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Is Cognitive Apprenticeship A Gender Non-Chauvinistic Instructional Strategy For Improving Pre-Service Integrated Science Teachers' Cognitive Achievement Towards A Knowledge Economy?

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IJIRAS

Abstract: ***An adequate Teacher Education relevant in creating enabling Education; and, consequently promote a better Nigeria remains a deep quest among concerned citizens. In addition to several research efforts on this discourse, this study explored two models of cognitive apprenticeship: Outside-School Cognitive Apprenticeship (OSCA) and Inside-School Cognitive Apprenticeship (ISCA). A non-randomized pre-test post-test quasi-experimental research design was adopted for the study. Three intact classes of 115 male and female Pre-service Integrated Science Teachers (PISTs) from three Colleges of Education within South-West, Nigeria, participated in this study. Integrated Science Achievement Test with a Cronbach alpha reliability coefficient of .703 was used to collect data in this study. The results showed that both ISCA and OSCA are gender non-chauvinistic [$F_{(1, 94)} = .57$; $p > .05$] on the PISTs' cognitive achievement. This study therefore recommends OSCA and ISCA as gender non-chauvinistic models of cognitive apprenticeship that could be explored to improve male and female PISTs' cognitive achievement, thereby improving their resourcefulness in re-branding the Nigerian Education for a knowledge economy.***

Keywords: ***Inside-school cognitive apprenticeship, Outside-school cognitive apprenticeship, enabling education, knowledge economy, gender non-chauvinistic instructional strategy***

I. BACKGROUND TO THE STUDY

There are global efforts to create an enabling Education for both male and female students; an enabling Education that brings about sustainability of individuals and nation, and which fosters self-reliance. Enabling Education is imperative at a time like this when there is a further decline of women and youth unemployment after the COVID-19 pandemic. The United Nation (2023) reported that after the COVID-19 pandemic, many youths within ages 15 and 24 continue to experience serious difficulties in securing decent employment, and that the global youth unemployment rate is much higher than the rate for adults aged 25. Enabling Education is beyond just impacting knowledge; it is empowering and training both male and female students to create knowledge; such that, beyond the walls of the classroom, the students can solve everyday problems.

If the pre-service teachers will offer an enabling Education, it is logical to say that they should be exposed to an enabling Teacher Education. There are various contributory

factors that make up an enabling Teacher Education, the factors include: Education policies, philosophy of Education, school administration, availability of funds, adequacy of usable school facilities, functional curriculum, content knowledge, pedagogical knowledge, assessment and evaluation styles, field experiences and gender equity. It cannot be over-emphasised that Teacher Education is central to the creation of an enabling education for every child. Oludipe and Kalejaiye (2012) identified teachers' teaching skills and mastery of content as determinants of students' academic performance in chemistry. In the same vein, Adeosun (2011) remarked that knowledge is no longer a lifetime experience but an asset that needs consistent update; hence, the need for constant update of teacher education. Also, Barnes *et al*. (2019) posited that Teacher Education should enable pre-service teachers identify and effectively apply the content-area and pedagogical skills to the subject of instruction. Without mincing words, Teacher Education is an imperative for promoting a knowledge economy.

With growing global efforts to catch up with the present wave of building a knowledge economy that is viable through an enabling Teacher Education; where more than ever, solutions to several societal problems are generated from the world of academia, it becomes vital to expose male and female pre-service teachers to more pedagogies and content that can help them become more resourceful to their students and nation at large. A knowledge economy that will diminish the distance between economic activity and intellectual discovery, as in some developed climes, where problems identified in the society are brought as research focus for lecturers and students to solve. Unger (2019) described knowledge economy as 'the close relation that establishes between how we work and how the mind develops ideas and makes discoveries; and that the growth of knowledge becomes the centrepiece of economic activity'. To achieve this enabling Education that will foster a knowledge economy, desires and interests are springing up in Nigeria to improve and rebrand the Nigerian Teacher Education, since teachers are highly pivotal in this discourse of interest. It becomes important to help pre-service teachers have improved cognitive achievement in Science; especially now that unemployment stares at us in Nigeria.

This study investigated cognitive apprenticeship as a teaching strategy among Pre-service Integrated Science Teachers (PISTs). Cognitive apprenticeship is an instructional model derived from the metaphor of the apprentice working under the master craftsperson in traditional societies (Norman & Jarvis, 2006). Cognitive apprenticeship helps the students to make discoveries through planned exposures that bring real life to the classroom, the students are taught to think on how to identify problems, think on possible ways of solving assigned tasks and proffer solutions to identified problems. While solving problems, the students make mistakes, but the teacher does not write off the students because of the mistakes, rather the teacher explores the mistakes to guide the students towards a better learning outcome. The teacher uses relevant scaffolds to make the students think on solving an assigned task. Norman and Jarvis (2006) explained that 'cognitive apprenticeship, places emphasis on the thinking that must precede and be part of the task, and accompany any necessary observations made after its completion.

Cognitive apprenticeship is a teaching strategy, which is an amalgamation of six teaching methods; these are: Modelling, Coaching, Scaffolding, Articulation, Reflection and Exploration. Stalmamijer *et al*., (2009) observed that these six teaching methods foster autonomy of students' learning processes by encouraging students to formulate personal learning goals. These teaching methods are essential in equipping students towards the reality of the labour market because they help situate learning thereby familiarising the learners with the demands of the world-of-work and; assisting the learners to take responsibility of his learning. In cognitive apprenticeship, the pre-service teacher systematically evolves to an expert from a novice. Cognitive apprenticeship is a pedagogic strategy at the core of situated learning theory. It extends situated learning to diverse settings so that students learn how to apply their skills in varied context with intrinsic motivation (Collins *et al.,* 1989). Stein (1998) explained that situated learning is essentially a matter of creating meaning from the real activities of daily living. Also, Brown (1994) posited that schools are not islands, they exist in wider communities; and that situated cognition theory is a theory that posits that knowing is inseparable from doing (Brown *et al*., 1989). Cognitive apprenticeship situates learning for the pre-service science teacher and creates a platform for him to make a meaningful contribution to the desired knowledge economy.

In situating learning experiences in cognitive apprenticeship, this study explored (outside-school cognitive apprenticeship (OSCA) and inside-school apprenticeship (ISCA) models. In the outside-school model, pre-service Integrated Science teachers (PISTs) went beyond the walls of the school to acquire knowledge. The PISTs were guided to interact with relevant experiences in the real world outside the physical environment of the school; for instance, they went to relevant work sites and related with mavin in the biogas production site. While the inside-school cognitive apprenticeship (ISCA) model brings cognitive apprenticeship to the PISTs, to facilitate learning within the school premise. The PISTs were exposed to relevant experiences and were guided in activities that are similar to the real world. For example, the expertise of a mavin was engaged in collaboration with the Science teacher to facilitate learning on biogas production within the school premise.

There are research efforts on the potency of cognitive apprenticeship on various learning outcomes especially students' achievement. Olagunju and Animasahun (2016) found cognitive apprenticeship strategy as effective in enhancing the achievement of two hundred and seventy students from nine junior secondary schools in three local government areas of Osun state, Nigeria. Also, Eze *et al.* (2020) found cognitive apprenticeship strategy significantly efficacious in improving academic achievement of one hundred and fourteen auto mechanics technology students in six technical colleges in Delta state, Nigeria. Similarly, the study of Kuo *et al.* (2012) found cognitive apprenticeship effective among eighty-eight fifth-grade students in fostering the development of web-based collaborative problem solving skills. Dimakos *et al.* (2010) conducted a study among first-year class students at a public high school in Peristeri. Their study showed that students taught perpendicular bisector

IJIRAS

employing the cognitive apprenticeship model did better in achievement than their colleagues in the lecture group. Stalmeijer *et al.* (2009) found cognitive apprenticeship model very impactful in improving students' skill during clinical training in the academic year 2006–2007 among 24 medical students in the 6-year undergraduate curriculum of Maastricht Medical School, the Netherlands. Further to the submissions of these studies, Oludipe & Bankole (2017) indicated that students' achievement can remarkably improve with appropriate instructional strategy, this submission is based on their findings from their quasi-experimental research among two hundred and fourteen senior secondary schools (S.S.S. 1) Chemistry students in Lagos State, Nigeria. In the same vein, Akindoju & Ogunwomoju, (2007) established that students who were taught Chemistry with developed instructional game outperformed their colleagues who were taught the same topic without the use of developed instructional game. Ajayi *et al.* (2023) in a study of three hundred and thirteen S.S.S. III in Abeokuta South and Abeokuta North of Ogun state, Nigeria; found Ethnobiology-based instruction impactful in improving students' academic achievement in Biology.

There are divergent positions on gender and achievement in Science. Oludipe and Bankole (2017) posited that both female and male Science students can do very well in Chemistry achievement test, and that if given fair playground, both gender can thrive equally well without prejudice. Likewise, Saibu *et al.* (2022) argued that entrepreneurial-motivated approach significantly removed gender disparity among 118 senior secondary school students in Chemistry. This position is not at variance with Atomatofa (2014) who submitted that cognitive apprenticeship aided the achievement of both male and female junior secondary school students in Delta Central Senatorial district located in Delta State, Nigeria. Similarly, Okoye and Okechukwu (2008) also found gender did not have statistical effect on one hundred and thirteen senior secondary three students in genetics. Also, Alebiosu *et al.* (2017) found constructivism-based instructional strategy effective in reducing gender differences in the achievement of male and female students in Chemistry. On the contrary, Kaldo, and Õun (2020), submitted that female students showed better organizing skills and better repeating strategies than males in mathematics, in a study among first-year Estonian university students' students from 440 university students. The study of Bilesanmi-Awoderu (2018) on learning cycle models among one hundred and eighty- eight senior secondary schools students in three Local Education Zones of Lagos Education District III, found that there was a significant difference in the achievement of male and female students in Chemistry.

However, several studies have shown that there are needs to help Science teachers achieve better in Science. Ademola *et al*, (2022) in a survey of 5,032 secondary Biology students decried that the achievement level in school and public examinations has failed to climb beyond the average and many of the various methods adopted before now, although have been found to improve the learning of biology concepts but have singly or in combination failed to sustainably promote meaningful learning of Science to a level that can be regarded as significant in the face of contextual mitigating factors. Also, in a study involving 1397 students in India Lalrinmawia & Fanai (2020) found out that the level of achievement in science among higher secondary students was very low, 95.64% fell under below average level. The popular research clarion call that has been on for a long time now, among others, is the need to improve students' achievement in science at all levels (Owens, 2009; Oludipe & Bankole, 2017; Saibu *et al.*, 2022; Ezugwu *et al.*, 2022; Oludipe *et al*., 2022;). Therefore, with emerging needs to package Teacher Education programme as an enabling Education that is gender non-chauvinistic and that can foster a knowledge economy, this study examined the effects of two models of cognitive apprenticeship (ISCA and OSCA) on Colleges of Education male and female pre-service Integrated Science teachers' achievement in anaerobic respiration.

II. RESEARCH PURPOSE

This study investigated the:

- ✓ difference in the achievement of male and female pre-service Integrated Science teachers' taught anaerobic respiration with inside-school cognitive apprenticeship, outside-school cognitive apprenticeship, and lecture method.
- ✓ interaction effect of teaching strategies and gender on pre-service Integrated Science teachers' achievement in anaerobic respiration.

RESEARCH QUESTION

The following question was raised to guide this study:

What is the difference in the achievement 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

The following null hypotheses were tested in this study at 0.05 significance level:

H_{01}: There is no significant difference between the achievement 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_{02}: There is no interaction effect of teaching strategies and gender on pre-service Integrated

Science teachers' achievement in anaerobic respiration.

III. METHODOLOGY

RESEARCH DESIGN

The study was a non-randomized pre-test and post-test, control non-equivalent quasi-experimental research design, it explored the effects of Inside-School Cognitive Apprenticeship (ISCA), Outside-School Cognitive

Apprenticeship (OSCA) and lecture method on the PISTs' achievement in anaerobic respiration.

POPULATION AND SAMPLE

The study was conducted among 115 male and female Nigeria College of Education (NCE) Integrated Science year I students, otherwise referred to as Pre-service Integrated Science Teachers (PISTs) in this study. Three intact classes were from three Colleges of Education. The three Colleges were purposively selected from five public Colleges of Education offering Integrated Science Education within the South-West geo-political zone of Nigeria. The selection was premised on the following: the schools are Colleges of Education offering Integrated Science Education at NCE level; the year one students in such schools were in the second semester or almost starting second semester as at the time of this study; availability and proximity of resource workshop to the campus; and, willingness of the students to participate in the study.

RESEARCH INSTRUMENTS

The research instrument used to collect data from the PISTs in this study was Integrated Science Students' Achievement Test (ISAT). ISAT was designed to measure the PISTs' cognitive achievement in anaerobic respiration. (ISAT) had two sections: A and B. Section A contained items that elicited demographic data from PISTs. The data were: name, school and gender. The time allocated for the administration was forty-five minutes. Section B had two parts (I and II), part I contained six multiple choice test questions and part II had eleven short essay questions constructed from selected topics related to this research work. The topics were: respiration, anaerobic respiration, aerobes and anaerobes, methanogens, biotechnology, fuel from biomass, biogas and biogas production. The development of the test blueprint for ISAT was guided by the Bloom et al (1956)'s taxonomy of educational objectives and knowledge–based taxonomy of Anderson and Krathwohl (2001). Anderson and Krathwohl (2001) taxonomy includes: remembering, understanding, applying, analyzing, evaluating, and creating. The researchers adopted Okebulola (2015) standard rules for setting multiple choice questions to ensure the structure conformity of ISAT. The essay questions were simply constructed to avoid ambiguity in the students' attempt to answer the questions. ISAT was administered as both pre-test and post-test; after the ISAT had been administered as pre-test, the questions in ISAT were re-arranged before administering it as post-test. This was to ensure good assessment of the learners and as much as possible, avoid situations where the learners would have memorized the pre-test questions.

VALIDITY AND RELIABILITY OF ISAT

ISAT was given to three evaluators; one of the evaluator was from the department of Science and Technology, Lagos State University, Nigeria. The second evaluator was from the department of Integrated Science Education, Federal College of Education (Technical), Akoka, Lagos, Nigeria; and the third evaluator was from Lagos State University of Education, Otto-Ijanikin, Nigeria. The suggestions given by these evaluators were considered. After administering ISAT as pre-test, the questions which the PISTs found difficult to interpret were re-constructed for a better use. The ISAT was subjected to sample of 108 PISTs for pilot test. The data collected at the pilot stage, was fed to SPSS to determine its reliability. The Richard Kuderson reliability index of ISAT was established as 0.703. This index implies that ISAT was a reliable research instrument.

PROCEDURE FOR DATA COLLECTION

Permission to carry out this research was sought from the department of Integrated Science and respective course lecturers. Permission was also obtained from the College management where students needed to be taken out of the school premises (i.e. PISTs in the outside-school cognitive apprenticeship treatment). The Lagos State Ministry of Veterinary services is well appreciated for the kind permission given to the College of Education Integrated Science Students (referred to as PISTs in this study); to visit the Ikorodu abattoir for learning exposure, where Lagos state has a biogas production site.

Three facilitators' guides were designed for the three groups; i.e. Inside School Cognitive Apprenticeship (ISCA), Outside School Cognitive Apprenticeship (OSCA) and lecture method. The guides contained weekly plans on topics, behavioural objectives, learners and facilitators' expected activities at each instructional stage in each treatment, instructional materials and evaluation procedures. The facilitators' guides were subjected to content analysis using Scott's Pi inter-rater reliability index formula. The proportion of agreement which is P (observed) was calculated and it gave 0.875; this implies that the two assessors agreed that the facilitators' guides were suitable for the intended purpose to the degree 87.5%. Treatments lasted for six weeks. Pre-tests were conducted on the PISTs' cognitive achievement and entrepreneurial skill development using ISAT and ISEPT. Items on ISAT and ISEPT were re-arranged, and administered as post-tests. Summary of the treatments are written below.

TREATMENT ON INSIDE-SCHOOL COGNITIVE APPRENTICESHIP

In the Inside-School Cognitive Apprenticeship treatment (ISCA), the PISTs were exposed to cognitive apprenticeship within the school premises, with lessons taken in the laboratory. The facilitator introduced the topics to the PISTs and provided theoretical support in the laboratory. The facilitator assigned tasks on: "what is anaerobic respiration, what are the economic benefits of anaerobic respiration, the Science behind bio-digester and how can bio-digester be constructed"? He gave a puzzle, he showed a related video for the students to think about and discuss, to create a quest in the PISTs to get the puzzle solved. All the PISTs' answers are noted on the board for an evaluation later in the class.

Sequel to this, the facilitator used simple activities as scaffolds in the lesson, this was to guide the PISTS to identify the link between the simple activities and anaerobiosis as it

occurs in life. Before this, the facilitator ensured that the laboratory is well ventilated with all windows and doors opened to avoid suffocation. This was followed by demonstrating and explaining his way of thinking for learners to understand e.g. by discussing sources of liquefied petroleum gas (which is a fossil gas familiar to the PISTs) and biogas, he increases the complexity of the problems, the level of assistance decreases as the learners' progress increases; therefore, the facilitator progressively helped the students until they are able to independently accomplish the given task. He also gave scaffolds by giving useful hints to the PISTs while they were trying to accomplish the given task. The facilitator gave room for articulation by presenting PISTs with opportunities to explain and articulate their own way of thinking. This was then enhanced by reflection where PISTs compared their own thoughts and ways with those of the facilitator, mavin and their peers.

Finally, at the self-exploration phase, the facilitator re-assigned the same task which was given initially to the PISTs at the beginning of the class. He then withdrew hints and support from the PISTs, while they were encouraged to solve tasks alone and with their peers. The facilitator then asked the PISTs to identify their mistakes in the initial answers noted on the board for corrections. Tasks such as steps in constructing the bio-digesters and designing protocol for biogas production were assessed and mistakes corrected.

TREATMENT ON OUTSIDE-SCHOOL COGNITIVE APPRENTICESHIP (OSCA)

In the OSCA, the PISTs were exposed to cognitive apprenticeship outside the school premises, with some lessons taken in the class and others at biogas production site. The facilitator gave a task or puzzle to the PISTs that will challenge them to think. The facilitator then introduced the topic to the PISTs and provided theoretical support. At the biogas production site, the PISTs were taken round the workshop for familiarization and given precautionary measures for safety. The facilitator modelled by demonstrating and explaining his way of thinking for learners to monitor and understand e.g. the PISTs were shown the bio-digester, with a demonstration of how the biogas is used to the students. The PISTs were guided to observe the set up, through the various sections of the biogas production sites like where the cow dung is separated from non-biodegradable wastes. Where cow dung is liquefied and fed into the bio-digester. This was then followed by coaching which entails the mavin presenting substrates, materials needed for building the bio-digester. The facilitator linked the topics for each week. The facilitator expatiated on the link by giving various examples, and he encouraged the PISTs to ask questions.

At the support phase, the facilitator gave scaffolds in the lesson e.g. by discussing basic ideas on respiration, (which is familiar to the students). The level of assistance decreased as the learners' progress increased; therefore, the facilitator progressively helped the PISTs until they were able to independently accomplish the given task. He also gave additional scaffolds during the lesson by giving useful hints to the PISTs while the PISTs made attempt to accomplish the assigned task. The facilitator gave room for articulation by presenting PISTs with opportunities to explain and articulate their own way of thinking. This was then enhanced by reflection, where they compared their opinions with their peers. At the self-exploration phase, the facilitator withdrew hints and support from the PISTs, while they were encouraged them to solve tasks independently. The facilitator observed the PISTs, guides them to identify their mistakes for corrections, and identify their strength for reinforcement after the phase.

LECTURE METHOD (CONTROL GROUP)

In this treatment, the Pre-service Integrated science teachers (PISTs) were taught using lecture method. The facilitator introduced the topics to the PISTs. He presented the lesson objectives for the day to the PISTs. The facilitator introduced the lesson by asking the PISTs questions related to the topic. He corrected wrong answers, and built on the responses of the PISTs to explain the concept of the lesson. The facilitator assigned tasks to the PISTs. The facilitator spoke on the concepts. He distinguished between concepts where necessary and then evaluated the lesson. The facilitator summarised the lesson, emphasised salient points and re-assigned tasks to the PISTs.

METHOD OF DATA ANALYSIS

Mean and standard deviation were used to answer the research question, while the two null hypotheses were tested using Analysis of Co-Variance (ANCOVA) at 0.05 level of significance. The homogeneity test among the PISTs across the ISCA, OSCA and lecture method groups was calculated as $[F_{(2,111)} = 98; p > 0.05]$.

IV. RESULTS

RESEARCH QUESTION

Group type	Gender	Mean	Std. Deviation	N
ISCA	Male	64.59	10.776	17
	Female	60.19	13.136	21
OSCA	Male	67.56	11.469	9
	Female	64.23	13.104	26
Lecture method	Male	38.69	13.098	13
	Female	40.52	10.357	29

Table 1: Mean and Standard deviation of gender achievement of PISTswith in inside-school cognitive apprenticeship, outside-school cognitive apprenticeship and lecture method

The result in Table 1 shows that the cognitive achievement post-test mean of the male PISTs in the ISCA group is higher than the female PISTs by 4.4 but the higher standard deviation in the female PISTs shows that there is a higher variance among the individual cognitive achievement post-test score compared to the male PISTs with comparatively a lower standard deviation. The cognitive achievement post-test mean of the male PISTs in the OSCA group is higher than the female PISTs by 3.3.With the standard deviation depicting a more homogeneous group for the female. (The difference between the male and female

PISTs was noted to be 1.83 in the lecture group. These differences were analysed to determine if they were significant or not.

H_{02}: There is no significant difference in the cognitive achievement of male and female pre-service Integrated Science teachers' taught anaerobic respiration 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	23184.702[a]	6	3864.117	53.272	.000	.747
Cognitive achievement pre-test	7882.332	1	7882.332	108.668	.000	.502
GENDER	83.977	1	83.977	1.158	.284	.011
Error	7833.872	108	72.536			
Total	378124.000	115				

a. R Squared = .747 (Adjusted R Squared = .733)

Table 2: Summary ANCOVA of the impact of inside-school cognitive apprenticeship and outside-school cognitive apprenticeship on pre-service Integrated Science teachers' cognitive achievement in anaerobic respiration

The ANCOVA result in Table 2 shows the homogeneity test among the PISTs across the ISCA, OSCA and lecture method groups before the commencement of the test [$F_{(1,108)}$ = 108.67; p > 0.05]. This shows that there was no significant difference in the PISTs' cognitive achievement across the ISCA, OSCA and lecture method groups before the commencement of the treatments. The table also shows that after the treatment, the difference in the male and female PISTs' cognitive achievement in anaerobic respiration was not found to be statistically significant: [$F_{(1,108)}$=1.16; p>.05]. The Partial Eta Squared (.011) depicts that gender accounts for 1.1% of the variation in the male and female PISTs' cognitive achievement in anaerobic respiration. This implies that both ISCA and OSCA were gender non-chauvinistic models of cognitive apprenticeship.

DECISION

The first null hypothesis which states that there is no significant difference in the cognitive achievement 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_{02}: There is no interaction impact of teaching strategies and gender on pre-service Integrated Science teachers' achievement in anaerobic respiration.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	23184.702[a]	6	3864.117	53.272	.000	.747
Cognitive achievement pre-test	7882.332	1	7882.332	108.668	.000	.502
GROUP_TYPE * GENDER	481.859	2	240.930	3.322	.040	.058
Error	7833.872	108	72.536			
Total	378124.000	115				

a. R Squared = .747 (Adjusted R Squared = .733)

Table 3: Summary ANCOVA of the interaction impact of teaching strategies and gender on pre-service Integrated Science teachers' achievement in anaerobic respiration

The ANCOVA result in Table 3 shows that there was a statistically significant impact of the teaching strategies and gender on the pre-service Integrated Science teachers' achievement in anaerobic respiration [$F_{(2,108)}$=3.32; p<.05].

DECISION

The second null hypothesis which states that there is no significant interaction impact of teaching strategies and gender on the pre-service Integrated Science teachers' cognitive achievement in anaerobic respiration is rejected. Furthermore, a Bonferroni pairwise comparison was conducted to locate the significant difference across the three teaching strategies; the post-hoc is indicated in Table 4.

(I) GROUP TYPE	(J) GROUP TYPE	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Lecture method	ISCA	-20.842*	1.996	.000	-25.697	-15.988
	OSCA	-19.282*	2.277	.000	-24.819	-13.745
ISCA	Lecture method	20.842*	1.996	.000	15.988	25.697
	OSCA	1.560	2.209	1.000	-3.811	6.931
OSCA	Lecture method	19.282*	2.277	.000	13.745	24.819
	ISCA	-1.560	2.209	1.000	-6.931	3.811

Table 4: Bonferroni pair-wise comparison of interaction impact of teaching strategies and gender on PISTs' cognitive achievement

The pair wise comparison table 4 shows that there is a negative 20.84% difference between the mean of lecture method and ISCA, negative 19.28% difference between the mean lecture method and OSCA. In the same vein, there is a 20.84% difference between the mean of ISCA and lecture method but in contrary, 1.56% difference between the mean of ISCA and OSCA is not significant. Similarly, 19.28% difference between the mean of OSCA and lecture method while there is a negative 1.56% difference between the mean of OSCA and ISCA. The values with asterisks show significant level at 0.05. Therefore, there are positive significant differences between the mean of ISCA and OSCA to lecture method, while there are negative significant differences between the mean of lecture to both ISCA and OSCA respectively. Notably, ISCA and OSCA or OSCA and ISCA are not significant.

DISCUSSION OF FINDINGS

The research anthems are increasingly evident in the quest to bridge gender gaps in Science Education. This study adds to the anthem that there is a need to employ teaching strategies that are gender non-chauvinistic. The findings of this study revealed that the outside-school cognitive apprenticeship and inside-school cognitive apprenticeship models assisted both male and female pre-service Integrated Science students statistically equally in improving their cognitive achievement in anaerobic respiration [$F_{(1,108)}$=1.16; p>.05]. This means that no statistical disparity was identified in the cognitive achievement of male and female PISTs. This finding is in agreement with Oludipe and Bankole (2017) that both female and male Science students can do very well in Chemistry achievement tests and that if given a fair playground, both

genders can thrive equally well without prejudice. In the same vein, Saibu *et al.* (2022) pointed out that gender disparity can be evidently thinned off in chemistry when the teacher uses the appropriate teaching strategy.

Likewise, Atomatofa (2014) found that cognitive apprenticeship gave leverage for both male and female junior secondary school students in Delta Central Senatorial district located in Delta State, Nigeria. Similarly, Okoye and Okechukwu (2008) also found gender as not having statistical effect among one hundred and thirteen senior secondary three students in genetics. Also, constructivism-based instructional strategy was found effective in the equal achievement of both male and female students in Chemistry in the study conducted by Alebiosu *et al* (2017). But, this finding is at variance with the submission of Kaldo, and Õun (2020), whose finding showed that female students had better organizing skills and repeating strategies than males in mathematics. Also, the study of Bilesanmi-Awoderu (2018) on learning cycle models among one hundred and eighty- eight senior secondary schools students in three Local Education Zones of Lagos Education District III, found that there was a significant difference in the achievement of male and female students in Chemistry.

In addition to this, the findings also show that there was a significant interaction impact between the teaching strategies and gender [$F_{(2,108)}$=3.32; p<.05], although p value for the interaction impact is .04. The Bonferroni pair wise which was conducted to locate where the interaction impact exist shows that there was no significant difference between the two cognitive apprenticeship models (i.e. ISCA and OSCA). A significant difference was however noted between lecture method and ISCA; and between, lecture method and OSCA. It could be inferred that when PISTs are taught anaerobic respiration using the two models of cognitive apprenticeship (ISCA and OSCA), both male and female PISTs can perform significantly well without any chauvinism. On the other hand, the findings indicated that gender may interact with lecture method. This finding is not at variance with the study of Saibu *et al.* (2022), where entrepreneurial motivated approach which is also a constructivism based instructional method was not found to significantly interact with gender. Furthermore, Nkong (2022) found that both male and female did well when taught sexual reproduction in plants using computer simulation strategy while lecture produced low achievement in male and female students in the same science concept. Also, Obodo and Ani (XX) found that there was significant interaction of teaching method and gender on Basic Science students' achievement.

V. CONCLUSION & RECOMMENDATIONS

This study gives empirical evidence that cognitive apprenticeship is very relevant in helping pre-service Integrated Science teachers improve their cognitive achievement in Science. As an imperative, being an amalgamation of six instructional methods places cognitive apprenticeship on a pedestal of relevance in preparation of pre-service Integrated Science teachers that are needed to build a knowledge economy. Also, this study queues behind the situated cognition theory: that advocates for creating meaning from the real activities of daily living; and that, knowing is inseparable from doing, since schools are not islands, but exist in wider communities. This study adds to literature that contemporary and relevant instructional strategies like cognitive apprenticeship that is gender non-chauvinistic can bridge the much desired gender gaps in learning and doing of Science.

Based on the findings of this study,

- ✓ This study recommends cognitive apprenticeship as a viable gender non-chauvinistic instructional strategy towards a knowledge economy.
- ✓ This study recommends use of cognitive apprenticeship as an instructional strategy for improving pre-service Integrated Science teachers' achievement in Science.
- ✓ Pre-service Integrated Science teachers should be exposed to more Science-based entrepreneurial activities, so that they can be more resourceful to their students.
- ✓ Pre-service teachers should be trained to be creative thinkers rather than being creative consumers of knowledge.
- ✓ The Government should avail the school an enabling environment in all its ramifications for an enabling Teacher Education.

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