

Effects of Individualized and Collaborative Instructional Strategies on Basic Science Students' Acquisition of Science Process Skills in Idah Education Zone of Kogi State

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Abstract

This study investigated the effects of Individualized and Collaborative Laboratory Instructional Strategies on the acquisition of basic science process skills (SPS) among Junior Secondary School Two (JSS2) students in Idah Education Zone of Kogi State, Nigeria. The study was guided by three research questions and three null hypotheses. Quasi-experimental research design, specifically, non-randomized pre-test post-test non-equivalent control groups was used. The population consisted of 996 JSS2 Students (523 males and 473 females). The sample for the study comprised of 96 JSS2 Basic Science Students. Four intact classes were randomly assigned to experimental group I (40) and group II (46). Two instruments were used for data collection; SPS Observation Rating Scale (SPSORS) and Thermal Energy Practical Activities (TEPA) were validated and used for data collection. Interventions implemented in four weeks. Reliability of the instrument was done using Cronbach's Alpha that yielded 0.80 which indicates good internal consistency. Mean and standard deviation were used to answer research questions, and Analysis of Covariance (ANCOVA) used in testing hypotheses at 0.05 significance level. Findings revealed among others that individualized instructional strategy significantly enhanced students' acquisition of SPS than collaborative strategy. The study further showed that gender had no significant influence on students' SPS acquisition. It was recommended that basic science teachers adopt individualized instructional strategy in order to improve students' acquisition of SPS. The study concludes that structured activity-based experiences centered on individual learner is efficacious in inculcating SPS.

Keywords: Individualized; Collaborative; Instructional strategies; Science Process Skills

Introduction

One of the core purposes of education, and perhaps its most enduring legacy, lies in equipping students with essential skills that shape their ability to navigate real-world challenges and foster lifelong learning. These skills emphasize experimenting and manipulating the physical world through individualized and collaborative instructional strategies which may promote science process skills (SPS). The science process skills include but not limited to observation, classification, measurement, prediction, communication, inference, hypothesizing, experimentation, and data interpretation. For inculcating the skills in the learner, basic science education serves as a critical platform for nurturing SPS, as it encourages learners to explore their environment, ask questions, and solve problems through inquiry-based learning.

Basic science education forms the foundation of all scientific disciplines and serves as a prerequisite for advanced studies in science and technology. According to UNESCO (2020), basic science focuses on fundamental scientific skills essential for solving real-world problems and achieving sustainable development. Building capacity in basic sciences requires high-quality instructional strategies that promote the acquisition of science process skills, particularly at the junior secondary school level. Poor acquisition of these skills has been linked to students' low performance in science subjects at higher educational levels (Peng & Kievit, 2020). Poor performance in Basic Science have reported by Basic Education Certificate Examination (BECE) (Chief Examiner's report, 2023). Addressing these abnormally through effective teaching strategies is vital for enhanced SPS acquisition and learners'

readiness for future studies in science and technology (Jirgba, Eriba, and Achor, 2018).

Research has shown that students in Nigeria struggle to acquire SPS in Basic Science due to the use of inappropriate teaching strategies, lack of hands-on activities, and insufficient facilities (Jirgba, Eriba & Achor, 2018; Achor, 2020). In addition, conventional teaching strategies employed by teachers, such as lecture and demonstration are teacher-centered and limit students' active engagement in the learning process, resulting in poor performance by students. Scholars like Koksai and Berberoglu (2014); Ibe and Nwosu (2017) emphasize that the acquisition of SPS supports students in exploring their environment and addressing real-life challenges.

The American Association for the Advancement of Science (AAAS) grouped SPS into basic and integrated skills, with basic skills serving as the foundation for more complex processes. The study was anchored on the six basic science process skills, namely: observation, classification, measurement, prediction, communication, and inference. These skills are regarded as the foundational skills in science learning because they help students to develop scientific thinking and problem-solving abilities. The skills form the foundation upon which more advanced and integrated science skills are built. Learners acquire SPS more effectively through hands-on activities learning strategies.

Individualized instructional strategy is a teaching approach that adapts to the unique needs, abilities, and learning styles of each student, ensuring that learners progress at their own pace and engage with content in ways that suit their strengths and weaknesses. Individualized instruction focuses on providing personalized learning experiences that promote critical thinking, independent inquiry, and self-paced learning. According to (Tomlinson, 2014; Anthony, 2023) the strategy fosters an inclusive learning environment by tailoring instruction to each student's prior knowledge and interests, which enhances engagement and improves learning outcomes. In the context of Basic Science, individualized instruction encourages hands-on, practical activities that allow students to independently explore scientific concepts, thereby facilitating the acquisition of SPS. The Another strategy that can enhance SPS acquisition is the Collaborative instructional strategy which involves students working in groups to achieve shared learning goals through hands-on scientific tasks. This strategy

encourages social interaction, teamwork, and the exchange of ideas, which promotes a deeper understanding of scientific concepts and improves learning outcomes. According to Chen, Wang, Kirschner, and Tsai (2018), collaboration is particularly effective at the Junior Secondary School level, as it fosters peer learning and coordination within both formal and informal learning environments, regardless of gender differences.

Purpose of the study

The purpose of the study is to determine the effects of individualized and collaborative instructional strategies on Basic Science students' acquisition of SPS in Idah Education Zone of Kogi State. Three research questions and three corresponding null hypotheses guided the study.

Research Questions

1. What are the mean SPS acquisition scores of students taught using individualized instructional strategy and those taught using collaboration instructional strategy
2. What is the influence of gender on students' mean acquisition scores on SPS in Basic Science?
3. What is the interaction effect of instructional strategies and gender on students' mean acquisition scores of SPS in Basic Science?

Hypotheses

HO₁: There is no significant difference in the mean SPS acquisition scores of students taught Basic Science using individualized instructional strategy and those taught using collaborative instructional strategy.

HO₂: There is no significant influence of gender on students' mean acquisition scores of SPS

HO₃: There is no significant interaction effect of instructional strategies and gender on students' acquisition of SPS.

Methods

The design of the study is quasi-experimental of non-equivalent comparison group where two classes involved remained intact. This research was carried out in Idah education zone of Kogi State. Kogi State is located in Nigeria's North-Central Zone. The research population included 996 JSS2 Basic science students (523 male and 473 female) for the 2023/2024

academic session in the four Local Government Areas in Kogi State's Idah Education Zone. The study's sample was 96 of two intact classes in JSS2 Basic science. Multi-stage sampling procedure was employed. Firstly, simple random sampling was used to sample two local governments out the four in the zone using balloting. Simple random sampling was used to sample two schools from each Local Government Area. Simple random sampling was used also to assign the two schools to experimental Group I (Individualized Group) and two schools to experimental Group II (Collaborative Group). Science Process Skills Observation Rating Scale (SPSORS) and Thermal Energy Practical Activities (TEPA) were instruments for data collection. The researcher developed the Science Process Skills Observation Rating Scale and Thermal Energy Practical Activities for the study. The SPSORS contained two (2) parts A and B. Section A contain students' demographic information. B contained data on thermal energy categorized into activities (1-3) with respect to Observing Thermal Energy and corresponding Rubric for Observing and Measuring. Classifying Materials Based on Thermal Conductivity and corresponding Rubric for Classifying and Measuring. Measuring Temperature Change and corresponding Rubric for Measuring and Observing. The SPSORS and TEPA

instruments were face validated by three experts in Department of Science Education, Faculty of Education, University of Nigeria, Nsukka. Thirty copies of the SPSORS and TEPA instrument were administered to JSS 2 students in Dekina Education Zone in order to establish the internal consistency of the SPSORS and TEPA instrument. The scores obtained from the administered instrument was recorded and subjected to determine reliability coefficient of SPSORS using Cronbach's alpha (α) formula.

The overall reliability analysis of the instrument reveals a Cronbach's Alpha value of 0.80 across all 30 items.

Basic science teachers teaching JSS2 students in the four schools was trained by the researcher for four days before the study began. The purpose of the training was to enable the teachers of both schools that will teach students understand individualized and collaborative laboratory instructional strategies on Basic science students' acquisition of science process skills using the lesson plans.

The data collected was analyzed using descriptive statistics of mean and standard deviation to answer the research questions, while the hypotheses were tested using Analysis of Covariance (ANCOVA) at .05 level of significance.

Results

Results are presented in tables according to the research questions and corresponding hypotheses

Table 1: Pretest-Posttest mean SPS acquisition scores of basic science students when taught using individualized and collaborative instructional strategies

Methods	N	Pretest		Posttest		Mean gain	Mean Difference
		$\bar{X}$	SD	$\bar{X}$	SD		
Individualized Strategy	50	43.35	8.94	62.96	6.31	18.96	10.75
Collaborative Strategy	46	32.76	10.95	40.97	8.34	8.21	

Result in Table 1 showed that Basic Science students who were taught using individualized strategy had mean score of ($= 43.35$, $SD = 8.94$) at the pretest and mean score of ($= 62.96$, $SD = 6.31$) at the posttest level while the mean gain score was 18.96. Furthermore, the students taught using collaborative instructional strategy had a pretest mean score of ($= 32.76$, $SD = 10.95$), and posttest mean score of ($= 40.97$, $SD = 8.34$) with mean gain of 8.21 and mean difference of 10.75. Meanwhile, the higher gain scores

of 18.96 for individualized instructional strategy showed that individualized instructional strategy improved students' mean scores in acquisition of science process skills more than collaborative laboratory instructional strategy with individualized instructional strategy proving more efficacious. The closeness of SD in the two groups indicate that the respondents were homogenous in their responses to the Basic Science SPS test items.

Table 2: Pre-test/Post-test of the Influence of Gender on Students' Mean Scores in the Acquisition of Science Process Skills in Basic Science

Gender	N	Pretest		Posttest		Mean Gain	Mean Difference
		$\bar{x}$	SD	$\bar{x}$	SD		
Male	51	41.98	7.20	56.50	6.51	14.53	0.69
Female	45	42.00	10.40	55.84	9.53	13.84	

Result in Table 2 showed the influence of gender on students' mean acquisition scores of SPS. Result showed that male students had pretest mean score of ($\bar{x}$ =41.98, SD = 7.20) and a post-test mean score of ($\bar{x}$ = 56.50, SD = 6.51), while the female students had a pretest mean score of ($\bar{x}$ =42.00, SD =

10.40) and a posttest mean score ($\bar{x}$ = 55.84, SD = 9.53). Result showed that the male students performed slightly higher than their female counterparts with mean gain of 14.53 while the female students had mean gain of 13.84 with a mean difference of 0.69 in favor of the male counterpart.

Table 3: Pretest/Posttest Interaction Effect of Instructional Strategies and Gender on Students' Mean Scores in the Acquisition of Science Process Skills in Basic Science

Methods	Gender	N	Pre test		Posttest		Mean gain
			$\bar{X}$	SD	$\bar{X}$	SD	
Individualized Strategy.	Male	23	35.91	4.64	63.28	4.73	27.37
	Female	27	31.35	2.98	52.48	4.64	21.13
Collaborative Strategy	Male	28	30.41	4.52	45.28	4.63	14.87
	Female	18	28.11	3.23	40.65	4.47	12.54

Result in Table 3 showed the interaction effect of instructional strategies and gender on students' mean acquisition scores of SPS. Result showed that after the treatment, the male and female students acquisition of SPS using individualized instructional strategy had mean gains of 27.37 and 21.13 respectively, while the male and female students taught the same topics with collaborative instructional strategy had mean gains of 14.87 and 12.24 respectively. This imply that male students showed

greater mean gain scores in the two groups. To test for the significant interaction effect of strategy and gender on students' mean scores in acquisition of science process skills, see hypothesis three. The Standard deviation presented in Table 3 above show that the interaction effect of teaching strategy among the two groups are relatively low judging from the amount of variation of values in their mean score and gender. This is because of the homogeneity of items response among the male and female students in Basic Science.

Table 4: Analysis of Covariance (ANCOVA) of mean Acquisition scores of students taught Basic Science using individualized instructional strategy and those taught using collaborative instructional strategy

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Decision
Corrected Model	27477.982 ^a	2	7738.991	259.463	.001	.403	
Intercept	30962.280	1	30962.280	622.377	.000	.246	
PretestScores	10659.228	1	10659.228	316.476	.002	.481	
Methods	5981.622	1	5981.622	215.287	.0003	.270	S
Error	11485.227	93	23.681				
Total	1157590.000	96					
Corrected Total	28963.209	95					

Note: S = Significant, NS = Not Significant and η^2_p = partial eta squared

The result in Table 4 showed the ANCOVA result of the difference in the mean scores of students when exposed to individualized strategy and those exposed to collaborative instructional strategy. The

result was statistically significant at (F) = 215.287, p = 0.03, η^2_p = 0.370). Since the associated probability value of 0.03 is less than 0.05 set as level of significance, the null hypothesis was rejected.

Table 5: Analysis of Covariance (ANCOVA) of the difference between the mean scores of male and female students taught basic science using individualized and collaborative strategies

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Dec.
Corrected Model	18182.685 ^a	2	6060.895	131.11	.000	.628	
Intercept	20434.684	1	20434.684	644.46	.000	.655	
Pretest Scores	11279.393	1	11279.393	355.74	.000	.511	
Methods	.421	1	.421	.013	.908	.002	
Gender	704.703	1	704.703	12.215	.440	.211	NS
Error	10780.524	93	31.707				
Total	1157590.000	96					
Corrected Total	28963.209	95					

Note: S = Significant, NS = Not Significant and η^2_p = partial eta squared

The result in Table 5 showed the ANCOVA of the difference between the mean scores of male and female students' taught Basic Science using individualized and collaborative strategies. The result was statistically significant at (F) = 12.22, p = 0.44, η^2_p = 0.021). Since the associated probability value of 0.44 is greater than 0.05 set as level of significance, the null hypothesis was accepted. Thus, inference drawn is that there is no statistically significant

difference between the mean scores of male and female students' taught Basic Science using individualized and collaborative strategies. The result further showed the effect size (η^2_p = 0.21), which indicates that twenty-one percent (21%) variance in the mean scores of male and female students taught Basic Science using individualized and collaborative strategies can be attributed to gender.

Table 6: Analysis of Covariance (ANCOVA) of Interaction Effect of Instructional Strategies and Gender on Students' Acquisition of Science Process Skills.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Decision
Corrected Model	21002.931 ^a	2	5250.733	223.60	.000	.725	
Intercept	16565.261	1	16565.21	705.46	.000	.675	
PretestScore.	12299.186	1	12299.16	523.79	.000	.607	
Gender	913.844	1	913.844	28.914	.001	.030	
Methods*Gender	.000	1	.000	.560	.530	.010	NS
Error	7960.278	93	23.482				
Total	1157590.000	96					
Corrected Total	28963.209	95					

Note: S = Significant, NS = Not Significant and η^2_p = partial eta squared

The result in Table 6 showed the ANCOVA of the significant interaction effect of instructional strategies and gender on students' acquisition of Science Process Skills. The result was not statistically significant at (F) = 0.560, p = 0.530, η^2_p = 0.10). Since the associated probability value of 0.530 is greater than 0.05 set as level of significance, the null hypothesis was accepted. Thus, inference drawn is that there was no statistically significant interaction effect of instructional strategies and gender on students' acquisition of Science Process Skills in Basic Science.

Discussion of Findings

The results showed that Basic Science students taught using individualized strategy had a significant improvement in their science process skills acquisition, with higher post-test scores compared to pre-test scores. This suggests that tailored instruction, which meets individual learning needs, is effective for teaching complex science content. The findings align with studies by Saadu (2020) and Ugwu et al. (2020), which found that individualized instruction enhances student performance in Basic Science. Dawal (2021) also supported the idea that individualized strategies are more effective than traditional methods. Overall, both individualized and collaborative teaching strategies were shown to improve students' science process skills acquisition.

The results showed that male students slightly outperformed female students in acquiring science process skills in Basic Science, regardless of whether individualized or collaborative teaching strategies were used. The gender difference was not significant in this study. This finding disagree with studies by Iwanger and Sani (2019), that reported gender

differences in science skill acquisition. It aligns with Ekon and Eni (2015) who found no significant gender influence in their study, possibly due to differences in education level.

Result revealed Interaction Effect of Instructional Strategies and Gender on Students' Mean Scores in the Acquisition of Science Process Skills in Basic Science. After the treatment, male and female students who were taught using the individualized instructional strategy recorded higher mean gains respectively. In contrast, those taught with the collaborative instructional strategy had lower mean gains for males and females. This suggests that individualized instruction was more effective in enhancing students' acquisition of science process skills than collaborative instruction, regardless of gender. The findings of this study agree with the view of Anari, Nja and Neji, (2023) who reported that the interaction effect of treatment and gender on students' acquisition of science process skills was statistically significant. Also result of this study is in agreement with Ekpo, Nsikhe and Mfam, (2025) that the interaction between teaching strategies and gender was significant.

The analysis showed no statistically significant difference in the academic performance of male and female students taught Basic Science using either individualized or collaborative instructional strategies. The null hypothesis was accepted, indicating that gender did not significantly influence students' performance or their response to the teaching methods. Although the effect size suggested a minor, non-significant influence of gender, it was not strong enough to warrant gender-based instructional adjustments. These findings align with previous studies reporting no gender differences in the

acquisition of science process skills. Overall, both male and female students benefit equally from individualized and collaborative strategies, suggesting that educators should focus on the effectiveness of instructional Strategies rather than gender considerations.

The analysis in Table 6 found no statistically significant interaction between instructional strategy and gender on students' acquisition of Science Process Skills in Basic Science. This indicates that the effectiveness of individualized and collaborative strategies did not vary by gender, and both male and female students benefited similarly from each strategy.

Conclusion

The study establishes that individualized instructional strategies positively influence students' acquisition of Science Process Skills, with statistically significant differences observed. This offers concrete empirical support for the effectiveness of these student-centered strategy in Basic Science classrooms. The findings reinforce the importance of active, hands-on learning in Basic science. The study highlights how collaborative laboratory instruction, in particular, enhances students' engagement and practical understanding, providing a foundation for revising traditional, teacher-centered methods in favor of more interactive models. The study align with competency-based curricula that emphasize skill development over rote learning. The demonstrated impact of these strategies provides valuable insights for curriculum developers and policymakers aiming to foster scientific literacy and inquiry-based learning at the basic education level. While the effect of gender was not significant, the study contributes to the growing body of research confirming that individualized and collaborative methods are equally effective across genders. This supports the adoption of inclusive instructional designs without the need for gender-specific modifications. This study opens pathways for further exploration into the long-term impacts of these strategies, their application in other science subjects, and their adaptability across different educational contexts and learning abilities.

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