

# Process Skills Application and Higher Order Thinking Skills among Biology Students in Colleges of Education in Southwestern Nigeria

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**Abstract** The study determined the level of Process Skills Application (PSA) and utilization of Higher Order Thinking Skills (HOTS) among Biology students in colleges of education in southwestern Nigeria as well as the relationship between the PSA and HOTS of Biology students in colleges of education in the study area. The population comprised of all Biology students in colleges of education in southwestern Nigeria. One hundred students were selected from each of two federal colleges and three state colleges of education in the study area making a total of five hundred students. Thirty students were randomly selected for observation for process skills application of the students. The study revealed that there was a moderate level of PSA while the utilization of HOTS among the respondent was low. It was also revealed that there was no significant relationship between process skill application and higher order thinking skills ( $r=0.10$ ,  $p>0.05$ ) of Biology students in the study area.

**Keywords:** *process skill application, higher order thinking skills, colleges of education*

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## 1. Introduction

An important part of science education is the development of skills and cognitive abilities of students. The national policy of education emphasized the development and efficient application of skills by teachers. One important dimension of science is the acquisition of process skills. The skills through its various components are what students imbibe to be called scientists. What they practice as well as actualization of their expectations upon graduation from educational institutions is through effective application of learnt skills. This will help to facilitate development through industrialization which will in turn help to improve the quality of life of the people. Reference [2] emphasized that through science education, scientific skills will be inculcated in the students and this will help them acquire the basic knowledge, skills, understanding and attitude needed for efficient performance in their chosen occupations/careers. These skills are essential for self-reliance and national development. Science education would help to improve the living conditions of individuals in a nation. Educational institutions in Nigeria especially at the secondary school level has delineated core science education in schools to be classified into Biological, Physical and Chemical which are taught in school subjects

as Biology, Physics and Chemistry although other sciences like agricultural science, Computers science called data processing and Information communication and technology as school subjects are beginning to gain more recognition in the school systems

Reference [25] believed that generalized science like Biology is needed to form a basis for society to make informed decisions. Every subject offered at every institutional level is channeled towards being impactful in order to aid national development and Biology is not an exception. In Nigeria, Biology is seen as an important science subject as revealed by its cardinal in the National Policy of education [10]. The National Policy on Education in the National Curriculum for Senior Secondary Schools volume 3 Science stated specific objectives to be achieved by each subject curriculum.

These cardinal objectives for Biology include:

1. Adequate laboratory and field skills in Biology
2. Meaningful and relevant knowledge in Biology
3. Ability to apply scientific knowledge to everyday life in matters of personal and community health and agriculture; and
4. Reasonable and functional scientific attitudes.

This means that students must be able to possess necessary Biology skills needed in the laboratory and on the field. They are also expected to apply this knowledge gathered in their everyday life. This is necessary to understand how experiments will be carried out and can

be transmitted in later life when they are studying higher course. Learning the rudiments of practical skills is essential for fields like medicine, pharmacy, animal sciences and even the teaching profession as they will be able to transfer these skills to students in the future.

Reference emphasized the importance of Biology as being an important component of knowledge to meeting man's requirements as it contributes to sustainable development. Teng believed that the human society has greatly investigated and employed the use of biological knowledge over time to produce beverages, food, feed and fibre, while the advent of modern technologies and new biological knowledge has vastly improved the application of Biology. It could then be concluded that if Biology is taught efficiently and effectively in schools through effective application of the right skills and inculcating of the right attitude, the society stands a great benefit towards national development as creative skills of individual will improve.

Reference [20] stated that science has three aspects which are interrelated and this include science contents, processes and attitudes. Contents are the concepts in various fields of sciences which their practical application is taught using process skills and the resultant effects of these aspects are reflected in the student's scientific attitudes. The holistic effect of these components is to ensure that students are able to generate ways to solve their own problems as well as those of the society. Hence science teaching is to train individuals that will apply scientific skills effectively. It is important that students as well as teachers learn to apply science skills to bring about innovative societal development. This will then go beyond learning through rote memorization or just sitting to listen to teachers in class.

Internalizing the contents and efficient application of the process skills depend largely on the various cognitive abilities of the students. If students are not able to internalize these concepts, skills and attitudes, it will then be impossible for them to improve on what they have been taught and/or develop new ways of doing science. Reference [27] opined that students must integrate skills, attitudes and knowledge to have a better and more grounded understanding of scientific concepts. To be able to do this, each student's thinking skills would play a big role. Reference [19] explained that thinking skills have a close relationship with cognitive and affective domains in enhancing problem solving for various activities and this brings about learning. Thinking skills have been categorised in different ways but the most widely accepted categorization is based on the six levels of cognitive domains by Bloom commonly referred to as Bloom's Taxonomy. The higher order thinking skills are the higher level of domains which are analysis, synthesis and evaluation [3]. These skills deal with breaking down components of what is learnt, streaming together components as well as making valid judgments about various concepts and abilities. Higher Order Thinking Skills (HOTS) are not about rote learning but engaging students at the highest levels of thinking to create exciting learning environments where students become formulators of new ideas, analysers of information and generators of knowledge [18]. These skills are important for students to solve any problem and issue in their environment.

Problems arise from new situations that individuals are unfamiliar with and this demands the development of novel approaches through the application of known skills. It believed that when individuals try to find answers to societal challenges without the appropriate skills, abilities and adequate understanding of the problems, they would not only behave recklessly and unpredictably but also in manners that would have a negative impact on their own future and human condition in the society. [1] This shows that thinking skills have an impact on the process skills and attitudes of students towards problem solving, particularly in science.

The nature of science demands a high level of thinking as the scientific processes involve observation which requires application skills, thinking through hypotheses (postulation), carrying out an experiment which requires analytical skills, drawing inferences and conclusion requiring evaluative and synthetic skills and application of the results into laws or theories which could be applied in further experiments and problem solving. Higher order thinking skills can help promote learning outcomes and understanding of information in order to improve learning among students [6]. The world is changing and more than ever before, there is a need to inculcate HOTS in students as the demands in the world of Science and Technology are becoming rapid and diverse. It was also stated that HOTS can help students to understand vital details and information which will help to improve the scientific literacy of students. In many developing countries, government has made several efforts to improve scientific literacy of students by improving the Scientific skills. For example, the Indonesia government has attempted to introduce HOTS in the new curriculum. The learning process is meant to lay emphasis on scientific approach. It then calls for emphasis on using learning models that will emphasis the use of scientific approach like problem-based learning, contextual teaching and learning [4]. Developing higher order thinking and science process skills of the student can be improved by specific activities.

Reference [28] explains that HOTS is non-algorithmic and can be complex as it often brings about different criteria and solutions which leads to a lot of uncertainties. The world nowadays demands that learning goes beyond low level thinking as innovation and scientific improvements are dependent on higher order of thinking. Society demand that individuals raised by such are intellectuals, forward moving and promoters of changes in such societies.

Literature revealed how the performance of Nigeria students in international examination has been worrisome. One of the reasons suggested for this poor performance in external examination was that these students are not being taught in line with global standards which will inculcate ways that would make them ready for life in a global and competitive world that requires innovation, creativity and critical thinking. [9] Reference [5] emphasised that employers are no longer in search of those with technical skills but those with critical thinking, problem solving and good reasoning skills. Reference [26] drew attention to the low level of skills (technical and essential) by graduates but possession of a high level of general and theoretical knowledge. This could mean that teachers in schools do not inculcate the right attitudes and skills required to make

students capable, qualified and employable as they have not been taught to engage the higher cognitive domains of thinking which are mostly developed through application of skills during practical classes.

An important offshoot of the dearth of application of HOTS is the acquisition of science skills. One important part of these skills is the science process skill. This is an area that prepares students for scientific explorations and endeavours. Many pieces of research have speculated and given various problems to science education. It has been observed the major challenges in science education among many others to include overcrowded science classroom, strict compliance to traditional teaching methods despite exposure to recent and more effective alternatives, acute shortage of qualified science teachers, undue emphasis on syllabus coverage thereby forfeiting meaningful learning of science concepts, students' attitude towards science, etc. [8] In present times, the challenges of science education has obviously nosedived beyond the point of unavailability of Physical, human and non-human facilities and resources. The challenges have in way snowballed into factors relating to intellectual properties and capacities of the students.

Not much has been reported on the problems associated with learning science concept or individual differences as relating to students' science process skills acquisition or application. Reference [16] notion of process skills was that ability to merge the Science Process Skills (SPS) with classroom lessons as research and experimental activities would make the learning experiences more valuable and meaningful for students. They believed that students would learn the skills of science and also science content and would be actively engaged with the science they are learning. Reference [22] emphasised the importance of SPS as fundamental to science, allowing all categories of learner to conduct investigations and reach logical conclusions. It was observed that SPS are learnt and acquired among learners in environments that promote thinking, positive attitude to work, and finding out novel information. Thus, emphasizing the importance of higher order thinking skills to the learning of science process skills. This could only be achieved if teachers have an adequate understanding of these skills to be able to create such an enabling environment. The role of adequate teacher education to promote science teaching in schools across all levels is therefore important. Promoting science education will demand that emphasis is laid on the development of both the process skills and the thinking skills.

Reference [23] sees process skills as approaches to learning that centres around developing the skills that will enable students to gain knowledge, facts and concepts which will be of scientific relevance. Science process skills refer to various abilities that affect the understanding, acquisition, retention, organisation or use of verbal and/or non-verbal information. *This emphasizes why SPS is important for HOTS.* There are suggestions as regards challenges in the education received by students in Nigerian schools, especially in sciences. It has been observed that even though students pass out with good grades, their level of cognitive and creative abilities has not met with the levels required by companies and society at large. This could be due to a low level of utilization of

higher order cognition and skills in schools and this is likely to affect how students think critically and come up with various ideas for solving problems. Also, the West African Examination Council (WAEC) has consistently complained about the performance of students in Biology especially the practical aspect which is supposed to be an essential part of science teaching. [13] This shows that the students have had a low level of application of process skills to effectively produce results. All these problems could stem from various factors, but one of the most important factors to be considered will bother on the corresponding abilities of teachers who are trained to teach these students in schools as teachers play an important role in nation building and development of academic individuals. Teachers are a major factor in the development of the mental abilities of students. [12] The global educational trends demand that teachers act as facilitators of knowledge as they are expected to assist students to acquire science skills. If the teachers that train students do not have these relevant skills at their various institutions, it will be difficult to inculcate these skills in the students they will begin to teach when they graduate.

When students are taught to develop and acquire various components of basic and integrated skills, they are expected to transform this information by applying it and this will help them to develop certain attitude that are essential for their development, thus making cogent decisions. The cognitive component provides meaning and helps to organize experiences which allows individuals to go beyond information given. According to Bruner, learning processes involve active inquiry and discovery, inductive reasoning, and intrinsic motivation. He believed that cognitive structures help to provide meaning and organization for experiences and this makes an individual to inquire beyond information given. As students apply process skills and employ the use of higher order thinking skills, it is required that attitudes and beliefs that will make them develop innovative and creative ideas will be developed.

According to Reference [14], SPS are important if we desire improvement in students' cognitive development. It helps to facilitate students' active participation during the process of teaching and learning. Science process skills will then have a huge part to play in then development of higher order thinking skills of students. The development of skills in students will help to improve various attitudes that are necessary to make an individual scientifically literate. Pre service teachers are supposed to be trained in order to learn and apply the needed skills that will make them function effectively when they eventually start teaching. It is then the responsibility of teachers to try and encourage students to discover principles, concepts and ideas on their own. They are expected to learn in an atmosphere that encourages practical work so that they can engage the teachers and their peers in active dialog which will improve their cognitive components. The responsibility of the teacher is to help transform concepts into student's level of understanding which will in turn provide a platform for students to develop new knowledge. Reference [26] believed that teachers are those who have a critical role in promoting learning and development of activities for the students to learn science process skills and enjoy the learning science to achieve the specific

educational objectives. It is however impossible for teachers to be able to teach these essential scientific skills if they have not learnt, acquired nor conversant with the application of these skills during and after their training process. It is then important to assess the level of possession of process and higher order thinking skills of Biology students who are called pre service teachers in colleges of education in Southwestern Nigeria. Hence, this study.

## 2. Objectives of the Study

- a) assess the Process Skills Application (PSA) of Biology students in Colleges of Education in Southwestern Nigeria;
- b) determine the utilization of Higher Order Thinking Skills (HOTS) among Biology students in colleges of education in Southwestern Nigeria;
- c) examine the relationship between Process skills Application and higher order thinking Skills among Biology students in colleges of education in southwestern Nigeria;

## 3. Research Questions

- i) What is the level of process skill application of Biology students in colleges of education in Southwestern Nigeria?
- ii) What is the level of Utilization of HOTS of Biology students in colleges of education in Southwestern Nigeria?

## 4. Research Hypothesis

- i) There is no significant relationship between PSA and HOTS among Biology students in colleges of education in Southwestern Nigeria

## 5. Significance of the Study

The study will provide information on the level of process skill application among biology students in colleges of education in Nigeria. It will also provide information on the level of the components of process skill application of Biology students in the study area. Furthermore, the study will provide insight as regards the utilization of higher order thinking skills of Biology students as well as provide the relationship between process skills application and higher order thinking skills among the respondents. The study will finally inform lecturers as well as National bodies in charge of the curriculum of teacher training institutes on the relationship between process skills application and higher order thinking skills of the respondents in the study area.

## 6. Methodology

The study adopted correlational survey research design.

The population comprised all Biology students in colleges of education in Southwestern Nigeria. Five hundred Biology students were selected as sample for the study from which One hundred and fifty were selected for practical observation for process skills application. This was done by randomly selecting two Federal colleges and three state colleges of education in Southwestern Nigeria. From each of the institutions, One hundred students were selected randomly for the higher order thinking skill test while thirty students were randomly selected for process skill application practical observation. Two instruments were used for the study. This include Biology Process Application Rating scale (BPSARS) which was used to assess the application of process skills of respondents in the study area and Biology Higher Order Thinking Skill Test (BHOTST) which was used to assess the Higher Order Thinking Skills of respondents in the study area. The students were observed twice during their practical classes to assess their process skills application. Higher order thinking skill was assessed using Higher Order Thinking skills Test. The test consists of questions that assessed Analysis, Synthesis and evaluation. The test consists of five branches of Biology which are Taxonomy, Morphology, Physiology, Anatomy and Ecology. These branches related to topics that the students have been taught. The test was done under standard conditions. The data collected were analysed using descriptive statistics of frequency, percentage, mean and adjusted mean while inferential statistics of correlation and regression analysis.

## 7. Results

### 7.1. Research Question One

What is the level of process skill application of Biology students in colleges of education in Southwestern Nigeria?

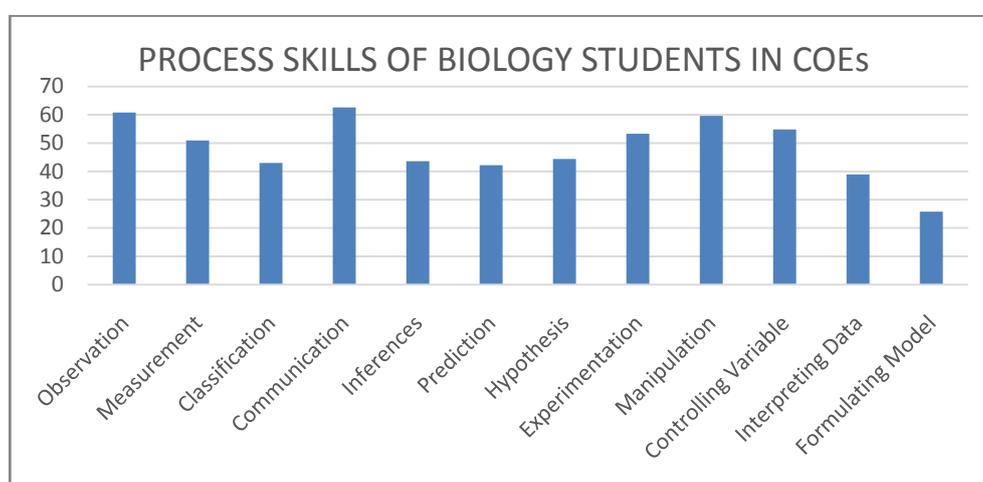
To answer this research question, data were collected for each of the components of the process skills application. Components that had more than one description which were; observation, measurement, prediction, hypothesis, experimenting, interpreting data were summed up to give a total process skill score for each item. The various skills were then grouped into the two basic categories of process skills which are basic process skill and Integrated process skills.

Table 1 revealed the mean and adjusted mean values for each of the process skills. This was to determine the most applied process skills among the respondents in the study area. It was shown from the table that communicating skill was the most applied skill by the respondents in the study area as it was ranked 1 with adjusted mean value of 62.60. This was followed by observation and manipulative skills respectively with the adjusted mean value ( $\bar{x}$ ) of 60.80 and 59.6 respectively. This was followed by controlling variable, experimenting, measurement, hypothesis, inferencing, classification, predicting, interpreting data and formulating models which were ranked from 4 to 12 with adjusted mean scores of 54.8, 53.30, 50.93, 44.40, 43.60, 43.00, 42.00, 38.9, 25.8.

**Table 1. Descriptive Analysis of Process Skills of the Biology Students in Colleges of Education in Southwestern Nigeria**

Skills	Min.	Max.	Mean.	Stand. Dev.	Stand. Error	Adjusted Mean	Rank	Skewness	Std. Error of Skewness
Observation	1.00	14.00	9.12	2.85	0.23	60.80	2	-0.65	0.20
Measurement	0.00	15.00	7.64	3.40	0.28	50.93	6	0.25	0.20
Classification	0.00	4.00	2.15	3.52	0.29	43.00	9	0.10	0.20
Communicating	0.00	5.00	3.13	1.32	0.11	62.60	1	-0.09	0.20
Inferencing	0.00	5.00	2.80	1.15	0.09	43.60	8	-0.13	0.20
Predicting	0.00	9.00	4.22	2.31	0.19	42.20	10	0.31	0.20
Hypothesizing	1.00	10.00	4.44	2.03	0.17	44.40	7	0.49	0.20
Experimentating	2.00	10.00	5.33	2.47	0.20	53.30	5	0.25	0.20
Manipulating	0.00	5.00	2.98	1.49	0.12	59.6	3	0.05	0.20
Controlling Variable	0.00	5.00	2.74	1.47	0.12	54.8	4	0.36	0.20
Interpreting Data	0.00	8.00	3.89	1.72	0.14	38.9	11	0.13	0.20
Formulating Model	0.00	5.00	1.29	0.84	0.07	25.8	12	1.42	0.20

$$\text{Adjusted Mean} = \frac{\text{mean of classified SPS} \times (\text{Total max. Score obtainable from TSPS})}{\text{Max. Score obtainable in items of classified SPS}}$$

**Figure 1.** Bar Graph of Process Skills Application of Respondents in Colleges of Education in Southwestern Nigeria

The level of each of the skill categories based on the number of students was also determined. The sampled respondents' responses to the first 6 items in section B of BSPSARS which measured basic process skills were scored and the scores were used to determine the level of process skills (basic process skills) possessed by the students. From the list of items for the process skills application, the responses were graded from 5 to 0. The scores for each respondent were added. For the basic process skill, there were 11 items, a maximum total obtainable score was 55. This was divided into three categories. Scores between 0 which was the lowest possible score and 18 were termed low level of basic process skill application, scores between 19 and 36 were termed moderate level of basic process skill application while scores from 36 to the highest score which was 55 was termed high level of process skills application by the respondents.

For the integrated process skills application, there were 9 items, the total maximum obtainable score was 45; scores between 0 and 15 were termed low level of integrated process skills application, scores between 15 and 30 were termed moderate level of integrated process skill application while scores from 31 to 45 were termed high level of integrated process skill application.

For the overall PSA, all the items and components of both generic process skills application and integrated PSA

were added together. On the scale, the minimum score obtained was 19, the maximum score was 83. The maximum obtainable score for the total process skills was 100. This was also categorized into low level, moderate level and high level of application of process skills using the percentile. Scores between the lowest possible score which was 0 and 33 were termed low level of process skill application, scores between 33 and 66 were termed moderate level of process skill application while scores from 67 and above were termed high level of process skill application. The result is presented in Table 2.

**Table 2. Level of Process Skills Application of Respondents in Colleges of Education in Southwestern Nigeria.**

HOTS	Frequency	Percentage (%)	Decision
<b>Basic Process Skills</b>			
Low	20	13.3	<b>Moderate</b>
Moderate	91	60.7	
High	39	26.0	
<b>Integrated Process Skills</b>			
Low	40	26.7	<b>Moderate</b>
Moderate	90	60.0	
High	20	13.3	
<b>Total Process Skills</b>			
Low	20	13.3	<b>Moderate</b>
Moderate	101	67.3	
High	29	19.3	

Table 2 shows the level of basic process skills exhibited by the respondents. From the table, the majority (60.7%) demonstrated a moderate level of basic process skills application, while 26.0% of the respondents demonstrated a high level of basic process skills application. Only 13.3% demonstrated a low level of basic process skills.

The result in Table 2. also showed that the level of integrated process skills demonstrated by the respondents. From the table, it was revealed that 60.0% of the respondents demonstrated a moderate level of integrated process skills, 26.7% of the respondents demonstrated a low level of integrated process skills while 13.3% demonstrated a high level of integrated process skills.

The overall level of process skills application exhibited by the respondents was also determined. From the table, most of the respondents (67.3%) demonstrated a moderate level of basic process skills, while 19.3% of the respondents demonstrated a high level of process skills application. It was revealed that only 13.3% demonstrated a low level of process skills application.

It could be concluded that there was a moderate level of application of basic process skills and integrated process skills application among the respondents as there was also a moderate level of application of overall process skills among the respondents.

### 7.2. Research Question Two

How adequate is the level of utilization of higher order thinking skills of Biology students in Colleges of Education in the study area?

The data for the objective was derived from a test that was administered to the students. The mean score for each of the components was determined and the adjusted mean was calculated. There were nine items under the *analysis* component of HOTS, five items under the *synthesis* components and six items under the *evaluation* components. The mean scores for each component were compared to the total obtainable score to determine the adequacy of the thinking skills.

**Table 3. Descriptive Analysis of Higher Order Thinking Skill (HOTS) of the Biology Students in Colleges of Education in Southwestern Nigeria**

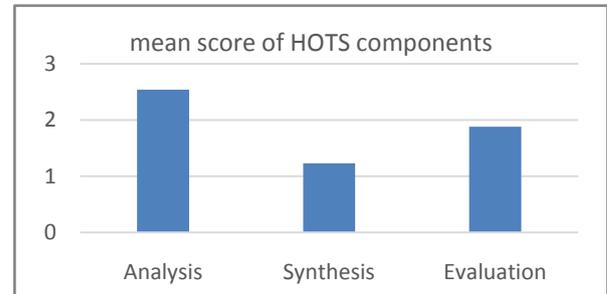
Skill	Max. Score	Min.	Max.	Mean.	Stand. Dev.	Adjusted Mean	Rank
Analysis	9	0.00	7.00	2.54	1.48	5.64	2
Synthesis	5	0.00	4.00	1.23	0.95	4.96	3
Evaluation	6	0.00	5.00	1.88	1.28	6.26	1
<b>Total HOTS</b>	<b>20</b>	<b>0.00</b>	<b>12.00</b>	<b>5.63</b>	<b>2.47</b>		

Adjusted Mean = (mean of classified HOTS x (Total max. Score obtainable from HOTS)/Max. Score obtainable in items of classified HOTS.

The table above revealed items under the analysis components had a mean score of 2.54, the synthesis component had a mean score of 1.23 while the evaluation component had a mean score of 1.88. These scores were lower than the mid score showing that the respondents had a low level of utilization of Higher order thinking skills in the study area. Comparing the relative level of utilization of each of the HOTS using the adjusted mean since the number of items under each component was not the same, it was revealed that the students possessed more of the evaluative thinking which was ranked 1 with an adjusted

mean value of 6.26, followed by analytical skills with Rank 2 (Mean=5.64) and lastly synthetic skill with adjusted mean score of 4.96

The study also revealed that the mean score for the total higher order thinking skill was 5.63 indicating that there existed a low level of utilization of Higher order thinking skills among the respondents.



**Figure 2. Bar Chart of HOTS Components of Higher Order Thinking skills of Respondents in Colleges of Education in Southwestern Nigeria**

Each of the components was classified into low level, moderate level and high level of utilization. For analysis, scores between 0-3 were termed low level of analytic skills, scores between 4-6 were termed moderate level of analytic skills while scores from 7-9 were termed high level of analytic skills.

For the synthesis component of higher order thinking skills, the highest possible score was 5, scores from 0-1 were termed low level of synthetic skill, 2-3 were termed moderate level of synthesis while 4-5 were termed high level of synthetic skills. There were six items for the evaluative skill, scores between 0-1 were termed low level of evaluation, respondents that scored between 2-3 were a moderate level of evaluation while those that score from 4 and above had high evaluative skill.

The same measure was used to categorize the overall higher order thinking skills, the total items for the higher order thinking skill was 20, students that scored between 0 and 6 were termed low level of utilization of higher order thinking skills, those that scored between 7 and 12 were adjudged moderate level of utilization of higher order thinking skills while those that scored 13 and above were adjudged to possess a high level of utilization of higher order thinking skills.

The result was presented in Table 4.

**Table 4. Percentage Analysis of HOTS of the respondents in the study area**

Parameters	Frequency	Percentage (%)
Analysis	Low	372 (74.4)
	Moderate	126 (25.2)
	High	2 (0.4)
Synthesis	Low	330 (66.0)
	Moderate	162 (32.4)
	High	8 (1.6)
Evaluation	Low	208 (41.7)
	Moderate	231 (46.3)
	High	60 (12.0)
Total HOTS	Low	320 (64.0)
	Moderate	280 (36.0)
	High	0 (0.0)

From Table 4, it was revealed that 74.4% had a low level of utilization of analytic skills while 25.2% have a moderate level of analytic skills and 0.4% of the respondents had a high level of the analytic skill. It could be concluded that there existed a low level of utilization of analytic skills among most of the respondents in the study area. It was also shown that 66.0% had a low level of utilization of synthetic skill while 32.4% had a moderate level of utilization of the skills and 1.6% of the respondents had a high level of utilization of the skills. This shows a low level of utilization of synthetic skills by respondents in the study area. It was also revealed that there was a low level of utilization of evaluative skills 41.7% of the respondents while 46.3% had a moderate level of use of this skill and 12.0% had a high use of this skill. It could also be concluded that there exists a moderate level of use of evaluative skills by Biology students in COEs in southwestern Nigeria.

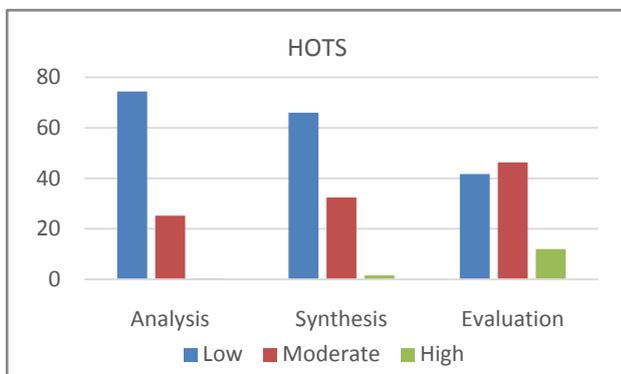


Figure 3. Bar Graph of Level HOTS of Respondents

On the overall level of utilization of HOTS by respondents in the study area, it was revealed that 64.0% had a low level of utilization of the skills while 36.0% had a moderate level of utilization of HOTS and none of the

respondents had a high level of utilization of HOTS. It could then be concluded that relative to the study area, there was a low level of utilization of HOTS by Biology students in colleges of education in Southwestern Nigeria.

### 7.3. Research Hypothesis One

There is no significant relationship between PSA and HOTS among Biology students in colleges of education in Southwestern Nigeria

To test this hypothesis, bivariate correlation was used to test if there was a relationship between each of the components of process skills application and higher order thinking skills of the respondents in the study area. Thereafter, the correlation between the total process skills application and higher order thinking skills was also determined.

The bivariate correlation in Table 5 above revealed that there was no significant relationship between basic process skill application and analytic component of higher order thinking skills of respondents in the study area ( $r = -0.033, p > 0.05$ ). The study also showed that no relationship exists between basic process skills and synthesis component of higher order thinking skills ( $r = -0.150, p > 0.05$ ) while no significant relationship also existed between basic process skill component of process skills application and evaluation component of higher order thinking skills component ( $r = 0.033, p > 0.05$ ).

It was also revealed that no significant relationship between integrated process skills application and analysis component of higher order thinking skills ( $r = -0.005, p > 0.05$ ), synthesis component of higher order thinking skills ( $r = 0.30, p > 0.05$ ) but there was a significant relationship between integrated process skills application and evaluation component of higher order thinking skills. ( $r = 0.163, p < 0.05$ ). The relationship is however weak and positive.

Table 5. Correlation of Component of Process Skills Application, Higher Order Thinking Skills, Scientific Attitude and Creativity among Colleges of Education in Southwestern Nigeria

		Correlations				
		bsps	Isp	analysis	Synthesis	evaluation
Bsp	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	150				
Isp	Pearson Correlation	.656**	1			
	Sig. (2-tailed)	.000				
	N	149	149			
Analysis	Pearson Correlation	-.033	-.005	1		
	Sig. (2-tailed)	.689	.953			
	N	150	149	150		
Synthesis	Pearson Correlation	-.150	.030	.159	1	
	Sig. (2-tailed)	.066	.714	.052		
	N	150	149	150	150	
Evaluation	Pearson Correlation	.033	.163*	.297**	.134	1
	Sig. (2-tailed)	.689	.047	.000	.102	
	N	150	149	150	150	150

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\* . Correlation is significant at the 0.05 level (2-tailed).

**Table 6. Correlation Table of Overall PSA, HOTS, SC and SA in Colleges of Education in Southwestern Nigeria**

		Correlations	
		TotalPSA	HOTS
Total PSA	Pearson Correlation	1	
	N	149	
HOTS	Pearson Correlation	.010	1
	Sig. (2-tailed)	.908	

It was revealed from Table 6 that there was no significant relationship between process skill application and higher order thinking skills among Biology students in colleges of education in Southwestern Nigeria ( $r=0.10$ ,  $p>0.05$ ). This shows that the correlation between process skill application and Higher Order thinking Skill is weak and positive.

## 8. Discussion of Findings

The findings of the study agreed with the work of Rabacal (2016) as it was revealed that there was an average level of possession of basic and integrated process skills. The findings agreed with that of Rabacal (2016) as it was also observed that there was an average level of observation, measurement, classification skills. It, however, disagreed with the study as Rabacal's study revealed an average level of predicting skills while this study revealed a poor level of predicting skills. There was also disagreement in inferring skills as the study revealed an average level of inferring skill while Rabacal's revealed a low level of inferential skills.

It was revealed that there was a low level of utilization of HOTS in the study area. Relative to the group, the study revealed that there exists a low level of utilization of analytic, synthetic and evaluative skills among respondents in the study area. The study agreed with the works of Reference [15] on the overall possession of thinking skills by respondents in the study area. The study also agreed with those of Reference [21] whose work revealed a low level of synthetic skills among respondents in the study area. The result of the study also agreed with those of Reference [21], on the evaluation and analytic components as well as the overall level of higher order thinking skills as the study also showed a low level of HOTS among respondents in the study area. The findings also agreed with Reference [11] whose work revealed a low level of utilization of HOTS among respondents in the study area.

The reason for this relatively low level of utilization of HOTS could be due to the fact that most of the evaluation procedures in the colleges of education in the study area were focused on the lower level of thinking skills and few were based on the higher order of the skills. It was observed that examination questions centered around knowledge, comprehension and application and few were based on the analytic and synthetic skills. Reference [24] revealed that most of the questions set for evaluations did not have an adequate number of HOTS. The implication for this is that students will not be able to contribute constructively and engage their higher level of cognition.

There was no correlation between the findings of this study and that of [11] whose work revealed a correlation between process skills and HOTS, this disagreement could be due to the fact that this work relates to the application of process skills rather than the acquisition. The study revealed that evaluation component of HOTS had relationship with the process skills application. Hence, a partial discordance with the findings of the study and that of [17] where there was a relationship between the elements of basic process skills like observation, Inferring and predicting and those of Higher order thinking skills. The findings did not also agree with [7] where findings of study revealed that mastery of basic process skills will help in application of higher order cognition. This discrepancy could be due to the fact that [7] research rather focused on the mastery and not the application of the skills.

The lack of relationship between process skill application and higher order thinking skills could also be due to the fact that practical in schools are mostly taught in groups and appropriate focus is usually not given to the development of the skills in each student. Lack of laboratory equipment in laboratories could also be a reason why the application of process skills do not help to improve or have a correlation with higher order thinking skills.

## 9. Conclusion

The study concluded that there was a moderate level of basic and integrated process skills application among respondents in the study area while there was also a moderate level of application of overall process skills among the respondents in the study area. The study also concluded there was a low level of utilization of Higher order thinking skills among respondents in the study area as analytic skill is the least utilized skills by Biology students in the study area. It was also concluded from the study that Integrated process skills application related to the evaluative component of higher order thinking skills while there was no significant influence of process skills on the components of higher order thinking skills except the evaluation component.

## 10. Recommendations

Teachers, curriculum experts and educationists should create teaching strategies, approaches and ways of improving the process skills of the respondents in the study area. More attention should be geared towards improving the integrated process skills of the students as this tend to be lower than the Basic process skills of the respondents. Instructors should provide students with appropriate guidelines that will help to improve the lowest level of process skills among respondents in the study area so that experiment conducted will be meaningful and students will be able to develop appropriate deductions from the results of their experiment which can lead to further learning. Assessment of students by lecturers in colleges of education should go beyond the lower cognitive domains and test students more on the higher

level of Bloom's taxonomy. When students get familiar with these domains of learning, they begin to think beyond the walls of their classroom hence, improving creativity. It will also help students to think about ways they can improve the environment, foresee future scientific and technological issues as well as look for ways to proffer solution to these issues.

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