

# IMPACT OF SCIENCE PROCESS-BASED APPROACH ON PROCESS SKILLS ACQUISITION AMONG SECONDARY SCHOOL BIOLOGY STUDENTS WITH VARIED ABILITY IN ZARIA, NIGERIA

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**ABSTRACT** The study investigated: "The Impact of Science Process - Based Approach on Process Skill Acquisition among Secondary School Biology Students' with Varied Abilities in Zaria, Nigeria." Two research questions and two null hypotheses guided the study, tested at a significance level of  $P \leq 0.05$ . The research employed a pretest and post-test quasi-experimental design with a control group. 133 SSII students, 63 in the experimental and 70 in the control groups, were selected from intact classes in two coeducational secondary schools in Zaria Educational Zone, Kaduna State. The experimental group received instruction in Biology using the Science Process-Based Approach (SPBA), while the control group was taught using the Lecture Method. Data were collected using a validated instrument called the Test of Science Process Skills Acquisition (TSPSA). Mean rank and standard deviation were used to analyze the research questions. At the same time, one-way analysis of variance (ANOVA), analysis of covariance (ANCOVA), and Kruskal Wallis tests were employed to test the null hypotheses. The results indicated that: (i) students taught using SPBA showed a significant difference in process skills acquisition, favouring the high experimental group over those taught using the lecture method; and (ii) there was no significant difference in process skills acquisition between male and female students taught using SPBA compared to those taught using the lecture method across varied ability groups. The findings suggest that SPBA instructional strategies enhance process skills acquisition in Biology concepts. Consequently, the study recommends organizing SPBA training workshops for Biology teachers to enable them to integrate SPBA into their lessons, thereby improving students' process skills acquisition.

**KEYWORDS:** Process Based Approach, Process Skills Acquisition & Varied Ability.

## I. INTRODUCTION

The relevance of science to humanity in giving humanity the ability to explain everyday phenomena and develop technologically cannot be overemphasized. Studying science and technology has become mandatory in this 21<sup>st</sup> century when the world is fast becoming a global village. This is because the growth of any nation economically, socially and politically is determined to a great extent by its advancement in science and technology [22]. Science is a valuable endeavour that employs human intellect to enhance comprehension of the natural world and its occurrences. Science has a significant impact on both national and individual lives. Anidoh and Eze [3] contend that science empowers individuals to make logical decisions, establish a fair society, and comprehend their surroundings. It increases a person's life expectancy and gives him tools to deal with everyday issues like hunger and illness. According to [3], the national contributions of science can be seen in automation, genetic engineering, gene cloning, modern health, agriculture, transportation, building, and construction. These individual and national effects of science also explain why most nations, including Nigeria, are investing heavily in science. According to Sarath and Geetha [20], science processes are interconnected tasks carried out by any qualified individual when doing cosmic investigation. Many authors have offered numerous interpretations of the "process of science". According to Shafiu [21], the American Association for the Advancement of Science (AAAS) sees it as a similar de-emphasis on particular science "content" and an emphasis on science "processes" in its programme, Science - A Process

Approach (SAPA). According to SAPA, scientists conduct science. According to SAPA, the science process skills are a collection of widely applicable talents suitable for various science fields and represent the conduct of scientists.

Hikmah et al. [8] state that SPS is a cognitive ability applied when thinking through issues and formulating conclusions. Scientists employ these science process skills in their jobs. It can help kids acquire these crucial science process abilities, empowering them to comprehend and learn about their surroundings. The foundation of scientific investigation and thought is these abilities of the scientific process. Per Maranan [11], scientists' findings stem from a collection of distinct and crucial proficiencies known as their scientific process skills. According to Okafor [18], the importance of process skill acquisition in science instruction lies in how it engages students in "doing science." Through "doing science," students can acquire process skills to facilitate their understanding of scientific concepts. However, student performance in science in Nigeria must improve despite science's value to humanity and researchers' efforts to enhance its teaching and learning. According to Nja et al. [14], even though science subjects are acknowledged, students continue to have a negative attitude towards the subject, which hinders their ability to acquire science process skills. Because most schools need more well-equipped laboratories, science is also taught in most classes as a collection of abstract concepts with no real-world applications. Due in part to this, students have acquired inferior science process skills, which is increasingly apparent in many students who fail the subject in public exams. In Nigeria, biology is one of the disciplines taught at the senior secondary school level. The goal of the present biology curriculum in Nigerian secondary schools is to give pupils a solid understanding of the fundamentals of the subject to help them better comprehend their environment. The curriculum strives to help students become globally employable and self-sufficient in the global economy by developing relevant skills like communication, critical thinking, problem-solving, and objective reasoning [13]. Considering the curriculum's goals, students are expected to contribute and be valuable members of society. Sadly, secondary school pupils frequently fail to meet these curricular requirements. According to Nsofor and Dada [15], biology professors who prioritize the theoretical explanation of biological ideas over the more significant and fulfilling practical components are to blame for this approach.

Therefore, Effective teaching strategies are required to instil in biology students the abilities that will enhance their academic achievement in the subject. Munna and Kalam [12] assert that to improve learning and teaching effectiveness; educators must implement instructional strategies that will improve student's assimilation of knowledge and acquisition of skills. One such strategy is the science process skill approach, which can significantly raise academic standards for students. Like Danladi [5], researchers in education have determined the elements and circumstances that either support or impede the acquisition of science process abilities. Their findings showed that activities that are hands-on and mentally stimulating, as well as cooperative learning opportunities, help students enhance their science process abilities. According to Darling-Hammond et al. [6], characteristics including non-cooperative learning experiences are associated with a decrease in interpersonal relationships. This is because, working alone, students are less likely to acquire Science Process Skills. In Gadzama [7], Harlen emphasized incorporating science process skills into evaluating science learning. Failure to do so may result in students' mismatched science concepts and abilities being uneven. Usman [24] used the NISTEP mode of instruction to conduct a study to determine the association between the academic performance of male and female students in integrated science and their performance in practical tasks. He discovered no discernible difference in academic accomplishment or practical performance between males and females. Ahmed [1] studied how gender affected students' development of formal reasoning skills and found that when genetics was taught using the learning cycle teaching technique, there was no discernible difference in male and female performance. Numerous research findings suggest that while specific educational approaches are gender-friendly, others are not. Determining if the Science Process Approach is gender-friendly and identifying whether one gender acquires more science process skills than the other is two of the study's goals.

Based on the idea that learning is an active process, Piaget's [19] constructivist theory served as the theoretical foundation for this investigation. According to the constructivist school of thinking, learning is an active process in which pupils develop their worldviews and conceptions. According to the constructivist school of thought, learning is an active process in which students build their understanding of the subject matter by drawing on prior knowledge that has already been acquired.

According to constructivism, students actively create knowledge rather than passively absorbing it. This hypothesis holds that pupils actively use their minds to build meaning as they interact with their surroundings.

The driving force for this research is derived from the fact that the Science Process-Based Approach (SPBA) is not taught for skill acquisition advocated for teaching biology in the national policy on education is seldom used by teachers, which might have contributed to poor performance and non-acquisition of skills by secondary schools' students [25]. Zayun in Danjuma [4] opined that several factors have been responsible for the low acquisition of science process skills, including teaching methods, learning materials, teacher factors, societal factors and strategies employed by the teachers. Therefore, this study seeks to determine the impact of the Science Process Approach on process skills acquisition among varied ability biology students in Zaria, Kaduna state. The objective of the study is to find out the effect of Process Skills Acquisition on varied ability Biology students taught using the Science Process-Based Approach (SPBA) and Lecture Method. Also, the study intends to find out the effect of Process Skills Acquisition on male and female varied-ability Biology students taught using a Science Process-Based Approach (SPBA) and Lecture Method.

## **II. METHODOLOGY**

### **A. RESEARCH DESIGN**

Two (2) schools and two (2) classes were used in the quasi-experimental research design, which included a control group using pre-and post-tests. Two (2) coeducational secondary schools were selected from Kaduna state's Zaria Local Government Area using a random sampling approach through voting. Because the principals of the impacted schools insisted on having every student attend both sessions and minimizing distractions, intact classes were used. He also said that the science classes should be the only ones open for research work.

### **B. POPULATION OF THE STUDY**

The study's target group was 3,929 Senior Secondary Schools II Biology students in the Zaria Local Government Area, consisting of SS II students in all 19 coeducational public senior secondary schools in Zaria, Kaduna State, Nigeria. The coeducational public schools were used because their condition of teaching and learning is relatively the same, which includes a lack of laboratory facilities and a large number of students. Because they have previously completed a year of study and will form a more stable group due to their lack of final tests, SS II students were deemed appropriate for the study due to their age and academic background.

### **C. SAMPLE AND SAMPLING PROCEDURE**

The study utilized a sample size of 133 students, selected through stratified randomization. This approach aligns with Lim and In's [9] recommendation of a minimum of 30 subjects for experimental studies. The sample was drawn from Senior Secondary II (SSII) classes in two Coeducational Secondary Schools out of the nineteen available in Zaria Local Government Area, Kaduna State. The two schools were selected randomly, ensuring equivalence in pretest performance. They were then randomly assigned to the experimental and Control groups, comprising 63 and 70 students. This allocation aimed to provide equal opportunities for student participation, ensure unbiased assessment of student performance and facilitate the formation of varied ability groups. From each school, three comparable ability groups were selected based on categorization into high, average, and low ability levels, following Ajewole and Okebukola's approach as outlined in Gadzama [7]. This categorization involved administering a pretest to all students, followed by arranging their grades in descending order, with the top 25% classified as high ability, the middle 50% as average, and the bottom 25% as low-ability students.

### **D. INSTRUMENTATION**

The Test of Science Process Skills Acquisition (TSPSA) was developed to assess the level of mastery of science process skills (SPS) among secondary school students. The instrument was constructed specifically for this study, ensuring alignment with the topic "CELL," which was also the basis for the Biology Performance Test. TSPSA integrates activity-based questions designed to measure students'

ability to apply various SPS in problem-solving scenarios. The test included items reflecting real-life and laboratory situations where students were expected to demonstrate skills in observation, measurement, hypothesis formulation, data interpretation, and experimentation.

The TSPSA questionnaire was divided into two sections. Section A collected biodata such as age and gender, providing demographic insights for deeper data analysis. Section B comprised six activity-based questions, each requiring students to engage in paper-and-pencil tasks reflective of actual science experiments or observations. Examples of these activities included:

- a) Controlling Variables: Students analyzed a scenario in which one variable (e.g., light intensity) was manipulated while others were held constant, then predicted the outcome for a plant's growth.
- b) Formulating Hypotheses: Given a statement such as "More sugar will increase the fermentation rate," students were tasked to write testable hypotheses related to enzyme activity in the cell.
- c) Interpreting Data and Graphs: Students reviewed graphical data showing enzyme activity at different pH levels and explained the patterns.
- d) Defining Operationally: Students were required to define terms like "rate of diffusion" using measurable or observable parameters.
- e) Experimentation: Activities such as designing a simple experiment to test osmosis using a potato were included to evaluate students' ability to apply experimental methods.
- f) Measuring and Observing: Students were asked to compare microscopic slides of plant and animal cells and record their observations systematically.

Each item in Section B was mapped to specific science process skills (e.g., observing, inferring, or analyzing data). For example:

- a) Observation and Measurement were evaluated through tasks requiring students to note differences in magnification levels under a microscope.
- b) Interpreting Data was assessed by presenting tables and graphs where students drew conclusions about enzymatic activity.
- c) Experimentation involved tasks where students outlined procedures for a hypothetical investigation and justified their experimental controls.

The TSPSA was scored using a rubric that awarded points for accuracy, clarity, and application of science process skills. Each question included structured guidelines to ensure objective scoring, making the test replicable in similar studies. The rubric categorized responses into levels such as "basic," "proficient," and "advanced," based on the completeness and correctness of the answers. In developing TSPSA, the inclusion of realistic, context-based questions ensured that students' practical abilities were evaluated rather than relying solely on rote memorization. This focus on actionable SPS provides a template for replicating the study across various topics within science education.

#### **E. VALIDATION OF TEST OF SCIENCE PROCESS SKILL ACQUISITION (TSPSA)**

The content of the TSPSA was submitted to three Lecturers with ranks of senior lecturers and above in the Science Education Department, Ahmadu Bello University, Zaria, for validation to determine the following:

#### **F. PILOT TESTING**

SS II students of Government Senior Secondary School Dakaci were identified and used for the pilot testing of the instrument.

#### **G. RELIABILITY OF TEST OF SCIENCE PROCESS SKILLS ACQUISITION (TSPSA)**

The Test of Science Process Skills Acquisition comprises six (6) questions, each with a process skill acquisition attributed to it. The researcher created the test based on the idea of life being taught during the research. Following the first test's administration, Tuckman gave a retest two weeks later on Maikano's [10] advice. The investigation was conducted using Pearson's Product Moment Correlation Coefficient statistic. The instrument was deemed reliable and utilized for data collection in the study, as evidenced by the reliability coefficient of 0.86 obtained from the results.

#### **H. PROCEDURE FOR DATA COLLECTION**

The researcher used the Test of Science Process Skill Acquisition Test (TSPSA) as a post-test after instructing the experimental and Control groups for five weeks. The TSPSA was marked over 100

according to ranks. After marking the scripts of the two schools, the scores were recorded accordingly based on the experimental and Control groups. After scoring, the data were subjected to inferential and descriptive statistical analysis using SPSS version 23.

## I. DATA ANALYSIS

The research issues were addressed utilizing the mean and standard deviations of the data collected from two groups, and ANOVA, ANCOVA, and KRUSKAL WALLIS were used to address the hypotheses.

## J. RESEARCH QUESTIONS

This study addressed the following research questions:

- What is the difference in the mean scores of Process Skills Acquisition among varied ability students taught biology using the Science Process-Based Approach (SPBA) and Lecture Method?
- What is the difference in the mean scores of Process Skills Acquisition among male and female students of varied abilities taught biology using the Science Process-Based Approach (SPBA) and Lecture Method?

## K. NULL HYPOTHESES

The following null hypotheses were tested at  $P \leq 0.05$  levels of significance.

- HO<sub>1</sub>: There is no significant difference in mean scores of Process Skills Acquisition among varied ability students taught Biology using the Science Process-Based Approach and Lecture Method
- HO<sub>2</sub>: There is no significant difference in mean scores of Process Skills Acquisition among male and female students of varied ability taught Biology using the Science Process-Based Approach and Lecture Method.

## III. RESULTS AND DISCUSSION

**Research Question One:** What is the difference in the mean scores of Process Skills Acquisition among varied-ability students taught biology using the Science Process-Based Approach (SPBA) and the Lecture Method?

**Table 1.** Mean and Standard Deviation of Students' Process Skills Acquisition Test Scores in Experimental and Control Groups

Ability Levels	Groups	N	Mean	Std. Deviation	MD
Low	Experimental	16	17.38	3.86	5.71
	Control	18	11.67	4.67	
Medium	Experimental	31	25.06	2.11	5.85
	Control	34	19.21	3.10	
High	Experimental	16	30.13	4.32	8.07
	Control	18	22.06	3.47	

The result in Table 1 revealed that the experimental and Control groups for low ability levels have a mean of 17.38 and 11.67, respectively, with a mean difference 5.71. For the medium ability level, the experimental has a mean value of 25.06 and 19.21 for the control group, respectively, with a mean difference of 5.85, while in the high ability level, the experimental group has a mean value of 30.13 and 22.06 and for the control group, respectively with a mean difference of 8.07. Therefore, the mean difference is highest in the high-ability group with a value of 8.07 and lowest in the low-ability group with a value of 5.71.

**Research Question Two:** What is the difference in the mean scores of Process Skills Acquisition among male and female students of varied ability taught biology using the Science Process-Based Approach (SPBA) and Lecture Method?

**Table 2.** Mean and Standard Deviation of Male and Female Students Process Skills Acquisition Test Scores in Experimental and Control Groups.

Ability Levels	Groups	Gender	N	Mean	Std. Deviation	MD
Low	Experimental	Male	7	22.86	1.07	5.64
		Female	9	17.22	3.27	
	Control	Male	9	15.56	1.24	3.12
		Female	9	12.44	7.00	
Medium	Experimental	Male	12	29.08	0.79	3.29
		Female	19	25.79	1.62	
	Control	Male	18	21.78	1.70	0.84
		Female	16	20.94	4.40	
High	Experimental	Male	10	33.30	4.55	0.63
		Female	6	32.67	2.73	
	Control	Male	9	25.33	3.28	2.55
		Female	9	22.78	3.35	

The result in Table 2 showed that among the Experimental group for low ability, male and female process skill acquisition scores are 22.86 and 17.22, respectively, with a mean difference of 5.64, and in the medium ability male and female process skill acquisition scores are 29.08 and 25.79 respectively with a mean difference of 3.29, while in the high ability, male and female process skill acquisition scores are 33.30 and 32.67 respectively with a mean difference of 0.63.

In the Control group for low ability, male and female process skill acquisition scores are 15.56 and 12.44, respectively, with a mean difference of 3.12; among the medium ability, male and female process skill acquisition scores are 21.78 and 20.94, respectively, with a mean difference of 0.84, while the high ability, male and female process skill acquisition scores are 25.33 and 22.78 respectively with a mean difference of 2.55. Therefore, the mean difference is higher in the low ability of the experimental group male and female process skill acquisition with a value of 5.64 and lowest in the high ability experimental group male and female process skill acquisition with a value of 0.63

**Null Hypothesis One (HO<sub>1</sub>):** There is no significant difference in mean scores of Process Skills Acquisition among varied ability students taught Biology using the Science Process-Based Approach and Lecture Method

**Table 3 (a):** Way Analysis of Variance (ANOVA) Results of Students Process Skills Acquisition in Experimental and Control Groups

	Sum of Squares	Df	Mean Square	F	F – crit.	P
Between Groups	3752.005	5	750.407	60.539	3.00	0.002
Within Groups	1523.874	127	11.999			
Total	5275.880	132				

$\alpha \leq 0.05$  level of significance

Table 3(a) reveals that the calculated p-value of 0.002 is below the 0.05 significance level, and the computed F-value of 60.539 exceeds the critical F-value of 3.00. These results indicate significant differences in the mean scores of Process Skill Acquisition performance among the varied ability students taught Biology using Science Process-Based Approach (Experimental) and Lecture (Control)



methods. Hence, we reject the null hypothesis, which posited that there is no significant difference in mean scores of Process Skill Acquisition among varied ability students taught Biology using the Science Process-Based Approach and Lecture method. The above interpretation of Table 3 (a) revealed that significant differences exist in Process Skill Acquisition performance mean scores among the varied ability students taught Biology using a Science Process–Approach (Experimental) and Lecture (Control) methods. Therefore, to ascertain the level of significance, the data was subjected to a Post hoc test using Scheffe’s test in Table 3 (b).

**Table 3 (b):** Posthoc Scheffe’s Result of Students Process Skill Acquisition in Experimental and Control Groups

Groupings		N	Subset for alpha = 0.05				
			1	2	3	4	5
Low	Experimental	16		17.3750			
	Control	18	11.6667				
Medium	Experimental	31				25.0645	
	Control	34		19.2059	19.2059		
High	Experimental	16					30.1250
	Control	18			22.0556	22.0556	
Sig.			1.000	.728	.242	.188	1.000

In Table 3 (b), the Post Hoc using Scheffe's test on Process skill acquisition showed that the low Control, 11.6667, is in the minor subset, followed by low experimental, 17.3750 and medium Control, 19.2059, in subset 2. In contrast, high Control in subset three as against medium experimental in subset 4 have 22.0556 and 25.0645, respectively. High experimental, 30.1250 is significantly higher in subset 5. This shows that high experimental in the highest subset have the significantly highest performance.

**Null Hypothesis Two (HO<sub>2</sub>):** There is no significant difference in mean scores of Process Skills Acquisition among male and female students of varied ability taught Biology using the Science Process-Based Approach and Lecture Method

**Table 4:** Analysis of Covariance (ANCOVA) results of students Male and Female Process Skills Acquisition in Experimental and Control group

Source	Type III Sum of Squares	Df	Mean Square	F	P
Corrected Model	4150.286 <sup>a</sup>	11	377.299	35.391	.000
Intercept	64192.768	1	64192.768	6021.326	.000
Groups	1453.346	1	1453.346	136.325	.000
Gender	211.808	1	211.808	19.868	.000
Process Levels	2286.115	2	1143.058	107.220	.000
Groups * Gender	7.657	1	7.657	.718	.398
Groups * Process Levels	50.086	2	25.043	2.349	.100
Gender * Process Levels	39.059	2	19.530	1.832	.160
Groups * Gender * Process Levels	29.588	2	14.794	1.213	.250
Error	1289.969	121	10.661		
Total	77463.000	133			
Corrected Total	5440.256	132			

$\alpha \leq 0.05$  level of significance

a. R Squared = .763 (Adjusted R Squared = .741)

- Process skill levels (Low, medium, and High)
- Groups (Control, Experimental)
- Gender (Male and Female)

Table 4 indicates that the computed p-value for comparing groups versus process skill ability levels is 0.100, which exceeds the 0.05 significance level. Similarly, the calculated p-value for process skills

ability levels versus gender is 0.160. For study groups versus process skills ability levels versus gender, it is 0.250, all higher than the 0.05 alpha significance level. These findings suggest no significant difference in mean scores of Process Skills Acquisition among male and female students with varied abilities taught biology using the Science Process-Based Approach and Lecture Method. Therefore, we retain the null hypothesis, positing no significant difference in process skill acquisition mean scores among male and female students with varied abilities taught biology using the Science Process-Based Approach and Lecture Method.

This study explored the impact of the Science Process-Based Approach (SPBA) on Process Skills Acquisition among Biology students of various abilities in Zaria, providing critical insights into how instructional strategies influence skill development and academic performance. By comparing the Science Process-Based Approach and traditional lecture methods, the study highlights the significant role of active, skill-focused learning in improving students' understanding and application of Biology concepts. Based on the findings, two hypotheses were formulated and tested, focusing on students' process skills and their performance on the concept of "living" in SS II Biology. The findings indicate a significant improvement in process skills acquisition among students exposed to SPBA compared to those taught using traditional lectures. These results align with prior studies by Nworgu and Otum [16], Ugwuanyi and Nwafor [23], and Gadzama [7], which collectively emphasize that active engagement in process-based learning enhances comprehension, critical thinking, and practical abilities in Biology. The study's findings underscore that process skill acquisition is not merely a means to improve academic outcomes but a critical enabler of scientific literacy and inquiry skills essential for lifelong learning. For broader educational policy, these results suggest integrating SPBA into secondary school science curricula to foster deeper engagement and equip students with essential 21st-century skills.

Interestingly, the study also highlights how exposure to science process skills positively impacts learners' motivation and engagement. By actively participating in tasks such as observing, hypothesizing, and experimenting, students develop a stronger connection to the subject matter. This finding has implications for curriculum development, suggesting that embedding inquiry-based learning across ability groups can help bridge educational gaps and ensure equitable skill acquisition. However, contrasting results from Nwosu [17], which attribute low process skill acquisition to insufficient instructional focus on experimental activities, underline the need for teacher training programs that emphasize structured process-skill instruction.

The absence of significant gender differences in process skill acquisition between males and females, as observed in this study, indicates a leveling of the playing field when effective instructional methods like SPBA are employed. This finding aligns with Maikano [10], who reported no gender disparities in skill-based instruction, highlighting the potential of SPBA to promote inclusive and equitable learning environments. However, it contrasts with Nwosu [17], whose findings suggested gender-specific variations in skill acquisition under traditional methods. These discrepancies emphasize the importance of further research to explore the nuanced dynamics of gender in science education.

From a policy perspective, the study advocates for widespread adoption of SPBA to enhance the quality of science education and align instructional practices with modern educational goals. By fostering scientific reasoning and inquiry skills, SPBA can help prepare students for advanced studies and STEM careers, addressing national workforce needs. Additionally, policymakers should consider incorporating SPBA into teacher training programs, ensuring educators are well-equipped to facilitate active, process-focused learning environments. In conclusion, the study reinforces the critical role of Science Process-Based Approaches in promoting skill acquisition, academic performance, and equitable learning outcomes in science education. Its implications for curriculum design, instructional strategies, and teacher training offer a pathway to transforming science education to meet the demands of a knowledge-driven economy.



## IV. CONCLUSION

The following conclusions were deduced from the findings:

1. The SPBA enhanced the Process Skill Acquisition of students with all the varied abilities and favoured the high ability levels in the experimental group.
2. The SPBA is ineffective for males and females compared with the process skill acquisition of their counterparts using the lecture method.

In light of the study's conclusions, the researcher suggests the following actions:

- i. The curriculum of secondary schools should be reviewed regularly by colleges of education, universities' faculties of education.
- ii. Ministries of education to introduce modern teaching methods that will help improve students' acquisition of process skills.

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