



Integrated Science Education: A Veritable Tool for Power and Employment Skills Acquisition for Changing Communities

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ABSTRACT

Rapid technological, economic, and environmental change in Nigerian communities has intensified demand for graduates who combine sound scientific understanding with transferable power skills and job-ready competencies. This study examined the extent to which integrated science education predicts power skills and employment skills acquisition among final-year pre-service Integrated Science teachers in Enugu State, Nigeria. Anchored on Human Capital Theory and Experiential Learning Theory, the study adopted a correlational survey design. A proportionate stratified random sample of 324 students was drawn from a population of 1,240 across three public teacher-education institutions, and 302 usable questionnaires (93.2%) were analysed. The 34-item Integrated Science Education and Skills Acquisition Questionnaire measured five constructs, all of which showed adequate reliability and validity (Cronbach's $\alpha = .86-.93$; composite reliability = .86-.93; average variance extracted = .55-.61). Hierarchical multiple regression showed that curriculum relevance and inquiry-practical instruction jointly explained 27% of additional variance in power skills beyond demographic controls, $\Delta R^2 = .27$, $F(2, 295) = 56.39$, $p < .001$, $f^2 = .38$, and 20% of additional variance in employment skills, $\Delta R^2 = .20$, $F(2, 295) = 37.73$, $p < .001$, $f^2 = .26$. Inquiry-practical instruction was the stronger predictor in both models. A bootstrapped mediation analysis (5,000 resamples) showed that power skills partially mediated the effect of integrated science education on employment skills, $ab = 0.185$, 95% CI [0.110, 0.270], accounting for 33.5% of the total effect. Inquiry-practical instruction was, however, the only construct rated below the criterion mean ($M = 2.47$). The study recommends deliberate expansion of hands-on, community-anchored practical work in Integrated Science programmes.

Keywords: integrated science education; power skills; employment skills; experiential learning; human capital; Enugu State

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1. Introduction

Communities across Nigeria are changing at a pace that few earlier generations experienced. Urban expansion, the spread of mobile and digital technologies, a persistent electricity supply gap, climate-related pressures on farming, and a youthful population entering a crowded labour market have together altered the kinds of knowledge and competence that people need in order to earn a living and to participate in community life. Enugu State reflects these dynamics sharply: it combines a fast-growing metropolitan centre with peri-urban and rural local government areas where agriculture, artisanal trades, small-scale commerce, and informal services remain the dominant sources of livelihood. In such settings, education is expected not merely to certify learners but to equip them with capabilities that can be converted into productive work and adaptive problem-solving.

Science education occupies a central place in this expectation. Nigeria's National Policy on Education positions science, technology, and vocational education as instruments for self-reliance and national development and emphasises practical, activity-based teaching at every level [1]. Within this policy architecture, Integrated Science has a distinctive role. At the junior secondary level the subject, now taught as Basic Science, presents concepts from biology, chemistry, physics, and earth and agricultural sciences as a unified body of knowledge organised around themes and real-life problems rather than disciplinary boundaries. At the tertiary level, colleges of education and faculties of education prepare Integrated Science teachers who are expected to model this integrated, problem-centred approach in schools and communities. The quality of integrated science education received by these pre-service teachers therefore matters twice: it shapes their own employability and it shapes the skills they will transmit to the next generation of learners.

International evidence suggests that integrated and inquiry-oriented approaches to science can yield substantial learning benefits. Meta-analyses have reported positive effects of integrative STEM approaches [2], inquiry-based teaching [3], [4], and active learning in undergraduate science [5]. Labour-market research shows that employers increasingly reward a combination of analytical, social, and adaptive competencies [6]–[8]. These transferable capabilities, which include critical thinking, communication, collaboration, adaptability, and self-management, are now widely described as power skills because they amplify the value of technical knowledge across occupations. What remains less clear is whether, and through what pathways, integrated science education as experienced by

students in Nigerian teacher-education institutions contributes to these power skills and to the more specific employment skills that enable graduates to secure or create work.

1.1 Statement of the problem

Despite policy commitments to practical, integrated science, several Nigerian studies have observed that science teaching at many levels remains largely theoretical and teacher-centred, with limited laboratory work, field investigation, or project activity [9]. When integrated science is taught mainly through lecture and note-taking, students may pass examinations without developing the investigative, collaborative, and entrepreneurial capabilities that the subject is designed to foster. The consequence is visible in the growing number of science-related graduates in Enugu State who report difficulty converting their qualifications into employment or self-employment, even as local economies generate demand for skills in renewable energy installation, water and sanitation, agro-processing, and science-based small enterprise.

Existing empirical work in Nigeria has concentrated on the effects of particular teaching methods on achievement scores in Basic Science and related subjects. Comparatively few studies have examined, with psychometrically validated instruments and effect-size reporting, how the broader quality of integrated science education relates to skill outcomes that matter for work and for community adaptation. Fewer still have tested whether power skills serve as a mechanism through which integrated science education contributes to employment skills. The problem of this study is therefore to determine the extent to which integrated science education, conceptualised as curriculum relevance and inquiry-practical instruction, predicts power skills and employment skills acquisition among pre-service Integrated Science teachers in Enugu State, and whether power skills mediate that relationship.

1.2 Purpose, questions, and hypotheses

The general purpose was to examine integrated science education as a predictor of power and employment skills acquisition among final-year Integrated Science students in public teacher-education institutions in Enugu State. Specifically, the study sought to determine the extent of curriculum relevance and inquiry-practical instruction; students' levels of power skills, employment skills, and awareness of community change; the effect of integrated science education on power skills and on employment skills; and whether power skills mediate the effect of integrated science education on employment skills.

Three research questions guided the study: (1) To what extent do students perceive curriculum relevance and inquiry-practical instruction? (2) What are students' levels of power skills, employment skills, and awareness of community change? (3) How strongly are the dimensions of integrated science education associated with power and employment skills?

The following null hypotheses were tested at the .05 level:

- H^0_1 . Integrated science education (curriculum relevance and inquiry-practical instruction) has no significant effect on students' power skills acquisition after controlling for sex, age, and institution.
- H^0_2 . Integrated science education has no significant effect on students' employment skills acquisition after controlling for sex, age, and institution.
- H^0_3 . Power skills acquisition does not significantly mediate the effect of integrated science education on employment skills acquisition.

The findings are expected to benefit curriculum planners, lecturers, students, and Enugu State policymakers by identifying which aspects of integrated science education carry the greatest weight for skills outcomes, and by providing construct-level reliability, validity diagnostics, and effect sizes as a replicable baseline.

2. Conceptual Clarification

Integrated science education refers to an approach in which scientific concepts and processes are presented as a unified whole, so that learners appreciate the fundamental unity of scientific thought and apply it to real problems rather than to isolated disciplinary exercises [10], [11]. In this study it was operationalised through two dimensions. Curriculum relevance (ISC) captures the degree to which course content is perceived as connected to everyday life, local industry, and community problems. Inquiry-practical instruction (IPI) captures the frequency and quality of hands-on laboratory work, investigations, fieldwork, projects, and improvisation of materials.

Power skills are transferable human capabilities that enable individuals to apply knowledge effectively across tasks and settings. Consistent with employer surveys and labour-market analyses [8], [12], they were operationalised as critical thinking, problem-solving, communication, collaboration, adaptability, creativity, self-management, and leadership initiative. Employment skills are job-specific and enterprise-oriented competencies that enable a person to obtain paid work or create self-employment, including safe handling of equipment, basic installation and maintenance of simple technologies, production of science-based goods, record-keeping and costing, and identification of a viable science-based business opportunity. Changing communities are localities undergoing significant shifts in economic base, technology use, demography, and environment. Awareness of community change (CCA) was measured as students' recognition of such shifts and of the new skill demands they create. CCA was included to describe context, not as a hypothesised predictor.

3. Theoretical Framework

3.1 Human Capital Theory

Human Capital Theory, articulated by Schultz [13] and developed by Becker [14], holds that knowledge and skills are forms of capital in which individuals and societies invest, and that such investment raises productivity and earnings. Subsequent research refined the theory by showing that the quality of skills acquired, rather than years of schooling alone, drives economic returns [15], and that both cognitive and non-cognitive abilities are rewarded in the labour market [7]. The theory frames integrated science education as an investment whose value depends on whether it produces transferable and job-specific skills. It also implies that, in rapidly changing economies, general and transferable skills may protect individuals against skill obsolescence more effectively than narrow occupational training alone [16].

3.2 Experiential Learning Theory

Kolb's Experiential Learning Theory [17], which builds on Dewey's argument that genuine education grows out of experience [18], describes learning as a cycle in which concrete experience is followed by reflective observation, abstract conceptualisation, and active experimentation. When students conduct investigations, handle materials, work on projects that address community problems, and reflect on the outcomes, they move through the full learning cycle. Instruction that remains at abstract conceptualisation, without concrete experience or active experimentation, is unlikely to generate the problem-solving, collaboration, and hands-on capabilities that constitute power and employment skills. The theory therefore predicts that inquiry-practical instruction should be a stronger predictor of skills outcomes than curriculum relevance alone.

The two theories are complementary. Human Capital Theory specifies why skills acquisition matters. Experiential Learning Theory specifies the mechanism by which instruction is converted into skill. Bandura's concept of self-efficacy [19] adds a further link: mastery experiences in practical work strengthen learners' belief in their capacity to perform. Taken together, the framework implies a sequence in which integrated science education develops power skills, and power skills, alongside direct effects of instruction, enable employment skills. This sequence underlies Hypothesis 3.

4. Review of Empirical Studies

A substantial body of evidence links integrated and inquiry-oriented instruction to improved learning. Becker and Park [2] meta-analysed 28 studies of integrative STEM approaches and reported positive average effects on achievement. Minner et al. [4] synthesised 138 studies of inquiry-based science instruction and found that a majority reported positive effects on conceptual understanding, particularly where instruction emphasised active thinking. Furtak et al. [3] found a moderate average effect of inquiry-based teaching, with larger effects when teachers guided the inquiry. Schroeder et al. [20] found that enhanced context, collaborative learning, questioning, inquiry, and manipulation of materials were each associated with gains in science achievement. Freeman et al. [5] analysed 225 studies and found that active learning increased examination performance by about half a standard deviation. Design-based and project-based STEM studies likewise report achievement gains that vary with implementation quality [21], [22]. Within Nigeria, Ozoji [9] reported benefits of concept mapping in junior secondary Basic Science and Technology, while noting the persistence of conventional, teacher-centred instruction.

Hands-on engagement develops capabilities beyond content knowledge. Undergraduate research experiences have been associated with gains in data skills, tolerance for obstacles, and confidence [23]–[25]. Reviews of problem-based learning indicate that authentic problems support flexible knowledge and collaboration, provided learners receive adequate guidance [26], [27]. Economic research shows why these skills matter: computerisation reduced demand for routine tasks and increased demand for non-routine analytical and interactive tasks [6]; returns to social skills rose, particularly when combined with mathematical skill [8]; and non-cognitive abilities predict earnings as strongly as cognitive abilities [7]. Cognitive skills, rather than years of schooling, are strongly related to earnings and growth [15], and the advantage of general education grows over the life cycle as economies change [16]. Employers rate professionalism, teamwork, oral communication, and critical thinking among the most important skills for new entrants, and judge many entrants deficient in them [12].

Teachers value STEM integration but report pedagogical challenges, curriculum constraints, structural limitations, assessment pressures, and inadequate support [28], [29]. The benefits of integrated science education therefore depend on the extent to which inquiry and practical work are actually implemented. Most of the evidence comes from outside Africa, focuses on achievement rather than skills, and rarely examines the pathway from instruction through transferable skills to employment-oriented competence. No study known to the author has examined, with construct-level reliability evidence and effect sizes, whether integrated science education predicts power and employment skills among pre-service Integrated Science teachers in Enugu State, or whether power skills mediate that relationship.

5. Method

5.1 Design, area, and population

The study adopted a correlational survey design, appropriate where the aim is to establish the strength and direction of relationships among naturally occurring variables and to test predictive and mediational hypotheses without manipulating the independent variables. The study was carried out in Enugu State, South-East Nigeria, which comprises 17 local government areas and a mix of urban, peri-urban, and rural communities. The state was chosen because it hosts several public teacher-education institutions offering Integrated Science and because its communities are experiencing marked economic and technological change. The population

comprised all 1,240 final-year students enrolled in the Integrated Science programme in three public teacher-education institutions during the 2025/2026 session. Institutions are designated A, B, and C. Final-year students were targeted because they had completed most coursework, practical work, and teaching practice.

5.2 Sample

An a priori power analysis for multiple linear regression, following G*Power 3.1 [30], with six predictors, $\alpha = .05$, power of .80, and a conservative $f^2 = .05$, required 279 participants. The Krejcie and Morgan table [31] for a population of 1,240 indicated about 294. The larger estimate was increased by 10% for non-response, giving a target of 324. Proportionate stratified random sampling was used, with institution as the stratum. Of 324 questionnaires distributed, 302 were usable (93.2%). Achieved power to detect $f^2 = .05$ was .84. Mean age was 23.54 years ($SD = 2.34$).

Table 1. Distribution of population, sample, and usable returns.

Variable / category	Population	Distributed	Usable	% of returns
Institution A	484	126	118	39.1
Institution B	427	112	104	34.4
Institution C	329	86	80	26.5
Male	—	—	147	48.7
Female	—	—	155	51.3
Age 20 and below	—	—	26	8.6
Age 21–25	—	—	213	70.5
Age 26–30	—	—	63	20.9
Total	1,240	324	302	100.0

Note. Response rate = $302/324 = 93.2\%$. Dashes indicate that population figures were not stratified by sex or age.

5.3 Instrument, validity, and reliability

Data were collected with the researcher-developed Integrated Science Education and Skills Acquisition Questionnaire (ISESAQ). Section A captured sex, age, and institution. Section B contained 34 items in five clusters: curriculum relevance (ISC; 6 items), inquiry-practical instruction (IPI; 7), power skills acquisition (PSA; 8), employment skills acquisition (ESA; 8), and community change awareness (CCA; 5). Items were rated on a four-point scale from Strongly Disagree (1) to Strongly Agree (4). A criterion mean of 2.50 was used to interpret extent of agreement. Face and content validity were established by three experts. Confirmatory factor analysis of the five-factor model fitted well: $\chi^2(517) = 574.71$, $p = .040$, $\chi^2/df = 1.11$, CFI = .990, TLI = .989, RMSEA = .019 [32]. All standardised loadings exceeded .68, alpha and composite reliability exceeded .85, and average variance extracted exceeded .50 [33], [34]. Discriminant validity was supported by the Fornell–Larcker criterion and by HTMT ratios of .12 to .54, below .85 [35].

Table 2. Reliability and convergent validity of the ISESAQ constructs ($N = 302$).

Construct	Items	Loadings	α	CR	AVE	$\sqrt{AVE}$
Curriculum relevance (ISC)	6	.69–.81	.89	.89	.57	.76
Inquiry-practical instruction (IPI)	7	.72–.80	.91	.91	.59	.77
Power skills (PSA)	8	.72–.82	.91	.92	.57	.76
Employment skills (ESA)	8	.75–.84	.93	.93	.61	.78
Community change awareness (CCA)	5	.69–.78	.86	.86	.55	.74

Note. All loadings $p < .001$. Thresholds: α and CR $\geq .70$; AVE $\geq .50$. CFA: $\chi^2(517) = 574.71$, CFI = .990, TLI = .989, RMSEA = .019.

5.4 Data collection and analysis

The questionnaire was administered in person with three trained research assistants. Permission was obtained from heads of department. Participation was voluntary and anonymous. Research questions were answered with means, standard deviations, and Pearson correlations. Hypotheses 1 and 2 were tested with hierarchical multiple regression: sex, age, and two institution dummy codes (Institution A as reference) at Step 1, and the two integrated science dimensions at Step 2. Effect sizes were Cohen's f^2 [36]. Hypothesis 3 used a simple mediation model with the integrated science composite (mean of 13 ISC and IPI items) predicting employment skills through power skills. The indirect effect used 5,000 bootstrap resamples and 95% percentile confidence intervals [37], [38]. Variance inflation factors ranged from 1.02 to 1.25, Durbin–Watson statistics were 2.04 and 2.14, and skewness and kurtosis lay within ± 1 . Harman's single-factor test explained 32.2% of item variance, below the 50% level suggestive of serious common-method bias [39]. Analyses used Python 3 (statsmodels and semopy) at $\alpha = .05$.

6. Results

Students agreed that their integrated science curriculum was relevant to everyday life and community needs ($M = 2.83$, $SD = 0.70$), with 70.9% scoring at or above the criterion mean. Inquiry-practical instruction ($M = 2.47$, $SD = 0.72$) fell slightly below 2.50, and only 47.4% scored at or above it. Students reported moderate power skills ($M = 2.69$) and employment skills ($M = 2.58$), and high awareness of community change ($M = 2.89$). Inquiry-practical instruction had the strongest correlation with power skills ($r = .49$, $p < .001$) and a moderate correlation with employment skills ($r = .41$). Curriculum relevance correlated moderately with both ($r = .39$ and

.35). Power skills and employment skills correlated at $r = .45$. Community change awareness was weakly related to the other constructs.

Table 3. Descriptive statistics, criterion attainment, and intercorrelations ($N = 302$).

Construct	M	SD	% ≥ 2.50	Decision	1	2	3	4	5
1. ISC	2.83	0.70	70.9	High	(.76)				
2. IPI	2.47	0.72	47.4	Low	.41***	(.77)			
3. PSA	2.69	0.70	63.9	High	.39***	.49***	(.76)		
4. ESA	2.58	0.73	56.3	High	.35***	.41***	.45***	(.78)	
5. CCA	2.89	0.70	71.2	High	.10	.22***	.15**	.24***	(.74)

Note. Mean ≥ 2.50 = high extent. Diagonal values in parentheses are $\sqrt{\text{AVE}}$. ** $p < .01$. *** $p < .001$. ISC = curriculum relevance; IPI = inquiry-practical instruction; PSA = power skills; ESA = employment skills; CCA = community change awareness.

6.1 Hypothesis 1

Control variables did not significantly predict power skills, $R^2 = .02$, $F(4, 297) = 1.56$, $p = .185$. Adding the integrated science dimensions increased explained variance, $\Delta R^2 = .27$, $F(2, 295) = 56.39$, $p < .001$, a large effect ($f^2 = .38$). The full model explained 29% of the variance, adjusted $R^2 = .28$. Both inquiry-practical instruction ($\beta = .39$, $p < .001$, $f^2 = .182$) and curriculum relevance ($\beta = .22$, $p < .001$, $f^2 = .055$) were significant. Hypothesis 1 was rejected.

Table 4. Hierarchical regression of power skills on integrated science education (H01).

Predictor	B	SE	β	t	p	95% CI for B	f^2
Constant	0.972	0.377		2.58	.010	[0.230, 1.715]	
Female	0.028	0.069	.02	0.40	.686	[-0.109, 0.165]	
Age	0.009	0.015	.03	0.61	.544	[-0.020, 0.038]	
Institution B	-0.135	0.081	-.09	-1.68	.094	[-0.294, 0.023]	
Institution C	-0.123	0.087	-.08	-1.41	.159	[-0.294, 0.048]	
ISC	0.220	0.055	.22	4.03	<.001	[0.112, 0.327]	.055
IPI	0.386	0.053	.39	7.33	<.001	[0.282, 0.490]	.182

Note. $N = 302$. Step 1 $R^2 = .02$. Step 2 $R^2 = .29$, adjusted $R^2 = .28$; $\Delta R^2 = .27$, $\Delta F(2, 295) = 56.39$, $p < .001$; block $f^2 = .38$. Reference: male; Institution A. VIF = 1.02–1.25; Durbin–Watson = 2.04.

6.2 Hypothesis 2

Controls did not predict employment skills, $R^2 = .02$, $F(4, 297) = 1.26$, $p = .286$. Integrated science dimensions added $\Delta R^2 = .20$, $F(2, 295) = 37.73$, $p < .001$, a medium effect ($f^2 = .26$). The full model explained 22% of the variance. Inquiry-practical instruction ($\beta = .32$, $f^2 = .108$) and curriculum relevance ($\beta = .21$, $f^2 = .047$) were both significant. Hypothesis 2 was rejected.

Table 5. Hierarchical regression of employment skills on integrated science education (H02).

Predictor	B	SE	β	t	p	95% CI for B	f^2
Constant	0.868	0.413		2.10	.037	[0.054, 1.681]	
Female	-0.038	0.076	-.03	-0.50	.621	[-0.187, 0.112]	
Age	0.012	0.016	.04	0.77	.443	[-0.019, 0.044]	
Institution B	-0.055	0.088	-.04	-0.63	.531	[-0.229, 0.119]	
Institution C	0.078	0.095	.05	0.82	.411	[-0.109, 0.266]	
ISC	0.222	0.060	.21	3.72	<.001	[0.105, 0.340]	.047
IPI	0.326	0.058	.32	5.65	<.001	[0.213, 0.440]	.108

Note. $N = 302$. Step 2 $R^2 = .22$, adjusted $R^2 = .20$; $\Delta R^2 = .20$, $\Delta F(2, 295) = 37.73$, $p < .001$; block $f^2 = .26$. Durbin–Watson = 2.14.

6.3 Hypothesis 3

Integrated science education predicted power skills (path a: $B = 0.613$, $SE = 0.058$, $p < .001$). Controlling for integrated science education, power skills predicted employment skills (path b: $B = 0.301$, $SE = 0.061$, $p < .001$). The total effect was significant ($c = 0.552$) and remained significant, though smaller, when power skills were included ($c' = 0.367$). The indirect effect was 0.185, 95% CI [0.110, 0.270], excluding zero. The completely standardised indirect effect was 0.151, and power skills accounted for 33.5% of the total effect. Because both indirect and direct effects were significant, mediation was partial. Hypothesis 3 was rejected.

Table 6. Mediation of employment skills by power skills (H03).

Path / effect	B	SE	t	p	95% CI
a: ISE $\rightarrow$ PSA	0.613	0.058	10.52	<.001	—
b: PSA $\rightarrow$ ESA (controlling ISE)	0.301	0.061	4.93	<.001	—
c': Direct effect, ISE $\rightarrow$ ESA	0.367	0.072	5.11	<.001	—
c: Total effect, ISE $\rightarrow$ ESA	0.552	0.064	8.67	<.001	—

Path / effect	B	SE	t	p	95% CI
ab: Indirect effect via PSA	0.185	0.041			[0.110, 0.270]
Completely standardised indirect	0.151				[0.090, 0.221]
Proportion mediated (ab/c)	.335				

Note. ISE = mean of 13 ISC and IPI items ($M = 2.64$, $SD = 0.60$). Models controlled for sex, age, and institution. Indirect-effect intervals are 95% percentile bootstrap intervals (5,000 resamples).

Table 7. Summary of hypothesis testing.

Null hypothesis	Key statistic	p	Effect size	Decision
H01: ISE → PSA	$\Delta F(2, 295) = 56.39$	<.001	$f^2 = .38$ (large)	Rejected
H02: ISE → ESA	$\Delta F(2, 295) = 37.73$	<.001	$f^2 = .26$ (medium)	Rejected
H03: ISE → PSA → ESA	ab = 0.185, CI [0.110, 0.270]	<.05	PM = .335	Rejected (partial)

Note. Benchmarks for f^2 : .02 = small, .15 = medium, .35 = large [36].

7. Discussion

The first notable finding is a gap between the perceived relevance of the curriculum and the extent of inquiry-practical instruction. Students agreed that what they studied was connected to real life, but they did not report frequent hands-on investigation, fieldwork, or project work. This pattern is consistent with Nigerian observations that science teaching often remains theoretical despite curriculum intentions [9] and with international reviews identifying structural, material, and time constraints on integrated teaching [28], [29]. The integrated science curriculum in these institutions appears better designed than it is delivered.

Integrated science education made a large contribution to power skills ($f^2 = .38$) and a medium contribution to employment skills ($f^2 = .26$), after controlling for sex, age, and institution. These results support Human Capital Theory's prediction that the quality of educational investment is reflected in the skills learners acquire [14], [15], and they extend meta-analytic evidence on integrative and active approaches [2], [5] from achievement to skill outcomes that bear directly on work. Sex, age, and institution were not significant, indicating a broadly similar association across groups in the sample.

Inquiry-practical instruction was consistently the stronger predictor, with unique effects roughly three times that of curriculum relevance for power skills and more than twice that for employment skills. This is what Experiential Learning Theory predicts [17], and it echoes evidence that guided inquiry and practical experience develop independence and confidence [3], [4], [24], [25]. Combined with the first finding, it identifies a clear lever: the dimension that matters most for skills is the one students currently experience least. Power skills partially mediated the effect on employment skills, carrying about one-third of the total effect. The remaining direct effect is most plausibly explained by direct exposure to equipment, materials, and production processes. For changing communities, where occupations may appear and disappear quickly, transferable capabilities help graduates adapt when particular technical skills become obsolete [16]. Expansion of practical work should be structured and guided, not unsupervised discovery [3], [27].

7.1 Implications and limitations

For lecturers, reallocating contact time from lecture to structured investigation, fieldwork, and community-based projects is likely to yield the largest skills gains. Institutional managers need functional laboratories, consumables, and partnerships with local enterprises in renewable energy, water treatment, and agro-processing. Curriculum regulators should give practical and project work weight comparable to written examinations. For the Enugu State Government, the effect sizes suggest that investment in practical science facilities in teacher-education institutions is likely to have a multiplier effect, because these graduates will teach Basic Science across the state's changing communities.

The cross-sectional design does not permit firm causal conclusions. All constructs were self-reported; future studies should add performance-based assessments and employer ratings. The sample was limited to three public institutions in one state. The study measured employment skills rather than actual employment; a tracer study of graduates would test whether the skills identified here translate into work and enterprise.

8. Conclusion and Recommendations

Integrated science education is a meaningful predictor of both power skills and employment skills among pre-service Integrated Science teachers in Enugu State, and power skills form a significant pathway between them. The dimension that matters most, inquiry-practical instruction, is also the dimension that students experience least. Integrated science education can be a veritable tool for skills acquisition in changing communities, but only to the extent that its practical, experiential promise is realised in classrooms, laboratories, and the communities themselves.

1. Teacher-education institutions in Enugu State should increase the proportion of integrated science contact time devoted to structured laboratory work, investigations, fieldwork, and community-based projects, and should assess such work as a substantial component of course grades.
2. Government and institutional managers should equip and maintain integrated science laboratories and provide consumables, while encouraging improvisation from local resources.

3. Lecturers should be supported through continuing professional development in guided inquiry, project-based learning, and the explicit teaching of collaboration, communication, and problem-solving.
4. Institutions should partner with local enterprises and community organisations so that students can apply integrated science to real problems, for example in solar energy, water treatment, and food processing.
5. Researchers should conduct longitudinal, experimental, and graduate tracer studies to confirm the pathways identified here and to link skills acquisition to employment outcomes.

Declarations

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Data availability. Anonymised questionnaire scores are available from the corresponding author on reasonable request.

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