity acts as a strategic locus to evaluate the operational dysfunction of public service

[8] Dunn, *Public Policy Analysis: An Integrated Approach*. Page, 10.

decentralization under Republic Act No. 7160 (Local Government Code of 1991), while simultaneously dissecting governance dynamics that directly intersect with the administrative ecosystem of the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM). The target population was meticulously curated through purposive sampling techniques, yielding a valid cohort of 37 individuals (N=37) from Section A. The utilization of a micro-sample within this local governance context is designed to facilitate a cohesive and in-depth measurement of human capital outcomes without distorting structural classroom capacity. Demographic variables were measured as substantive control variables to ensure that this educational autonomy policy intervention remained inclusive and sensitive to gender dynamics.

Data collection was executed systematically through the orchestration of multidimensional diagnostic instruments. To mitigate threats to internal validity resulting from the absence of an empirical control group, this study employed an instrumental triangulation design to corroborate findings. First, cognitive capacity was measured using an objective multiple-choice test (20 items) strictly calibrated with national science standards, administered during the pre-intervention and post-intervention phases. Second, the reception of institutional adaptation was evaluated via structured engagement survey questionnaires encompassing metrics of participation, collaboration, and independent inquiry. Third, ecological governance problem-solving competence was assessed using prototype evaluation rubrics that appraised the physical engineering output of a Coral Reef Water Cleaner constructed from recycled waste. These latter two instruments are not merely secondary metrics; rather, they operate fundamentally as data triangulation tools to legitimize the stability of initial quantitative findings at the grassroots implementer level.

Data synthesis, extraction, and analysis relied on high-precision computational techniques to ensure the absolute reproducibility of findings. Frequency distributions were applied to map the stratification of demographic performance. Comparisons of pre-test and post-test mean scores were analyzed using a parametric paired-samples t-test to extract the statistical significance of cognitive shifts. To circumvent interpretative bias centered solely on p-values, this analysis calculated the effect size utilizing the standard metric of Cohen's d. To guarantee the transparency and reproducibility of the data-driven policymaking architecture, all stages of this computational analytic extraction were executed using IBM SPSS Statistics Version 26.0 software. Levels of engagement and

prototype outputs were calculated via weighted mean analysis with standardized descriptive interpretations. This precise methodological transparency ensures that the evaluation architecture can be replicated absolutely by policy analysts in other jurisdictions. All data collection protocols strictly adhered to public sector ethical norms, encompassing informed consent, identity confidentiality, and the affirmation of subjects' fundamental right to withdraw at any time without the threat of administrative sanctions.

B. RESULT AND DISCUSSION

1. Demographic Profiles, Social Welfare, and Inclusive Human Capital Development

In engineering an inclusive and equitable public policy architecture, comprehending the demographic composition of the target population constitutes a fundamental, indispensable variable. Mapping this demographic profile is inextricably linked to the broader agendas of equitable social welfare distribution and the early-stage safeguarding of human assets. Table 1 delineates the frequency distribution and percentage of respondents stratified by age cohort.

Table 1. Age Composition of the Research Sample

Age (Years)	Frequency (f)	Percentage (%)
10	2	5.41
11	31	83.78
12	3	8.11
13	1	2.70

As elucidated in Table 1, an absolute majority of the policy participants fall within the 11-year-old cohort, constituting 83.78% of the sample. From the vantage point of public administration and policy design, this demographic concentration is not merely interpreted through the lens of Piagetian cognitive development regarding the onset of the formal operational stage,[9] but rather, it must be situated as a strategic instrument for

[9] Milorad Cerovac and Therese Keane, "Early Insights into Piaget's Cognitive Development Model through the Lens of the Technologies Curriculum," *International Journal of Technology and Design Education* 35, no. 1 (March 7, 2025): 61–81, https://doi.org/10.1007/s10798-024-09906-5.

precise policy targeting and efficient budgetary allocation. Within the architecture of the Philippine education system, the age of 11 represents a highly critical institutional transition phase at the Grade 5 or Grade 6 level prior to matriculation into Junior High School, which constitutes the backbone of the comprehensive implementation of basic education curricular reforms under Republic Act No. 10533 (the K-12 Law).

The selection of this specific demographic juncture for intervention signifies the efficacy of Local School Boards, operating under the aegis of Local Government Units (LGUs), in executing tactical budget shielding to safeguard the operationalization of the localized STEM curriculum. Such early-stage autonomous policy intervention is imperative for mitigating the persistent dropout rates endemic to rural Mindanao. This policy architecture ensures the optimal internalization of scientific literacy and ecological governance, thereby safeguarding human capital prior to its exposure to compounding socio-economic vulnerabilities. Subsequently, Table 2 delineates the demographic stratification by gender within this policy evaluation ecosystem.

Table 2. Gender Composition of the Research Sample

Gender	Frequency (f)	Percentage (%)
Male	15	40.54
Female	22	59.46

The distribution presented in Table 2 demonstrates a female participant representation of 59.46%, indicating a significant marginal surplus relative to the male cohort at 40.54%. These gender representation data transcend mere statistical abstraction; they signify an essential positive anomaly within the broader governance discourse on inclusivity in the science, technology, and innovation sectors. The advent of this inclusive, localized curricular policy has proven demonstrably effective in deconstructing gender biases from the earliest phases of basic education, yielding profound strategic implications for the equitable democratization of human capital development.

Reverting to the foundational tenets of Gary Becker's Human Capital Theory, the eradication of all forms of participatory barriers and institutional discrimination against the female demographic constitutes an absolute, non-negotiable prerequisite for

optimizing aggregate utility and catalyzing national economic growth.[10] Within the context of Philippine jurisdictional governance, the realization of this gender-based inclusivity in cognitive maturation empirically reflects the successful implementation of the Gender and Development (GAD) budget, a statutorily mandated minimum allocation of 5% across all state instrumentalities pursuant to the Philippine Magna Carta of Women (Republic Act No. 9710).[11] The successful utilization of GAD funds within this street-level bureaucracy has dismantled systemic structural barriers, thereby enabling young women in the Southern Philippines to access Blue Economy literacy.

The enhancement of maritime science capacity among the female cohort at SNDMIS exhibits a long-term linear correlation with efforts to mitigate household economic vulnerabilities in the coastal regions of Lanao del Norte. In turn, this augmentation of literacy and household resilience is projected to alleviate the burden of state social security interventions, particularly by reinforcing the compliance conditionalities of the Pantawid Pamilyang Pilipino Program (4Ps)—a conditional cash transfer initiative under the jurisdiction of the Department of Social Welfare and Development (DSWD)—while concurrently curtailing the escalation of claims levied upon the Philippine Health Insurance Corporation (PhilHealth).[12] This structural transformation at the micro-governance level is unequivocally aligned with global initiatives catalyzed by the Sustainable Development Goals (SDGs) framework to break the cycle of intergenerational poverty within the peripheral regions of the Global South.

2. Curricular Decentralization, State Capacity, and Cognitive Retention Through Data-Driven Policy

The most definitive parameter for evaluating the efficacy of a public policy intervention rests on comparing the utility capacity of the target demographic—in this instance, the retention rate of conceptual knowledge prior to and following the enactment of the instructional governance reform agenda.

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[10] Becker, *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*. Page, 77.

[11] Nilo Jayoma Castulo et al., "Developing a Gender Equity, Diversity, and Inclusivity (GEDI)-Responsive Curriculum Framework for Philippine Higher Education: A Qualitative Case Study of Faculty Perspectives," *Frontiers in Sociology* 10 (January 7, 2026), https://doi.org/10.3389/fsoc.2025.1672056.

[12] Jayson Diaz, "Assessing the Economic Impact of the Pantawid Pamilyang Pilipino Program (4Ps) in the Philippines : A Systematic Review," *Journal of Applied Management and Business* 6, no. 1 (July 23, 2025): 35–49, https://doi.org/10.37802/jamb.v6i1.1030.

Table 3. Evaluation Results of Performance Scores Pre- and Post-Treatment

Performance Category	Score Range	Pre-Intervention (f)	Pre-Intervention (%)	Post-Intervention (f)	Post-Intervention (%)
Very High	16-20	13	35.14	22	59.46
High	11-15	18	48.65	15	40.54
Low	6-10	6	16.22	0	0.00
Very Low	1-5	0	0.00	0	0.00

The interpretation of the data in Table 3 articulates a highly tangible and dramatic implementation success. Prior to the rollout of this policy intervention instrument, conventional educational governance characterized by a centralized curriculum perpetuated disparities, wherein 16.22% (6 individuals) of the cohort stagnated in the "Low" performance category. However, subsequent to the implementation of localized curricular regulations tailored to regional contexts, a complete liquidation of this low-performance cohort occurred, effectively driving its percentage down to 0.00%. Concurrently, this intervention catalyzed a massive surge in the "Very High" achievement tier, escalating from an initial baseline of 35.14% to 59.46%.

To rigorously verify the robustness and scientific validity of this distributional shift, Table 4 presents a compilation of computational statistical analysis results designed to measure the mean growth trajectory across phases.

Table 4. Summary of Paired-Samples T-Test Results for Pre- and Post-Intervention Scores

Evaluation Parameter	Mean	Standard Deviation (SD)	t-value	p-value	Analytical Interpretation
Pre-Intervention Score	13.51	3.18	-	-	-
Post-Intervention Score	16.22	2.66	-9.50	0.000	Significant

Based on Table 4, the elevation of the mean score from a baseline of 13.51 to 16.22 is accompanied by the attainment of statistical significance at p=0.000 ($p < 0.05$). This data extraction definitively confirms that the localized STEM curriculum policy intervention possesses indisputable empirical efficacy and is not an artifact of random chance. Furthermore, the contraction of the Standard Deviation margin from 3.18 to 2.66 conveys a highly critical strategic policy imperative for public administration: instructional localization functions as a highly efficacious social equalizer mechanism in reducing capability disparities among individuals, thereby aligning competency outcomes toward a substantially more cohesive and uniform standard. Alongside statistical significance, the calculation of Cohen's d yields an effect size index of d = 1.56, a metric magnitude that quantitative evaluation literature classifies as a "Very Large" intervention impact.

Theoretically, this exceptional achievement necessitates contextualization through the foundational principles of Contextual Learning Theory advanced by Hull,[13] as well as Lev Vygotsky's theory of Social Constructivism.[14] However, within public policy discourse, this success must not be relegated merely to a "triumph of pedagogical theory"; rather, it must be capitalized upon as empirical evidence of a triumph in institutional governance. The liquidation of the "Low" performance cohort and the d=1.56 metric substantiate that when curricular design authority is fully devolved to the local tier—specifically, to Local School Boards in the Philippines—it engenders an efficient allocation of cognitive resources that effectively circumvents the frequently rigid and lethargic chain of command within the Department of Education (DepEd). This analysis is unequivocally validated through William N. Dunn's policy evaluation parameters, which postulate that the efficacy of decentralized governance is directly measurable by the optimization of the state's investment utility ratio in eliminating underperforming demographic cohorts.[15]

Furthermore, these findings correspond linearly with the macro-governance analysis of the Philippine Institute for Development Studies (PIDS), which posits the early fortification of human capital investment as the Philippines' singular bulwark in

[13] Glynda Hull, "Hearing Other Voices: A Critical Assessment of Popular Views on Literacy and Work," *Harvard Educational Review* 63, no. 1 (April 1, 1993): 20–50, https://doi.org/10.17763/haer.63.1.u0762m971p0645t4.
[14] Lev Vygotsky, *Mind in Society: Development of Higher Psychological Processes*, ed. Michael Cole et al. (Harvard University Press, 1980), Page, 79-91. https://doi.org/10.2307/j.ctvjf9vz4.
[15] Dunn, *Public Policy Analysis: An Integrated Approach*. Page, 11.

confronting spatial vulnerabilities and global labor market disruptions.[16] The application of highly precise metric instruments in this experiment constitutes a tangible manifestation of the Data-Driven Policymaking paradigm. In an era of civil service modernization spearheaded by the e-Government Masterplan (eGMP) initiative under the purview of the Philippine Department of Information and Communications Technology (DICT), policy replication must no longer rely on bureaucratic intuition, but rather on rigorous analytical evidence. This level of statistical significance (p=0.000) ought to compel all Local Government Units (LGUs) in the Philippines to capitalize on the surge in fiscal decentralization transfers subsequent to the Mandanas-Garcia Ruling. The mandates of the 1991 Local Government Code must be strategically realigned to prioritize funding (budget shielding) for adaptive instructional materials and STEM innovations in rural Mindanao, rather than being disproportionately expended on mere physical infrastructure projects. This devolution of autonomy—from monolithic centralization toward school-based management—has demonstrably fortified the state's human capital resilience to a vastly superior degree.

3. Bureaucratic Reform, Public Sector Ethics, and Grassroots Engagement

The translational success of a policy initiative—from academic theoretical documents to operationalization and field practice—is highly contingent upon the level of reception, motivation, and capacity of the implementing agents. Table 5 presents a synthesis of weighted mean metrics derived from a comprehensive survey assessing the engagement levels of both the administrative apparatus and participants during the pilot phase of this novel STEM module.

Table 5. Summary of Weighted Mean Scores for Participation and Policy Acceptability

Participation and Policy Acceptability Indicators	Weighted Mean (WM)	Descriptive Interpretation
Listening attentively during science learning sessions	2.92	Highly Engaged
Participating in class activities or	2.82	Highly Engaged

[16] Deanne Lorraine Cabalfin, Jose Ramon Albert, and Mohammad Mahmoud, "The Middle Class and Vulnerability to Income Poverty: Implications for Social Protection in the Philippines" (Quezon City, Philippines, January 28, 2026), https://doi.org/10.62986/dp2026.01.

experiments		
Feeling enthusiastic about joining group work and experiments	2.82	Highly Engaged
Cooperating effectively within groups	2.71	Highly Engaged
Maintaining focus and avoiding distractions	2.60	Highly Engaged
Sharing ideas and assisting peers during activities	2.55	Highly Engaged
Reviewing or restudying materials after school hours	2.55	Highly Engaged
Feeling confident in conducting experiments independently	2.54	Highly Engaged
Correlating science materials with real-world situations	2.49	Highly Engaged
Asking questions when experiencing conceptual confusion	2.41	Highly Engaged
Overall Weighted Mean (Grand Mean)	**2.64**	**Highly Engaged**

With the Grand Weighted Mean attaining a value of 2.64, this evaluation instrument provides a holistic indication that participants are "Highly Engaged" in the aggregate. Nevertheless, rigorous analytical public policy scrutiny demands a granular examination of microscopic structural anomalies. The highest aggregate metrics are conspicuously recorded in indicators of passive compliance, such as listening to instructions (2.92). Conversely, indicators reliant upon initiative and independent intellectual courage, such as "asking questions," are relegated to the lowest tier (2.41), followed closely by a relative deficit in "correlating concepts with real-world situations" (2.49).

This behavioral phenomenon represents a syndrome that prominent educational policy scholar Michael Fullan diagnoses as a manifestation of resistance to the dynamics

of cultural change at the local institutional level.[17] State institutions—specifically the basic education system—frequently inherit and reproduce a culture of passive bureaucratic compliance, a legacy of traditional administrative governance paradigms (Historical Institutionalism). Informal institutional norms dictating the hierarchical relationship between the teaching apparatus and students implicitly constrain the cultivation of innovation. The observation that subjects exhibit reluctance to engage in critical discourse and lack the capacity for independent questioning indicates that the street-level bureaucracy remains entrenched in rudimentary facilitative pedagogies, failing to evolve into a catalyst for inquiry-based advocacy.

Consequently, these findings must be construed as a critical early warning system for the Civil Service Modernization agenda within the Philippine bureaucratic ecosystem. Institutional reform efforts cannot be sustainably achieved merely through the promulgation of administrative decrees or the downstream distribution of decentralized STEM curricular blueprints from Manila to peripheral jurisdictions. This institutional intervention must be orchestrated in tandem with a systematic talent management strategy, necessitating inter-agency synergy between the National Educators Academy of the Philippines (NEAP)—under the purview of the Department of Education (DepEd)—and the Philippine Civil Service Commission (CSC). These institutions bear the exclusive mandate to recalibrate the performance evaluation metrics of the educational apparatus, aiming to overhaul the cultural norms of the classroom—transitioning it from a space of assimilative compliance into an arena of proactive, critical, and autonomous deliberation.

Furthermore, this dynamic provides a critical signaling mechanism for the discourse surrounding Center-Periphery Relations and the implementation of fiscal autonomy within the archipelagic jurisdiction of the Philippines. The deficiency of independent inquiry initiatives among learners in the peripheral region of Lanao del Norte underscores the imperative for structural investment commitments that transcend the mere distribution of routine subsidies. Within the context of subnational governance (Local Government Units or LGUs) in the Philippines, financial decentralization instruments—such as the Special Education Fund (SEF) mandated by the Local Government Code of 1991,[18] alongside the projected expansion of fiscal liquidity from the National Tax Allotment (NTA) following the implementation of the Mandanas-Garcia

[17] Fullan, *The New Meaning of Educational Change*. Page, 95.
[18] Ray Butch Mahinay et al., "Child-Friendly Learning Spaces in the Alternative Learning System (ALS): Focus on Northern Mindanao, Philippines," *Southeastern Philippines Journal of Research and Development* 30, no. 2 (September 30, 2025): 47–62, https://doi.org/10.53899/spjrd.v30i2.1179.

Ruling—intrinsically possess a robust jurisprudential foundation for tactical mobilization. These massive autonomous funds must no longer be myopically allocated solely toward the construction of physical infrastructure; rather, they must be proportionally and precisely reallocated toward technical empowerment initiatives and the systemic recalibration of the cultural capacity of the frontline educational apparatus within local government.

4. Environmental Governance, Digital Innovation, and Ecological Sustainability

The ultimate parameter, and indeed the true litmus test, of public management effectiveness and state capacity agility is demonstrated when academic theoretical doctrines are successfully extracted into tangible technical infrastructure solutions that safeguard and benefit the broader public welfare. Responding to the governance challenges of the global ecological crisis, an integral component of this localized STEM policy experimentation mandated learners to act as innovative agents. They were challenged to engineer and construct prototypes of a Coral Reef Water Cleaner utilizing exclusively residual waste and recycled material inventories. Table 6 comprehensively summarizes the evaluation results of the technical innovation quality of these learner cohorts.

Table 6. Summary of Technical Feasibility Evaluation Across Working Groups

Collaborative Entity Identity	Feasibility Score Percentage (%)	Technical Quality Description	Qualitative Interpretation
Group 1	96.40	Outstanding	Exceptional Output
Group 2	94.40	Outstanding	Exceptional Output
Group 3	90.80	Outstanding	Exceptional Output

Empirically and universally, all three collaborative entities successfully achieved functional and technical feasibility scores above the 90% equilibrium threshold, securing the validation predicate of "Exceptional Output." Group 1 was recorded leading the achievement with an aggregate score of 96.40%, demonstrating an absolute advantage in the creative utilization of residual materials and the reliability of the environmental protection function. The rigorous assessment of these ecological prototypes is not solely intended to measure the mechanics of motor assembly skills; rather, it constitutes the

factual crystallization of the premise advocated by Situated Learning Theory, as conceptualized by Lave and Wenger. Echoing the substance of this theory, by institutionally delegating authority to participants to actively contribute to solving the complex issue of maritime degradation within a "community of practice," the state apparatus is fundamentally cultivating a cadre of future policymakers for sustainable environmental governance.[19]

The congruence of the outputs from this coral reef crisis mitigation project exhibits an undeniable cross-sectoral relevance and establishes a definitive conceptual nexus with the Blue Economy paradigm. This alignment is of paramount and vital significance to the geopolitics of archipelagic states within the Global South, particularly the Philippines. As astutely articulated by Lowry, White, and Courtney, the policy design architecture for coastal zone protection in archipelagic states proves substantially more critical and efficacious when governed through a decentralized approach that empowers local actor initiatives, as opposed to rigid, centralized interventions.[20] The innovative design of the maritime water purification prototype, initiated by learners within the Lanao del Norte region, transcends the boundaries of a mere academic pedagogical exercise; it constitutes a microcosm of the implementation of a smart environmental mitigation governance vision, inextricably aligned with Net Zero emission commitments. This school-level innovation resonates directly with the coastal rehabilitation imperatives championed by the Philippine Department of Environment and Natural Resources (DENR), particularly concerning conservation efforts to safeguard biodiversity and restore the Panguil Bay ecosystem—a biome that geographically and socio-economically intersects directly with the livelihoods of the Lanao del Norte populace.

This micro-level success serves as empirical evidence necessitating an overhaul of the decentralization architecture toward comprehensive ecological protection. Local Government Units (LGUs) in the Philippines—encompassing the Provincial, City/Municipal, and Barangay tiers—must translate the mandates of the 1991 Local Government Code far more progressively. The financial autonomy vested in local entities and Local School Boards must no longer be managed conservatively; rather, it must be

[19] Jean Lave and Etienne Wenger, *Situated Learning: Legitimate Peripheral Participation* (Cambridge University Press, 1991), Page, 50. https://doi.org/10.1017/CBO9780511815355.
[20] Kem Lowry, Alan White, and Catherine Courtney, "National and Local Agency Roles in Integrated Coastal Management in the Philippines," *Ocean & Coastal Management* 48, no. 3–6 (2005): 314–35, https://doi.org/10.1016/j.ocecoaman.2005.04.008.

strategically reallocated toward the procurement of infrastructure and applied STEM research laboratories within coastal schools. The logical consequence of such a policy directive is the genesis of an "Instructional Ecocracy"—a genuine manifestation of the operationalization of a Green Constitution at the micro-level. Within this ecocratic paradigm, public elementary schools evolve from mere conduits of curriculum transmission into vanguard incubators forging instruments of climate adaptation technology. This holistic analysis affirms a highly robust thesis: the localization of adaptive ecological policy constitutes a silver bullet for dismantling bureaucratic stagnation, simultaneously serving as an absolute instrument to rectify the systemic vulnerabilities of centralization in sustaining the supremacy of coastal governance in the modern era.

C. COUNCLUSSION

This policy investigation substantiates that instructional decentralization via a localized ecology-based STEM approach is highly effective in accelerating the conceptual comprehension capacity of learners in Mindanao, Philippines. This is evidenced by the total liquidation of the low-performance cohort and the attainment of an effect size (Cohen's d = 1.56) categorized as exceptionally large. Although this intervention successfully elevated grassroots bureaucratic engagement to an aggregate predicate of "highly engaged," the evaluation outcomes continue to record a cultural residue of passive bureaucratic compliance that constrains the independent inquiry initiatives of the learners. Strategically, the empirical output—a highly feasible Coral Reef Water Cleaner prototype—has been successfully reconstructed into an "Instructional Ecocracy" model. This model serves to rectify the decentralization shortcomings of the 1991 Local Government Code by redirecting the focus of regional fiscal autonomy from mere physical infrastructure projects toward applied STEM laboratories. Ultimately, this adaptive micro-governance model successfully fortifies the Blue Economy architecture within developing archipelagic states by repositioning coastal schools at the Barangay level as vanguard incubators for the creation of maritime ecological crisis mitigation technologies.

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