EXPLORING THE IMPACT OF THREE-TIERED COGNITIVE APPRENTICESHIP IN BRIDGING ENTREPRENEURIAL PEDAGOGICAL GAP AMONG PRE-SERVICE INTEGRATED SCIENCE TEACHERS

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Abstract

The global landscape is experiencing diverse emerging needs like: income inequality, quality education, gender equality, sustainable development and poverty eradication. In alignment with the giant strides by the world of academia to combat these problems, this study examined the impact of two models of three-tiered cognitive apprenticeship on bridging entrepreneurial pedagogical gap of Pre-service Integrated Science Teachers (PISTs). The study adopted a 3 x 2 quasi-experimental research design. The sample was 115 PISTs from three Colleges of Education located in South-West, Nigeria. Data were collected with a self-designed Integrated Science Entrepreneurial Practical Test (ISEPT) with a Richard Kuderson's value of 0.824, this implied a good reliability of the ISEPT. Two research questions were answered with mean and standard deviation and three null hypotheses were tested with Analysis of Covariance. The results showed that the two models (outside-school and inside-school) of cognitive apprenticeship had significant impact on the entrepreneurial skill development of the PISTs in the two experimental groups [$F_{(2,\ 111)}$ =75.08; p>.05]. This study therefore, recommends the two models of cognitive apprenticeship as three-tiered instructional strategies that can help bridge pedagogical gap by assisting PISTs learn entrepreneurial skill in an iterative, interpretative and incremental way.

Keywords: Poverty eradication, Cognitive apprenticeship, Entrepreneurial skill development, Entrepreneurial pedagogical gap, Three-tiered learning

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Introduction

More than ever, there are increasing diverse human needs across the globe; these needs include: poverty alleviation, income inequality, quality education, climate change mitigation and adaptation, access to healthcare and universal health coverage, digital inclusion and connectivity, peace, justice, and strong institutions, gender equality and women empowerment, and, sustainable development (United Nations, 2015; United Nations Educational, Scientific and Cultural Organization, 2015; Intergovernmental Panel on Climate Change, 2018; World Health Organization, 2019; International Telecommunication Union, 2017; and World Bank, 2019). There are research concerns on how to meet these needs; the world of academia is making giant strides on how to combat these problems especially on economic, social and environmental, which are the three dimensions of sustainable development identified in the 2030 agenda for sustainable development (United Nations, 2015). Although, in 2018, labour productivity increased by 2.1% from 2017 which is the highest since 2010, a persistent problem identified by United Nations (2019) is that 20% of young people are not in school, employment or training. This raises serious concern because it will affect their dependence on parents or guardians for survival; it will increase likely involvement in vices like drug addiction and crime, increase depression and reduce productivity, just like the popular saying goes *that an idle hand is the devil's workshop.* Youths of all shades: in school, employment, and training or in none of these are needed to be gainfully engaged if the 2030 sustainable development goals (SDGs) will be achieved.

Gainfully engaging these youths involves giving them an enabling Education that will make them useful to themselves, the nation and the globe as the case may be. The enabling Education that will prepare them to face the real world challenges. The 21st century world-of work places huge demand for creativity and innovation for those who will not only survive therein but contribute significantly to national and global growth; this raises research interests on how to adjust the primitive educational styles that put too much prominence on conformity to established and organised ways of doing things as this may reduce creativity and innovation. By nature, youths are usually energetic, they need educational platforms that can help develop creative critical thinking skills, problem identification skills, and develop entrepreneurial mindsets that are open to exploring new possibilities. Entrepreneurship is pivoted on identifying opportunities and generating innovative ideas. It translates creative ideas into tangible innovations that have value in the market. In entrepreneurship, risk taking is inevitable, as students are exposed to entrepreneurship, they are allowed to make mistakes as they explore in solving identified or assigned tasks. The teacher guides them to make meaning out of their mistakes and helps to identify better ways of doing things; this also creates resilience in them. It is important to train students who are not only active consumers of knowledge but creative consumers of knowledge.

Many tertiary institutions are making efforts to bring entrepreneurship into the formal Education setting. Some of these schools have incubation units where the entrepreneurial ideas of students or staff members are nurtured. For instance, University of Aberdeen has incubation units like: ABVenture Zone and Life Science Innovation (University of Aberdeen, 2023). Institutions like: University of Rio de Janeiro, State University of Campinas, Federal University of Parana among others. Also in Nigeria, entrepreneurship centres are becoming popular in tertiary institutions like Lagos state University, Ojo; University of Lagos, Akoka; and, Federal College of Education, Akoka among others. The Entrepreneurial classes offered in some of the institutions include: tailoring, baking, interior and exterior decorations, soap making, disinfectant production, insecticide production, automobile repairs, web designs, graphics and art designs. It is interesting to add that schools are making efforts to expose male and female students entrepreneurship, this against the primitive culture of treating the girl-child as a second fiddle. This stride needs to be amplified at a critical moment like this, in the globe when women use about triple the amount of time that men use each day in unpaid care and

domestic work, thereby widening their socioeconomic disadvantage (United Nations, 2015). This places huge request on maximizing every opportunity that a teacher has to interact with the female students. The teacher should seize the opportunity as being golden. As Educational institutions make assiduous efforts to reduce unemployment by bringing entrepreneurship into the formal Education; and with the needs to equip youths with needed skills to thrive well in the world-of work and also create job opportunities, it is important to examine instructional strategy that can help reduce pedagogical gaps in teaching entrepreneurship in schools. This study therefore examined triple-tiered cognitive apprenticeship as an instructional strategy for bridging pedagogical gaps among male and female pre-service Integrated Science teachers.

Research Questions

Two research questions were raised and answered in this study:

1. What is the impact of outside-school cognitive apprenticeship, inside-school cognitive apprenticeship and lecture method on the Pre-service Integrated Science teachers?

2. What is the difference in the entrepreneurial skill development of male and female pre-service Integrated Science teachers' taught anaerobic respiration with inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method?

Null Hypotheses

Three null hypotheses were formulated and tested:

H_{01}: There is no significant impact of outside-school cognitive apprenticeship, inside-school cognitive apprenticeship and lecture method on pre-service Integrated Science teachers' entrepreneurial skill development in anaerobic respiration.

H_{02}: There is no significant difference in the entrepreneurial skill development of male and female pre-service Integrated Science teachers' taught anaerobic respiration with inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method.

H_{03}: There is no significant interaction impact of teaching strategies and gender on pre-service Integrated Science teachers' entrepreneurial skill development in anaerobic respiration.

Literature Review

Learning occurs both in the formal and informal settings. In the informal setting, students can learn from social interaction in the family, among peers, social media, religious organisations, cultural settings and apprenticeship. Traditional or primitive apprenticeship is used to communicate entrepreneurship in many countries. For example, in South-East Asia, cotton is popularly woven on looms into various designs of textiles and Penan hunters of Sarawak make very beautiful mats (Novellino, 2019). In Ghana, apprenticeship is used teach carpentry, masonry, tailoring, vehicle driving, painting, wiring electronics and auto-mechanics is popular (Danso & Osei, 2021). There are families in Abeokuta (a city located in South-West, Nigeria) highly notable for locally made fabrics called "Adire". Similarly, the Ijaws are respected for their skilfulness in traditional orthopaedics while among the Hausa race, using horns for treatment is observed. All these and others pleasurably engage their children in apprenticeship. Jennifer *et al.*, (2016) noted that apprenticeship was employed in providing technical and artisan skills. The report added that training professionals such as lawyers and doctors for hundreds of years also involved apprenticeship. For example; in the Middle Ages, doctors-to-be learnt medicine as apprentices, they were taught something about herbs and surgical skills by

older peers (Gourevitch, 1999); up till the early 19th century when students who aspired to be physicians learned medicine from engaging in practical sessions and reading as offered by their preceptors. Apprenticeship later became a prototype for clinical training as still being practised today (Falvey, 2010).

In the formal setting, there are structured and planned activities for learning. A learning theory that this study is anchored on is constructivism. Constructivism is a learning theory that advocates that the teacher provides an enabling environment to aid his learners "construct meaning" from a lower level of knowledge to a higher level of knowledge without feeling that the learner is a *tabula rasa*; that is totally empty of knowledge. Major contributors to the foundations for constructivism are: Lev Semyonovich Vygostsky (1896-1943), Jean Piaget (1896-1980), John Dewey (1859-1952) and Jerome Bruner (1915-2016). Justin (2017) defines constructivism as a worldview which posits that learning is an active, constructive process where the learner is an information constructor. Townley (2010) presents constructivism as including students in not only the learning but the teaching. Similarly, Bates (2015) described constructivism as a constantly dynamic learning process that places a strong emphasis on learners developing personal meaning through reflection, analysis and gradual building of layers or depths of knowledge through conscious and ongoing mental processes.

In the words of Taber (2018), "constructivism focuses on the individual learner as a meaning maker, and considers that learning as a process of interpreting experience using prior learning as the basis for new learning. From this perspective, learning could be iterative (as new learning draws on existing understanding), interpretative (as the individual draws upon internal interpretative resources such as their existing conceptions for sense making) and, incremental (as the human cognitive system can only construct new knowledge at a limited rate, and it takes time for new learning to be consolidated sufficiently for it to act as robust foundations for further learning)". This study adopts this three-tiered learning ways to its use of cognitive apprenticeship as an instructional strategy for teaching anaerobic respiration.

The term cognitive apprenticeship was first introduced by Collins *et al.*, in 1989. The advocacy for cognitive apprenticeship also came into the limelight after Professor Lave visited Liberia in 1988, for a combination of participant-observation research (ethnography) among many tribal tailors and their apprenticeship; and, an experiment on cognitive skills. The research, by Lave (1988) showed the tailors' ability to generalise and transfer their arithmetic problem-solving skills to unfamiliar problems. The research generated a vital question if schooling was the only avenue to develop cognitive skills since the traditional tailor-apprenticeship system had a goal, which was to transfer complex inter-related knowledge. Since then, research concerns have been growing on how to devolve cognitive apprenticeship into the school setting. In cognitive apprenticeship, the teacher is expected to model the strategies and activities necessary to solve problems, while providing appropriate scaffolds also referred to as organizational strategies and other supporting resources to the learners (Kailani & Ikar, 2015). Dimakos *et al.* (2010) put it that 'learning is not detached from the world of actions' and the 'cognitive apprenticeship model doesn't split knowledge into abstract and de-contextualised concepts from real-world situations. Rather it unifies the knowledge with the context and the situations, in which the knowledge is gained, and used'. Cognitive apprenticeship involves six teaching methods, these are: modelling, coaching, scaffolding, articulation, reflection and exploration. Studies like Olagunju and Animasahun (2016) found cognitive apprenticeship an effective strategy for improving achievement among two hundred and seventy students from nine junior secondary schools in three local government areas of Osun State, Nigeria. Also, Kuo *et al.* (2012) evidenced that cognitive apprenticeship significantly helped students in the development of web-based collaborative problem-solving skills.

Literature presents a plethora of research efforts to reduce gender gaps in the Science classroom. Oludipe *et al.* (2023) in a quasi-experimental research found that cognitive apprenticeship bridged the gender gap of

students in integrated science. Similarly, Saibu *et al*. found no gender difference in the chemistry achievement of male and female students. In Ani *et al.* (2022), gender was not found to have a statistically significant effect on the achievement of seventy-two junior secondary school students in Enugu State. In the same vein, Yang *et al.* (2020) did not find a gender gap in the science achievement of Grade 4 and Grade 8 students sampled from the National Assessment of Education Quality in China. On the contrast, Kaldo and un (2020), evidenced that female students showed better organizing skills and repeating strategies in mathematics than their male colleagues in first-year Estonian university. In the same line, Bilesanmi-Awoderu *et al.* (2018) found a significant difference in the chemistry achievement of male and female students taught with learning cycle models.

Methodology

This was a 3 x 2 non-randomised pre-test and post-test, control non-equivalent quasi-experimental research design. It examined the impact of inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method on pre-service teachers' entrepreneurial skill development in anaerobic respiration, while recognizing gender as a possible intervening variable. The study population was 856 year one Integrated Science students in the five public Colleges of Education within Lagos and Ogun states, South-West geographical zone of Nigeria. These Integrated Science students are referred to as pre-service Integrated Science teachers (PISTs) in this study. Since this study was a non-randomised quasi-experimental research, intact classes of 115 PISTs from three Colleges of Education participated in the study. However, the three Colleges were purposively selected based on the following criteria: the PISTs in such schools were in the second semester or almost starting second semester as at the time of this study, availability and proximity of biogas production site to the College to the campus; and, willingness of the students to participate in the study.

The research instrument used for collecting data from the PISTs was Integrated Science Students' Entrepreneurial Skill Practical Test (ISEPT) which was designed by the researchers to measure students' entrepreneurial practical skills in anaerobic respiration. ISEPT had three sections: A, B and C. Section A contained items that requested demographic data from Pre-service Integrated science teachers; these are: Name, school and gender. Section A also reflects the duration for the administration of ISEPT which was three weeks. Section B has three test items that measured the Pre-service Integrated science teachers' business management skills while section C has entrepreneurial practical skills achievement in anaerobic respiration.

The entrepreneurial skills measured in this section were technical skills and business management skill. The entrepreneurial skills measured in the ISEPT are: observation, measurement, recording, time management, manipulation, perception and productivity. Section C contains questions on hands-on part of the work. ISEPT questions were drawn from practical biogas production, which include: construction of biogas digester, and construction of biogas collector, culturing of methanogens, feeding of methanogens with substrate and collection of biogas. The business management skill measured in the (ISEPT) is identifying business opportunities in biogas, challenges of biogas production and packaging of biogas. The development of table of specification for (ISEPT) was guided by the skills-based goals identified by Bloom *et al.* (1956) and the two highest levels of knowledge–based taxonomy of Anderson and Krathwohl (2001). After the validation of ISEPT, a pilot test was conducted among 108 PISTs outside the actual study sample. After administering ISEPT to the PISTs in the pilot test, questions identified as difficult for the PISTs to interpret were re-constructed. Then, ISEPT was subjected to reliability test; its reliability value was also established to be

Richard Kuderson 0.824. This value connotes that ISEPT has a very good internal consistency and can measure what it was targeted to measure.

The first experimental group was taught with inside-school cognitive apprenticeship (ISCA), the second experimental group was taught with outside-school cognitive apprenticeship (OSCA) while the third group was the control group taught with lecture method. Lessons and activities in ISCA and OSCA were structured to foster an iterative, interpretative and incremental learning using real life activities. For instance, an iterative learning was encouraged when scaffold of combustion was done during the lesson, the PISTs were guided to lit candles in both aerobic and anaerobic conditions; thereafter, the teacher guided them to link the combustion of candle in the deficiency of oxygen to anaerobic respiration in human. For interpretative learning, videos of before and during fire outbreak at the dumping site of Olusosun, Ojota, Lagos were played to the PISTs. To promote incremental learning, the teacher coaches the PISTs while helping the PISTs link the concept of anaerobiosis to biogas production. The lessons targeted construction of biogas digester, construction of biogas collector, culturing of methanogens, feeding of methanogens with substrate, collection of biogas, identification of business opportunities in biogas, challenges of biogas production and packaging of biogas.

Data analysis

The first and second research questions were answered with mean and standard deviation. The three null hypotheses were tested with Analysis of Covariance (ANCOVA) at 0.05 level of significance.

Presentation of Results

Research question 1

What is the impact of inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method on the Pre-service Integrated Science teachers?

Table 1: Mean difference and Standard deviation of the PISTs' entrepreneurial skill development using inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method

Teaching strategies	N	Pre-Entrepreneurial skill development		Post-Entrepreneurial skill development		Mean Diff
		Mean	SD	Mean	SD	
ISCA	38	3.29	1.59	54.68		51.39
OSCA	35	1.66	1.63	8.69		57.91
Lecture method	42	3.00	1.89	59.57		32.05
				11.04		
				35.05		
				10.56		

In Table 1, the highest mean difference was recorded in the OSCA group (57.91), followed by PISTs in the ISCA group (51.39), while the least mean difference was recorded among the PISTs in the lecture group (32.05). This implies that the PISTs in the OSCA group had the highest mean score in the entrepreneurial skill development post-test, followed by those in the ISCA group, while their colleagues in the lecture group did not perform as well as the other two groups. The low pre-test standard deviations show that the ISCA, OSCA and lecture groups are homogeneous. The post-test standard deviations of the groups indicate that the

three groups are moderately homogeneous with respect to their entrepreneurial skill development, i.e., the PISTs' entrepreneurial skill development scores are moderately clustered around the mean.

H_{01}: There is no significant main impact of inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method on pre-service Integrated Science teachers' entrepreneurial skill development in anaerobic respiration.

Table 2: ANCOVA of the main effect of impact of inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method on pre-service Integrated Science teachers' entrepreneurial skill development

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14499.550a	6	2416.592	25.284	.000	.584
Entrepreneurial skill development Pre-test	900.945	1	900.945	9.426	.003	.080
Teaching strategies	12577.237	2	6288.618	65.796	.000	.549
Error	10322.450	108	95.578			
Total	300937.000	115				

a. R Squared = .584 (Adjusted R Squared = .561)

The ANCOVA result in Table 2 indicates that there was a statistically significant impact of teaching strategies on the entrepreneurial skill development of PISTs [$F(2,108)= 65.80$; $p< .05$]. The R squared was .584, which means the teaching strategies contributed 58.4% to the entrepreneurial skill development of the PISTs. The Partial ETA squared was .549, which implies that the teaching strategies account for 54.9% of the variance observed in the PISTs' entrepreneurial skill development.

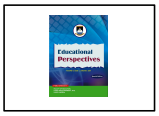
Therefore, the first null hypothesis which states that there is no significant main effect of inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method on pre-service integrated science teachers' entrepreneurial skill development in anaerobic respiration is rejected.

Research question 2

What is the difference in the entrepreneurial skill development of male and female pre-service Integrated Science teachers' taught anaerobic respiration with inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method?

Table 3: Mean and standard deviation of male and female PISTs' entrepreneurial skil development taught with inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method

Teaching strategies	Gender	N	Mean	Std. Deviation
ISCA	Male	17	56.53	7.1
	Female	21	53.19	9.7
OSCA	Male	9	63.22	10.67
	Female	26	56.31	11.08
Lecture method	Male	13	36.00	12.56
	Female	29	34.62	9.75



The entrepreneurial skill development mean for the male PISTs in the ISCA was higher than the female PISTs by 3.34. Similarly, entrepreneurial skill development mean for the male PISTs in the OSCA was higher than the female PISTs by 6.91. A difference of 1.38 was noted in the entrepreneurial skill development post-test mean score of the male and female PISTs in the lecture group, with a higher mean for the male. However, these differences were subjected to ANCOVA to test if there were significant difference between the male and female PISTs.

H_{02}: There is no significant difference in the entrepreneurial skill development of male and female pre-service Integrated Science teachers' taught anaerobic respiration with inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method.

Table 4: ANCOVA of the gender difference in entrepreneurial skill development of PISTs taught with inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14499.550[a]	6	2416.592	25.284	.000	.584
Entrepreneurial skill development Pre-test	900.945	1	900.945	9.426	.003	.080
Gender	123.976	1	123.976	1.297	.257	.012
Error	10322.450	108	95.578			
Total	300937.000	115				

The impact of gender as presented in table 4 was not statistically significant on the post-test scores of the PISTs' entrepreneurial skill development in anaerobic respiration with the F-value calculated as: [F(1,108)=2.57; p>.05]. The Partial ETA Squared (.012) means that statistically, gender accounts 1.2% difference in the PISTs' entrepreneurial skill development.

Therefore, the second null hypothesis which states that there is no significant difference in the entrepreneurial skill development of male and female pre-service integrated science teachers taught anaerobic respiration with inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method is not rejected.

H_{03}: There is no significant interaction impact of teaching strategies and gender on pre-service Integrated Science teachers' entrepreneurial skill development in anaerobic respiration.

Table 5: ANCOVA showing the significant interaction impact teaching strategies and gender on pre-service Integrated Science teachers' entrepreneurial skill development in anaerobic respiration

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14499.550[a]	6	2416.592	25.284	.000	.584
PRAC_PRE_TEST	900.945	1	900.945	9.426	.003	.080
GENDER * GROUP_TYPE	103.264	2	51.632	.540	.584	.010
Error	10322.450	108	95.578			
Total	300937.000	115				

Table 5 shows that there was no statistically significant interaction impact of teaching strategies and gender on the PISTs' entrepreneurial skill development [F(1,108)=5.40; p>.05].
Furthermore, the partial ETA squared was .01; which means that the interaction impact of teaching strategies and gender accounts for 1% variance in the entrepreneurial skill development of the PISTs.

Discussion

The first research question in this study examined the impact of inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method on the entrepreneurial skill development of pres-service integrated science teachers in anaerobic respiration. The results showed much higher means in the post-tests of PISTs in the ISCA and OSCA groups than in the lecture method group. The ANCOVA results show a significant impact of the teaching strategies on the PISTs' entrepreneurial skill development. In addition, the Partial ETA squared showed that the teaching strategies employed in this study accounts for 54.9% of the variance of the PISTs in entrepreneurial skill development. This infers that both ISCA and OSCA were able to bridge a gap in their entrepreneurial skill development. It is interesting to add that the PISTs demonstrated creativity in construction of the biogas digester. This could also be traced to the various activities that the PISTs were exposed to, through the lens of constructivism, where the PISTs were guided to learn in an iterative, interpretative and incremental way as argued by Taber (2018). This agrees with Kuo *et al.* (2012) that cognitive apprenticeship played a significant role in the development of web-based collaborative problem-solving skills. This is not different from the finding of the study of Olagunju and Animasahun (2016) on the effects of cognitive apprenticeship strategy on the achievement of two hundred and seventy students from nine junior secondary schools in three local government areas of Osun State, Nigeria. In correspondence with these findings, Eze *et al.* (2020) found the cognitive apprenticeship strategy significantly efficacious in improving the academic achievement of one hundred and fourteen students in six technical colleges in Delta State, Nigeria. In the same vein, Oludipe *et al.* (2022) also found that students performed better in Chemistry when taught with entrepreneurial motivated approach.

The second research questions examined gender differences in entrepreneurial skill development among the sampled PISTs. The male PISTs had comparatively higher means than their female counterparts. The observed differences were however not statistically significant when tested with ANCOVA. The results indicate that gender accounts for 1.2% of the variance observed between the male and female PISTs' entrepreneurial skill development. This implies that ISCA and OSCA assisted both the male and female PISTs develop entrepreneurial skill without posing gender bias. It therefore means that no gender especially

(female folks) is a second fiddle to the other; all students can thrive beautifully well when appropriate pedagogy is used for teaching. This agrees with Oludipe and Bankole (2017) that both male and female students can perform equally well in chemistry with an appropriate instructional method. Similarly, Oludipe *et al.* (2023) found cognitive apprenticeship a gender non-chauvinistic strategy for boosting pre-service integrated science teachers' achievement in science. In addition to these, Ani *et al.* (2022) also found gender not to statistically affect the achievement of seventy-two junior secondary school students in Enugu State, Nigeria. Also, constructivism-based instructional strategies were found effective in equalizing the achievement of both male and female students in chemistry in the study conducted by Alebiosu *et al.* (2017).

The third hypothesis tested the significant interaction of teaching strategy and gender on pre-service integrated science teachers' entrepreneurial skill development. The results show that there was no statistically significant interaction of teaching strategy and gender on the PISTs' entrepreneurial skill development. Since both male and female PISTs were involved in constructivism-based activities in the science lessons equally, both gender performed beautifully well in the entrepreneurial skill development. This finding aligns with Saibu *et al.* (2022) that was no significant interaction of teaching strategy with gender in the practical achievement of students in Chemistry. This finding also agrees with Oludipe *et al.* (2023) where teaching strategy was not found to be interact with gender on pre-service integrated science teachers' achievement. This study therefore submits that with constructivism-based instructional strategy like cognitive apprenticeship, male and female innovative and creative science entrepreneurs can be bred from the science classroom. Especially, remembering that poverty affects both genders, pedagogy that can prepare competent students to offer solve problems and create value in exchange for financial security is much needed. Therefore male science teachers should be equipped to be resourceful to themselves and their students.

Conclusion

This study explored the impact of ISCA and OSCA on bridging the entrepreneurial pedagogical gaps among PISTs. Both models were found viable with no identified gender bias. Faced with the reality that the world needs graduates that can identify and meet needs, such that when these graduates are given problems, they can give you solutions in exchange of the problems; consequently, they can get remunerated for their creativity and innovation. With the various efforts of the academia to contribute to building the needed manpower that is needed to steer entrepreneurship, bearing in mind that teaching science transmisively cannot foster the required innovation and creativity needed to survive in a very competitive world like ours; this study therefore presents the two models of cognitive apprenticeship as instructional strategies that can bring out innovation and creativity in male and female students through an iterative, interpretative and incremental learning.

Recommendations

1. Inside-school cognitive apprenticeship and outside-school cognitive apprenticeship models are recommended as applicable instructional strategies for bridging pedagogical gaps among pre-service Integrated Science teachers.
2. Entrepreneurial classes should be taught with life activities that can stimulate an iterative, interpretative and incremental learning.
3. Both male and female students should be given an enabling environment that can bring out their potentials.
4. Science entrepreneurial classes should help students identify needs and opportunities generate innovative ideas; and link students with incubation units that can help translate those creative ideas tangible innovations that have value in the market.

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