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GENDER DIFFERENCES IN ACQUISITION AND RETENTION OF SCIENCE PROCESS SKILLS AMONG BIOLOGY STUDENTS TAUGHT WITH INDIVIDUALIZED AND THINK-PAIR-SHARE INSTRUCTIONAL STRATEGIES IN ABUJA, NIGERIA

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Abstract

This study investigated the Gender Differences in Acquisition and Retention of Science Process Skills among Biology Students Taught with Individualized and Think-Pair-Share Instructional Strategies in Abuja. The study adopted a quasi-experimental pretest-posttest control group design. A sample of 124 Senior Secondary one (SS1) students was drawn from three co-educational public senior secondary schools in Gwagwalada Area Council, Abuja. Three research questions and three null hypotheses formulated and tested at 0.05 level of significance guided the study. A multi-stage sampling technique was used to arrive at one intact class each from the three schools. The schools was randomly assigned to two treatment groups; Individualized and Think-Pair-Share Instructional Strategies and a Control Groups. Instruments titled "Food Test Process Skills Acquisition Test" (FTPSAT) was developed, validated and used for the study. FTPSAT has a reliability coefficient (internal consistency) of 0.86 using KR-21. Mean and Standard Deviation were used to answer research questions while the null hypotheses was tested at 0.05 alpha level using Analysis of Co-variance (ANCOVA). The findings showed significant difference in the process skills mean scores and retention of the students in favour of Think-Pair-Share Instructional Strategy (TPSIS), followed by the individualized instructional Strategy (IIS) with the Control Group having the least process skill mean scores. However, no significant difference was found between the process skills mean scores of males and females in IIS and TPSIS. The findings also revealed no significant difference in the process skills and retention mean scores of male and female students in favour of TPSIS, followed by the students in IIS with the Control Group having the least process skills and retention mean scores. On the basis of this findings, it was therefore, recommended among others that teachers should be encouraged through organizing seminars, workshops and conferences, on efficacy and the usefulness of TPSIS so as to improve students acquisition of science process skills and retention in food test concept in order to eradicate the issue of poor performance as well as gender difference during delivery the concept of food test in a Biology class.

Keywords: Science process skills; Think-pair-share; Individualized instruction; Retention; Biology education; gender.

Introduction

Science process skills can be acquired and developed through training such as, scientists involved in practical activities, they are the operations through which scientific knowledge is generated and tested. Observing, measuring and inferring are classified as basic skills, and experimenting among others as an integrated skill that builds on them (Padilla, 2023; Padilla, Okey, & Dillashaw, 2023). Anaekwe (2023) stated that when a learner acquires the process skills of measuring, questioning designing, experimenting, interpreting data, and inferring, such learner becomes equipped with tools required for scientific inquiry, problem solving as well as the ability to use the skills in economic development of the society. The significance of science process skills has led to the expansion of the goal of science education to include understanding by development in, and the learners of these process skills in senior secondary science. Biology is one of the core natural science subjects in Nigeria secondary schools. Studies in Biology have shown that the mode of teaching, especially at the secondary school level remains overwhelmingly teacher-centered with greater emphasis on conventional teaching methods than engaging students in process skills acquisition through critical thinking across subject area and applying the knowledge acquired to real life situations.

Biology instruction at the senior secondary level is expected to develop these skills through practical work, yet national evidence points to a shortfall. Between 2020 and 2025, the proportion of Federal Capital Territory (FCT) candidates obtaining a credit in Senior Secondary Certificate Examination (SSCE) Biology ranged from 37.1% to 47.1% (Education Resource Centre, 2020–2025), and Chief Examiners' reports attribute much of the weakness to the practical paper, in which food-test questions recur and are answered poorly (West African Examinations Council, 2020–2025). Teacher-dominated lessons, in which students seldom handle reagents and specimens, are the commonly cited cause (Nworgu, 2025).

Food tests are a revealing context in which to study practical competence. The topic requires three skills to operate together: experimenting, the correct preparation of a sample and application of a reagent; observing, the accurate detection and recording of the diagnostic evidence, such as a colour change or a precipitate; and inferring, the conclusion about which nutrient is present and the recognition of what the evidence does and does not show. Students who have only heard the procedure described can recite it without being able to perform it, which is why instruction that obliges every learner to enact the procedure is widely regarded as the remedy. Because enactment is the common feature of the strategies examined here, the question of who benefits, and whether boys and girls benefit equally, is as important as the question of whether the strategies work.

It is one thing to acquire science process skills through individualized or think-pair-share instructional strategy; it is another thing to remember those acquired skills after some reasonable period of time must have elapsed. Retention of knowledge means recalling or remembering pieces of knowledge, process or skills that were acquired earlier in time. Encarta (2009) indicates that retention is the ability to

remember things. For the purpose of this study, retention is defined as the ability to keep or retain the acquired science process skills and been able to recall them when required. Retention of science process skills is not achieved through memorization or rote learning but through the use of appropriate instructional strategies (Nwagbo, 2023). A student who performs a food test well immediately after instruction may not do so later, and gender differences, if present, could emerge or disappear as learning is consolidated or lost. Memory research shows that forgetting is steepest soon after learning (Ebbinghaus, 1885/1913) and that the act of retrieval strengthens memory (Roediger & Karpicke, 2006), so a delayed test is both a measure of durability and a further learning opportunity. The study therefore examines gender at two points, the posttest (acquisition) and a delayed posttest one week later (retention), and interprets the second with the caveat that it indexes delayed performance.

Gender differences in science participation are usually attributed to socialisation and not to aptitude. Boys are often encouraged to explore, handle tools and take risks, whereas girls are more often steered toward conformity, so boys may bring more informal practical experience to the laboratory; and within classrooms, patterns in who handles equipment and who speaks in groups can reproduce these inequalities.

Think-Pair-Share (TPS) (Long=Crowell, 2021) asks learners to think alone, discuss with a partner and then share with the class. Individualized instruction (IIS) asks each learner to work through structured tasks alone and at his or her own pace, with feedback from the teacher (Anowor, 2021). TPS provides a peer scaffold from which all learners benefit, and that the individual think stage guarantees each learner first-hand practice; but pairing could also reproduce classroom dynamics in which one partner dominates the equipment. IIS, by contrast, gives each learner personal access to materials and self-paced practice, consistent with mastery theories (Carroll, 1963; Bloom, 1968), but it removes the peer support and the public accountability that may help less confident learners. Retention adds a further consideration. Forgetting is rapid soon after learning (Ebbinghaus, 1885/1913), and retesting is itself a learning event (Roediger & Karpicke, 2006), so gender differences at a delayed test may differ from those at the posttest.

The two strategies also differ in the routes by which gender could enter. In TPS, the think stage gives every student individual practice, but the pair stage places two students at one set of materials, and the interaction between partners may be shaped by confidence, status and prior experience; if one partner habitually operates the apparatus while the other records, the experience of the two will differ. In IIS, each student is responsible for his or her own materials and results, so access cannot be monopolized by a partner, but the learner who is uncertain has no peer to consult, and self-paced work may favour students who already have confidence in practical procedures. These considerations make gender differences possible under either strategy, and they make the empirical question open.

Few studies have investigated gender separately within TPS and IIS in the same experiment, on a practical food-test task,

with a delayed test. The present study did so for SS1 Biology students in Abuja.

The problem addressed is, therefore the absence of evidence on whether male and female SS1 students acquire and retain food-test process skills equally when taught with Think-Pair-Share and with individualized instruction. Teachers need to know whether either strategy requires adjustment to serve girls and boys equitably. Teacher educators and curriculum planners need evidence on which to base guidance on practical instruction. And researchers need effect-size estimates, with their uncertainty, to plan adequately powered studies.

Objectives of the Study

The study sought to determine gender differences in the acquisition and retention of science process skills among students taught food-test concepts with TPS and with IIS. Specifically, it sought to determine the effect of:

1. individualized and think-pair-share instructional strategies on SS1 students' retention in the acquisition of science process skills in food tests.
2. individualized instructional strategy on male and female SS1 students' retention in the acquisition of science process skills in the food test.
3. think-pair-share instructional strategy on male and female SS1 students' retention in acquisition of science process skills in food test.

Research Questions

The following research questions were asked to guide the study

1. What are the mean retention scores of SS1 students taught food test using individualized, think-pair-share and conventional instructional strategies in the acquisition of science process skills?
2. What are the mean retention scores of male and female SS1 students taught food test using individualized instructional strategy in the acquisition of science process skills?
3. What are the mean retention scores of male and female SS1 students taught food test using think-pair-share instructional strategy in acquisition of science process skills?

Research Hypotheses

The following null hypotheses were tested at 0.05 level of significance.

H_{O1}: There is no significant difference in the mean retention scores of SS1 students taught food test using individualized, think-pair-share and conventional instructional strategies in the acquisition of science process skills.

H_{O2}: There is no significant difference in the mean retention scores of male and female SS1 students taught food test using individualized instructional

strategy in acquisition of science process skills.

H_{O3}: There is no significant difference in the mean retention scores of male and female SS1 students taught food test using think-pair-share instructional strategy in the acquisition of science process skill

Methodology

The study adopted a quasi-experimental research design, specifically the pre-test, post- test, and post-post-test no-equivalent control group design, to determine gender differences in the acquisition and retention of science process skills among students taught food-test concepts with TPS and with IIS. The population was all SS1 Biology students in government secondary schools in Gwagwalada Area Council, FCT (N = 15,432). Multi- stage random sampling technique was used to drawn the sample of 124 students and randomly allocated to TPS, IIS and conventional-teaching control, and one intact SS1 class was randomly selected in each.: the sample consist of the following TPS, 23 male and 21 female; IIS, 22 male and 20 female, conventional method consist of 38 students. An instrument titled; food test process skill acquisition test (FTPSAT) consisting of 15 multiple choice questions and 5 practical skill test was used. The instruments underwent face, content, and construct validation by three experts in Science Education and Measurement and Evaluation. The reliability coefficients, determined through the Kuder-Richardson Formula 21 (KR-21), were 0.86 for FTPSAT, indicating high internal consistency**.** Descriptive statistic of mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

Results

Research Question One: What are the mean retention scores of SS1 students taught food test using individualized, think-pair share and conventional instructional strategies in the acquisition of science process skills?

Table 1: Retention Mean Scores and Standard Deviation in FTPSAT of Students in the Experimental and Control Groups

Group	Test	N	Mean	S.D
Individualized	Posttest	42	29.79	4.015
	Retention	42	42.14	6.019
Think-pair-share	Posttest	44	34.39	5.836
	Retention	44	47.75	6.488
Convention Method	Posttest	38	24.39	3.977
	Retention	38	30.39	6.092

Table 1 shows that the mean retention scores of students taught using IIS 29.79 and 42.14; TPSIS was 34.39 and 47.75 and conventional method 24,39 and 30.39 in the FTPSAT posttest and retention scores respectively; and the standard deviations of

4.015 and 6.019; 5.836 and 6.488, 3.977 and 6.092 in that order.

Null Hypothesis 1

Ho_1: There is no significant difference in the mean retention scores of student taught food test using IIS, TPSIS and CM.

Table 2: One-Way ANCOVA Results on Mean Retention Scores in FTPSAT of Experimental and Control Groups

Source	Type III sum of squares	df	Mean Square	F	Sig
Corrected Model	9019.047[a]	3	3006.349	184.455	0.000
Intercept	338.443	1	338.443	20.765	0.000
Posttest	2712.648	1	2712.648	166.435	0.000
Group	**790.296**	**2**	**395.148**	**24.244**	**0.000**
Error	1955.824	120	16.299		
Total	214690.000	124			
Corrected total	10974.871	123			

a. R Squared = .822 (Adjusted R Squared = .817)

Table 2 shows the summary of the one way ANCOVA results on students' process skills mean retention scores in FTPSAT in the experimental and control groups. The results in Table 2 revealed that the noted difference between the process skills retention mean scores of the students taught using IIS, TPSIS and CM was significant at 0.05 alpha levels. This is from the fact that $F_{(2,120)} = 24.244$ and, $P=0.000 < \alpha = 0.05$. The null hypothesis was therefore rejected, indicating that there is significant difference in the process skills retention mean scores of students' taught using IIS, TPSIS and CM.

Table 3: Bonferroni Test Analysis for Pair-Wise Comparison of Retention Mean Scores of FTPSAT for IIS, TPSIS and CM

i. Group	(J) Group	Mean Difference (I-J)	Std Error	Sig.	95% Confidence interval for Difference	
					Lower Bound	Upper Bound
IND	**TPS**	-1.005	0.941	0.864	-3.290	1.280
	CM	6.355*	0.996	0.000	3.937	8.773
TPS	**IND**	1.005	0.941	0.864	-1.280	3.290
	CM	7.360*	1.183	0.000	4.487	10.232
CM	**IND**	-6.355*	0.996	0.000	-8.773	-3.937
	TPS	-7.360*	1.183	0.000	-10.232	-4.487

The Post Hoc Analysis using Bonferroni test to determine the direction of superiority of means by Pair-wise Comparison is shown in Table 3. Based on the estimated marginal means, the Table shows the following mean retention difference between groups: IIS and TPSIS have mean retention difference of 1.005, P = 0.864 < $\propto$ = 0.05. IIS and CM have mean retention differences of 6.355 P = 0.000 < $\propto$ 0.05, while TPSIS and CM have 7.360, P = 0.000 < $\propto$ 0.05. Even though both mean differences are significant at 0.05 levels which rejected the hypotheses, the results of this test indicate that IIS and TPSIS were more effective in retention of science process skills among Biology students.

Research Question 2

What are the mean retention scores of male and female students taught food test using IIS in acquisition of science process skills?

Table 4: Mean Retention Scores and Standard Deviations in FTPSAT of Male and Female Students in the Experimental Group 1 (IIS)

GenderIND	Test	N	Mean	S.D
Male	Posttest	22	29.95	3.735
	Retention	22	43.00	6.000
Female	Posttest	20	29.60	4.394
	Retention	20	41.20	6.049

Table 4 shows that the mean retention scores of the male students taught using IIS was 43.00 and standard deviations of 6.000 in the process skills acquisition test. For the female students, it was observed that they had mean retention scores 41.20 and standard deviations of 6.409 in that order.

Null Hypothesis 2

There is no significant difference in the mean retention scores of male and female students taught food test using IIS in acquisition of science process skills.

Table 5: Results of ANCOVA on Male and Female Mean Retention Scores of FTPSAT in IIS

Source	Type III sum of squares	df	Mean Square	F	Sig
Corrected Model	969.393[a]	2	484.696	36.652	0.000
Intercept	32.261	1	32.261	2.440	0.126
Posttest	935.450	1	935.450	70.737	0.000
Gender IIS	**19.848**	**1**	**19.848**	**1.501**	**0.228**
Error	515.750	39	13.224		
Total	76078.000	42			
Corrected total	1485.143	41			

a R Squared = .653 (Adjusted R Squared = .635)

Table 5 shows the summary of the one-way ANCOVA table on male and female students' process skill mean retention scores in FTPSAT. The results in Table 4 reveals that the noted difference between the means retention scores of the male and female students taught using IIS was not significant at 0.05 alpha levels. This is from the fact $F_{(1, 39)} = 1.501$ and $P = 0.228 > \propto = 0.05$. The null hypothesis was therefore not rejected showing that there is no significant difference in the process skills retention mean scores of male and female students who are exposed to IIS.

Research Question 3

What are the mean retention scores of male and female students taught food test using TPSIS in acquisition of science process skills?

Table 6: Mean Retention Scores and Standard Deviations in FTPSAT of Male and Female Students in the Experimental Group 2 (TPSIS)

Gender TPS	Test	N	Mean	S.D
Male	Posttest	23	35.22	6.815
	Retention	23	47.83	6.939
Female	Posttest	21	33.48	4.523
	Retention	21	47.67	6.126

Table 6 shows that the mean retention scores of the male students taught using TPSIS was 47.83 and standard deviations of 6.939 in the process skills acquisition test. For the female students, it was observed that they had mean retention scores 47.67 and standard deviations of 6.126 in that order.

Null Hypothesis 3

There is no significant difference in the mean retention scores of male and female students taught food test using TPSIS in acquisition of science process skills.

Table 7: Results of ANCOVA on Male and Female Mean Retention Scores of FTPSAT in TPSIS

Source	Type III sum of squares	df	Mean Square	F	Sig
Corrected Model	1177.884[a]	2	588.942	38.185	0.000
Intercept	324.925	1	324.925	21.067	0.000
Posttest	1177.605	1	1177.605	76.351	0.000
Gender TPS	**21.632**	**1**	**21.632**	**1.403**	**0.243**
Error	632.366	41	15.424		
Total	102133.000	44			
Corrected total	1810.250	43			

a. R Squared = .651 (Adjusted R Squared = .634)

Table 6 shows the summary of the one-way ANCOVA table on male and female students' process skill mean retention scores in FTPSAT. The results in Table 6 reveals that the noted difference between the means retention scores of the male and female students taught using TPSIS was not significant at 0.05 alpha levels. This is from the fact $F_{(1, 41)} = 1.403$ and $P = 0.243 > \propto = 0.05$. The null hypothesis was therefore not rejected showing that there is no significant difference in the process skills retention mean scores of male and female students who taught using TPSIS.

Discussion of Findings

The result confirmed that there was a significant difference in the students' retention means scores in food test concepts in favour of think-pair-share instructional strategy. This implies that think-pair-share instructional strategy is more effective in making students retain food test concepts than those taught with the individualized instructional strategy and the conventional method. A post hoc analysis by Bonferroni test for Pair-wise Comparison of retention mean scores between IIS and TPSIS, IIS and CM and TPSIS and CM was done and the results of the test indicates that TPSIS is more effective in the retention of food test concept among Biology students followed by the Individualized Instructional Strategy and the conventional method being the least. The results on gender retention of the concept of food test when exposed to individualized instructional strategy shows that gender is not a significant factor even though there is a slight difference in the retention mean scores in favour of male students, the noted difference between the retention mean scores of male and female students is not significant at 0.05 alpha level

Conclusions

Based on the findings of this study, individualized and Think-Pair-Share instructional strategies enhanced students' acquisition of science process skills and retention in the food-test aspect of Biology compared with conventional teaching. Gender has no significant effect on students' acquisition of science process skills; although males recorded slightly higher mean scores than their female counterparts.

Recommendations

On the basis of the findings, the following recommendations are made.

1. The innovative learning strategies used in this study are highly recommended to be used in teaching food test in senior secondary schools, seeing that they have capacity to improve acquisition of science process skills and enhanced retention in Biology, teachers should be sensitized on the way of involving students in the use of these strategies to enable them perform better in Biology by way of conferences, paper presentations, seminars, workshops
2. Teachers should ensure that every student, boy or girl, handles the materials during the individual stage and does not merely observe a partner, because guaranteed hands-on access is the most plausible reason for the gender-neutral outcomes observed.

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