Re-skilling Science Teachers to Promote Inclusive Technology Integration and Productive Employment in Ogun State, Nigeria

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Abstract

This study investigates the impact of re-skilling science teachers on fostering inclusive and productive employment that will improve students' performance. One of the pivotal dimensions of this research is its emphasis on inclusivity in teachers' instructional practices. In an era characterised by diverse student populations, re-skilling initiatives that cater for educators from various backgrounds, fostering a more representative teaching force is imperative. By adopting an ex post facto design through a quantitative approach, surveys, and classroom observation checklists were used to rate teachers and students to identify the existing gaps in science education and illuminate the potential solutions for equitable access to quality learning. Data were collected from 90 teachers before and after a professional development programme held in Ogun state, Nigeria. Data were analysed using descriptive statistics, t-test, and structural equation modelling (SEM). Results indicated that teachers in the experimental group scored higher than their counterparts in the other group in technology integration in their instructional practices. The outcome of this research provides insights to inform policy decisions, curricular reforms, and teacher training programs on an international scale. By shedding light on effective re-skilling strategies and the symbiotic relationship between science education and employment opportunities, this study contributes to a more inclusive, skilled, and adaptable global workforce.

Keywords: Inclusive, Instructional Practices, Re-skilling, Teachers, Workforce

Introduction

In recent years, the demand for a highly skilled and adaptable workforce has intensified due to rapid technological advancements and changes in the global job market [1, 18]. Science education plays a pivotal role in preparing individuals to thrive in this evolving landscape. However, science education is equally undergoing transformation to impart knowledge in various forms, and continuously echoes the need for evolution. Therefore, as this transformation undergoes rapid technological advancements, the traditional roles of teachers are also evolving, necessitating a paradigm shift towards re-skilling and upskilling initiatives to ensure that science teachers are equipped to effectively integrate technology into their teaching practices. This imperative is especially crucial in the intersection of education, technology, and employment presents both challenges and opportunities [1, 3].

The integration of technology in education offers unparalleled opportunities to enhance learning outcomes, engages students effectively, and prepares them for the demands of the 21st-century workforce. However, realising these benefits requires science teachers to possess not only a strong pedagogical foundation but also proficiency in leveraging diverse technological tools and platforms. Moreover, in a global economy increasingly driven by digital innovation, the ability of teachers to foster digital literacy and critical thinking skills among students is essential for their future success and employability. Amidst this shift, a new beacon emerges in terms of an integrated Science, Technology, Engineering, and Mathematics (STEM) education which is a movement with the potential to reshape the trajectory of global employment and innovation [1, 2, 3,] Moreover, the scarcity of STEM-qualified professionals is in the heart of technological advancement. This alarming concern echoes across Africa, underscoring the importance of integrated STEM education [3, 6 19]. This paradigm shift beckons beyond the conventional silos of knowledge and embrace a more holistic approach. The shift therefore requires re-skilling science teachers with emerging pedagogies that incorporate technological tools in the classroom and several studies [30, 14] have indicated different ways of using technology and have shown positive results.

Today, despite the awareness of the importance of technology for effective teaching and learning, teachers are still not integrating technology into their classroom teaching. This problem contributes to teachers being deficient in knowledge, skills, abilities, or competencies in relation to technology use. Al-salami [4] anticipated that barriers to technology integration encompass not merely a deficiency in specific technological knowledge and skills but also a shortage of knowledge and skills related to pedagogical practices supported by technology and classroom management in a technological context. Integrated STEM education is not just a curriculum; it's a mindset, a way of thinking that empowers students to bridge disciplines, unravel complexities, and innovate solutions in STEM to solve real-world problems.

[1.] Adebusuyi, O. F., Bamidele, E. F., & Adebusuyi, A. S. (2020). Effects of In-Service Chemistry Teachers' Technological Pedagogical Content Knowledge on Students' Scientific Attitude and Literacy in Southwestern Nigerian Secondary Schools. *European Journal of Interactive Multimedia and Education*, *1*(2), e02009. https://doi.org/10.30935/ejimed/9306

[2.] Álvaro Aguilar-González, María Muñoz-Catalán, and José Carrillo, "An Example of Connections between the Mathematics Teacher's Conceptions and Specialised Knowledge," *Eurasia Journal of Mathematics, Science and Technology Education* 15, no. 2 (December 14, 2018).

[3.] Akaygun, Sevil, and Fatma Aslan-Tutak. "STEM Images Revealing STEM Conceptions of Pre-Service Chemistry and Mathematics Teachers." *International Journal of Education in Mathematics, Science and Technology* 4, no. 1 (January 3, 2016): 56.

[4.] Aksit, Necmi. "Educational Reform in Turkey." *International Journal of Educational Development* 27, no. 2 (March 2007): 129 – 37. 21.

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This is the essence of integrated STEM – cultivating minds that can identify, apply, and fuse concepts from diverse fields to tackle challenges and drive progress. [7, 8, 9, 10].

An aspect of Dewey's theory suggests that teachers serve as intermediaries between the student's needs and the curriculum's demands. Dewey [10] proposed that teachers hold a distinct reservoir of professional expertise, encompassing content-specific knowledge, broad pedagogical understanding, and insights into human development as it pertains to education.

Proficient educators employ technological and pedagogical knowledge to contemplate their teaching methodologies, adjusting them through feedback and self-evaluation. This reflective approach enables teachers to continuously improve their skills, stay relevant in an ever-changing educational landscape, and provide meaningful learning experiences for all students. At the heart of this transformation are the teachers – the guiding lights who shape the future. They are the architects of change, and their skills need to evolve to lead this revolution. A resounding success in re-skilling science teachers towards technology integration is the key to unlocking a wave of productive employment opportunities across the globe. Our educators need to be more than just instructors; they need to be catalysts of innovation.

Educational systems across nations are making concerted efforts to prioritise STEM education, channelling resources into initiatives, workshops, and programs. These endeavours are commendable, yet the true measure of their success lies in their impact on students' learning outcomes. The transformative power of professional development must not be lost – it must resonate in the classrooms, empowering educators to become champions of integrated STEM learning [7, 30].

The fusion of science, technology, engineering, and mathematics is more than just a pedagogical strategy – it is a paradigm shift. It is a bridge between theory and application, between the classroom and the real world. Teachers who embrace this integration are leading their students toward a future where boundaries are blurred, and possibilities are endless.

[4] Al Salami, Mubarak K., Carole J. Makela, and Michael A. de Miranda. "Assessing Changes in Teachers' Attitudes toward Interdisciplinary STEM Teaching." *International Journal of Technology and Design Education* 27, no. 1 (November 3, 2015): 63–88.
[7] Dong, Yan, Jing Wang, Yunying Yang, and Premnadh M. Kurup. "Understanding Intrinsic Challenges to STEM Instructional Practices for Chinese Teachers Based on Their Beliefs and Knowledge Base." *International Journal of STEM Education* 7, no. 1 (September 10, 2020).
[8] Du, Wenbin, Denghui Liu, Carla C. Johnson, Toni A. Sondergeld, Virginia L. J. Bolshakova, and Tamara J. Moore. "The Impact of Integrated STEM Professional Development on Teacher Quality." *School Science and Mathematics* 119, no. 2 (January 24, 2019): 105–14.
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However, ensuring inclusive and productive employment opportunities across the globe requires not only skilled professionals but also teachers who can impart these skills effectively. Apparently, success is not solely defined by knowledge and skills [11]. Beliefs are the underpinning of action [14]. Teachers' beliefs – their self-efficacy, their perceptions of what is possible – shape the classroom experience and these beliefs can be reshaped through purposeful, well-designed professional development. It's about equipping and reskilling teachers with the belief that they can lead their students into the uncharted territories of integrated STEM education. [13, 30].

The transformation needed in STEM education requires teachers to change their beliefs, and practices. It's about fostering a generation of learners and educators who can navigate the complex landscapes of the modern world.

This study therefore seeks to examine the influence of re-skilling science teachers to promote inclusive and productive employment in Ogun state, Nigeria.

Research Objectives

The specific objectives of this study are to:

1. determine the current level of science teachers' technological pedagogical knowledge in secondary schools in Nigeria
2. examine the epistemological beliefs held by science teachers in secondary schools in Ogun State, Nigeria, regarding the role of technology in education.
3. investigate the effectiveness of comprehensive technology integration training on science teachers' competence in using technology for instructional purposes.
4. explore the impact of effective re-skilling of science teachers through technology integration training on student performance in science subjects.

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[30] Walker, Tracy M., Trina Spencer, Shandra Claiborne-Payton, and Leslie Whiteman. "Putting Theory into Practice: An Examination of Preservice Teachers' Beliefs about Teaching Science." *International Journal for Cross-Disciplinary Subjects in Education* 8, no. 3 (September 30, 2017): 3151–59.

Research Questions

In line with the above stated objectives, the following research questions were raised:

i. What is the level of science teachers' technological pedagogical knowledge in secondary schools in Ogun State Nigeria?
ii. What epistemological beliefs do secondary school science teachers hold in Ogun State Nigeria?

Research Hypotheses

H_1: Science teachers who participated in training in technology integration will demonstrate a higher level of competence in using technology in their instructional practice compared to those who do not receive such training.

H_2: Effective re-skilling of science teachers through technology integration training positively led to increased student performance (SP) in science subjects.

Materials and Methods

This study employed an ex post facto research design, aiming to establish causal relationships among the identified variables. The population encompassed all science teachers (physics, chemistry, biology, mathematics, and computer teachers) and Senior Secondary School II students in Ogun State, Nigeria. The study collected data from a total of 90 selected science teachers and 884 students within their respective intact classes. Among the participants, 47 were re-skilled science teachers, while 43 were non-reskilled science teachers. To ensure a representative sample, a multistage sampling technique was utilised. The initial step involved the stratified random sampling of nine Local Government Areas (LGAs), with an unequal distribution of three LGAs from each senatorial district within the state. Subsequently, a total of five secondary schools were purposively selected from each of the chosen LGAs. The selection criteria for schools included the availability of technological tools and resources conducive to effective technology integration. Within each selected school, one science teacher was purposively chosen for participation, provided they had attended the two PSI-PMI training of trainers' program for STEM teachers in Ogun state in Dec 2022. This criterion ensured that the selected teachers had a substantial exposure to modern teaching methodologies and technology integration strategies.

The professional development programme in Ogun state, Nigeria took place between Dec 7-22, 2022 and it was a project sponsored by the Ogun State Government under its Ogun State Economic Transformation Project (OGSTEP). Two consulting organisations are involved viz: New Jersey Centre for Teaching and Learning (NJCTL) www.njctl.org and African University of Science and Technology (www.aust.edu.ng). As a way of background, AUST in response to the request for proposals (RFP) issued by Ogun State Ministry of Education on improvement of STEM education teaching and learning collaborated with the New Jersey Centre for Teaching and Learning (NJCTL) to engage in the training of a few cohorts of teachers in selected schools to introduce the Progressive Science initiative/Progressive Mathematics Initiative (PSI/PMI) which has a successful history of outcome improvement in schools across several continents of the world. Whereas NJCTL provides its digital content and align them with extant national and regional benchmarks, AUST in conjunction with 50 facilitators trained STEM teachers. During this period, 750 trainers of teachers (TOTs) drawn from a pool of STEM teachers working within the Ogun State public school's sector. Moreover, learning objectives were aligned with the West African Examinations Council (WAEC) syllabus with the NJCTL content in a manner that ensures stakeholder buy-in as well as understanding of the pedagogic, technological, and content arrangement being introduced during the training sessions. Embedded in the training plan are a series of stakeholders sensitisation activities and practical demonstrations of a flipped classroom that ensures interactive learning, integrated formative assessment and student-focused learning.

The instruments used were Science Teachers Technological Pedagogical Knowledge Observation Checklist (STTPKOC), Chemistry Teachers Epistemological Belief Questionnaire (CTEBQ), and Chemistry Students Science Process Skills Observation Checklists (CSSPSOC). By adopting this comprehensive sampling strategy and methodological approach, the study aimed to holistically explore the impact of re-skilling science teachers for technology integration on both teacher practices and student performance, thereby contributing valuable insights to the enhancement of science education in the context of global empowerment.

Results and Findings

Research Question 1: What is the level of science teachers', technological pedagogical knowledge, in secondary schools in Ogun State Nigeria?

Table 1: Level of Science teachers Technological, Pedagogical, Knowledge

Factors of TPK	N	Max. Score Obtainable	Min	Max	Mean	SD	Adjusted Mean	Level
PK	90	16	4	15	11.18	2.51	69.88	1
TK	90	16	4	14	8.04	2.69	50.25	2
TPK	90	12	3	9	5.55	2.11	46.25	3
Total		100						

Table 1 showed the level of science teachers' knowledge on the factors of technological pedagogical knowledge. Statistics of mean and adjusted mean were used to adjudge the factor that was possessed and applied more among the participants in in the study area. The pedagogical knowledge (11.18, 69.88) was ranked 1, followed by technological knowledge (8.04, 50.25), and technological pedagogical knowledge (5.55, 46.25). This can be represented as PK > TK > TPK. The result obtained showed that participants possessed the least knowledge on the TPK component.

Research Question 2: What epistemological beliefs do secondary school science teachers hold in Ogun State Nigeria?

Table 2: Epistemological beliefs of Science Teachers

Epistemological Beliefs	Range	N	Min	Max	Mean	Standard Deviatn	Level
NEB	0-100	78	73	100	91.83	7.79	0
SEB	102-150	12	101	120	111.71	5.91	1
	Total	90					

Note: SEB = Sophisticated Epistemological Beliefs; NEB = Naïve Epistemological Beliefs

The result obtained from the Table 2 implies that respondents with naive epistemological beliefs orientation in teaching with technology (n = 78) had significantly higher frequency of teacher-centred practices (*M* = 91.83, *SD* = 7.79) than teachers (n = 12) with sophisticated epistemological beliefs orientation in technology use. (*M* =111.71, *SD* = 5.91). The result implied that a higher portion of respondents in the study area possessed more naive epistemological beliefs than they possessed sophisticated epistemological beliefs.

Testing of Hypotheses

Hypothesis 1: Science teachers who participated in training in technology integration will demonstrate a higher level of competence in using technology in their instructional practice compared to those who do not receive such training.

Table 3: Independent Sample t-test for the Re-skilled and Not – reskilled Science Teachers on instructional practices and epistemological beliefs

	Group	N	M	SD	Df	T	Sig
Instructional Practices	Not-Reskilled Teachers	47	42.93	4.20	88	-2.667	.009** (Significant)
	Re-Skilled Teachers	43	47.53	4.04			
Epistemological Beliefs	Not-Reskilled Teachers	47	93.95	3.64	88	-1.703	.092 (Not significant)
	Re-Skilled Teachers	43	99.74	4.28			

Table 3 showed that the p-value associated with the t-test for instructional practices is significant ($p < 0.005$), indicating that there is a statistically significant difference in instructional practices between the two groups. Specifically, science teachers who underwent technology integration training (Re-Skilled Teachers) demonstrated a significantly higher mean score (47.53) in their instructional practices compared to those who did not receive such training (Not-Reskilled Teachers) with a lower mean score (42.93). Furthermore, from table 3, the difference in the mean score for epistemological beliefs between the two groups is not significant ($p >$

0.005), indicating that there is no statistically significant difference in epistemological beliefs between the two groups. In this case, science teachers who underwent technology integration training (Re-Skilled Teachers) did not exhibit a significantly different mean score (99.74) in their epistemological beliefs compared to those who did not receive such training (Not-Reskilled Teachers) with a mean score of 93.95.

Hypothesis 2: Effective re-skilling of science teachers through technology integration training positively leads to increased student performance (SP) in science subjects.

Table 4

Variables	SE	B	*P*	LL95% CI	UL95% CI
Direct effects					
TPK → EPB	.001	.53	<.01	.142	.996
TPK → SP	.003	.33	<.05	.008	.604
EPB → SP	.007	.05	Ns	-.156	.303

Note. TPK = Technological Pedagogical Knowledge, EPB = Epistemological Beliefs, SP = Students Performance, LL = lower limit, UL = upper limit, SE= standard error, ns = not significant.

The results from Table 4 provide insights into the relationship between the variables of interest. For the relationship between Technological Pedagogical Knowledge (TPK) and Epistemological Beliefs (EPB), a significant positive effect was found ($\beta = 0.53$, $p < 0.005$). Similarly, the association between TPK and Student Performance (SP) was found to be positive and significant ($\beta = 0.33$, $p < 0.005$). However, the relationship between Epistemological Beliefs (EPB) and Student Performance (SP) showed a positive effect, it was not statistically significant ($\beta = 0.005$, $p =$ Ns).

Discussion

This study addressed the issue of re-skilling science teachers as a strategic approach to fostering inclusive and productive employment in Ogun State, Nigeria. In an era of rapid technological advancements and evolving educational paradigms, the role of science education in preparing a skilled workforce has become increasingly pivotal. However, this task is hindered by various challenges, such as outdated pedagogical methods, inadequate teacher training, and a lack of inclusivity in educational approaches.

This study indicated that overall, respondents had a low level of technological pedagogical knowledge and therefore, are still operating at the level 1 of Akaygun [2] scale which connotes lack of technology use. This could be interpreted as teachers still lacking the integration of technology with appropriate pedagogical knowledge in their classrooms. This result is in agreement with the studies of [7, 25] where a standard-setting method was used to investigate teachers, proficiency levels (1-lack of use, 2-simple adoption, 3- infusive application, and 4-reflective application).

Research has posited that teachers with more sophisticated epistemological beliefs are more likely to integrate technology into their lesson notes than those that possessed naïve beliefs about technology use. Invariably this could translate to practicing technology integration into the teaching of science concepts in the classroom.

This study implied that a larger percentage of the respondents in the study area possessed naïve epistemological beliefs. The findings of this study regarding the level of science teachers' epistemological beliefs were generally consistent with initial work of researchers on epistemological beliefs like that of a study carried out by [30]. Their study showed teachers' epistemological beliefs were moderately favorable towards inquiry based instructional approach. About 83.4% of the teachers were found to have only moderately favorable epistemological beliefs while 14.6% of them have unfavourable beliefs.

The result obtained in the study indicated that reskilled science teachers' TPK had significant effect on students' performance. The finding is consistent with the results of Aguilar-Gonzalez [1] which explored a study on the relationship between teachers TPCK levels, students' self-efficacy and academic achievement. It also examined the difference between teachers' TPACK levels according to gender and professional experience. The study revealed that TPACK levels of teachers were related to 12% of students' achievement.

[7]Dong, Yan, Jing Wang, Yunying Yang, and Premnadh M. Kurup. "Understanding Intrinsic Challenges to STEM Instructional Practices for Chinese Teachers Based on Their Beliefs and Knowledge Base." *International Journal of STEM Education* 7, no. 1 (September 10, 2020). https://doi.org/10.1186/s40594-020-00245-0.
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However, the results of the study disagreed with the study of Farrell [10] which found no significant relationship with teacher's VAM score and the TPACK survey overall or its individual constructs. The present study shows that participation in SPDP, epistemological beliefs are important factors responsible for technology integration in science teachers' instructional practices. The study also mirrors that of Thibaut, et al. [31] who in their research concluded that though teachers do not have enough experience during their pre-service education at the teacher training college.

Therefore, ongoing professional development for science teachers, with mentorship programs where they could be given guidance and support is needed. This mentorship can be done remotely, offering personalised advice and a safe space for discussing teaching strategies. The journey towards effective STEM instruction requires a holistic approach. Re-skilling science teachers is not a simple task; it's a movement, a transformation of mindsets and methodologies. Through purposeful Professional Development Programs (PDP), a new generation of teachers can be nurtured who will inspire and empower the students. By merging technology with STEM, students will be equipped for a world brimming with opportunities and challenges. It's time to reiterates the re-skilling for teachers. If teachers are empowered, then success can be guaranteed in the future.

The study delved into the level of Technological Pedagogical Knowledge (TPK) among science teachers, revealing a prevalent deficiency in their technological pedagogical understanding. This observation corresponds to the acknowledgment that many teachers are still at the foundational stage of technology use, lacking the seamless integration of technology and pedagogy within their classrooms. This finding underscores the importance of enhancing teachers' proficiency in merging technological tools with effective pedagogical strategies to create engaging and impactful learning experiences. Furthermore, the investigation explored the epistemological beliefs of science teachers in the Ogun State area, uncovering a majority with less sophisticated beliefs. This revelation suggests a connection between teachers' beliefs about technology and their willingness to incorporate it into their instructional practices. These results align with earlier research in the field, underlining the need to address teachers' epistemological perspectives to facilitate the integration of technology and science concepts.

Recommendation

The study recommends that science teachers should be exposed to current technological pedagogical practices that can allow them to earn within and outside their own country through these enhanced skills. Invariably, the traditional narrative of seeking employment abroad will be challenged. A nation that invests in its educators invests in its future, fostering an environment where local talent thrives and contributes to economic growth, innovation, and societal progress. The study emphasises the role of purposeful professional development programmes in equipping science teachers with these skills which are also needed to cater to diverse learners effectively.

Governments and educational institutions can use the insights gained to design and implement more effective re-skilling initiatives. The research can also contribute to the broader conversation on curriculum development and teacher training in the context of the rapidly changing global employment landscape.

Conclusion

The study concludes that most of the participants displayed knowledge about TPCK at Levels 2 and 3, but their application was at Level 1. In a rapidly evolving era marked by technological advancements and shifting educational paradigms, the role of science education in preparing a skilled and diverse workforce has taken on heightened significance. However, this noble pursuit is impeded by several challenges, including outdated pedagogical practices, insufficient teacher training, and a lack of inclusivity in educational approaches.

The study suggests a significant link between re-skilled science teachers' TPK and students' academic performance. In the journey towards effective STEM instruction, the study advocates for a comprehensive approach to re-skilling science teachers. This process is not merely a task but a transformative movement that necessitates a shift in mindsets and methodologies. Through intentional Professional Development Programs, a generation of teachers can be nurtured to inspire and empower students. By harmonising technology with STEM subjects, students will be able to confront the opportunities and challenges of an ever-evolving world. The need to re-skill teachers resonates deeply, for in empowering teachers, there is a promising future for generations to come. This research vividly underscores the global significance of re-skilling science teachers to facilitate inclusive technology integration and to foster productive employment opportunities worldwide.

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Conflict of Interest Declaration

No conflict of interest was declared for this study.