# Effects of Individualized and Collaborative Virtual Biology Laboratory on Pre-Service Teachers` Achievement in Animal Dissection in North-East Nigeria

**By**

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**ABSTRACT**
This paper examined the effects of individualised and collaborative virtual biology laboratory on pre-service teachers` achievement in animal dissection. The study was carried out in North-East Nigeria. Three research questions and three null hypotheses were formulated to guide the study. The study adopted a pre-test post-test quasi experimental and 2x2 factorial design. The population of the study comprised all the 2,372 NCE II Biology students in the three Federal Colleges of Education in the North-East zone. The sample of the study constituted 80 pre-service teachers derived from the two randomly selected Federal Colleges of Education in the study area. Data were collected using Virtual Dissection Achievement Test (VIDAT). The instruments were developed by the researcher and validated by the experts. The VIDAT was tested with Kudder Rechardson (K-R21). A reliability index of 0.85 was obtained. Virtual biology laboratory was developed and used individually in experimental group I and collaboratively in experimental group II. The research questions were answered using mean and standard deviation and analysis of covariance was used to test the null hypotheses. The findings of the study revealed that; pre-service teachers who study animal dissection with IVBL had higher achievement in dissection when compared to their counterparts taught animal dissection with CVBL. The result also revealed that gender has no significant influence on students' achievement in animal dissection when pre-service teachers were exposed to either of the two designs of VBL packages. It was recommended among others that IVBL should be used in teacher training institutions in Nigeria for experimentations in animal dissection and more computers and training opportunities should be provided by the government. Lastly, it was recommended that lecturers, technologists and students should adopt virtual biology laboratory packages in carrying out animal dissection.

**KEYWORDS:** Individualized and Collaborative Virtual Biology Laboratory, Pre-service Teachers, Academic Achievement and Animal Dissection



## INTRODUCTION

Science and technology are the hope for developing nations especially in this 21st century. To unbundle the hope to be a reality, the knowledge of science and technology should be harnessed from the basis at secondary and tertiary school level. It is in recognition of this fact that Federal Republic of Nigeria through her national policy on education asserted that; Science education should be a centre piece for scientific and technological advancement of the country (FRN, 2013). The policy also states that science education should among other things equip students to live effectively in the modern age of science and technology. It further emphasized Science teaching and learning as an instrument for inculcating necessary scientific knowledge, skills, and competencies at all levels of education.

In connection to this emphasis, a number of scholars conceptualized and applied Science education differently. Okeke (2007) defines Science Education as an integrated field of study that considers both the subject matter of science discipline (Biology, Physics, Chemistry, and Agriculture) as well as the processes involved in the teaching and learning of science. Therefore, Science Education is the field of study that exposes learners to contents as well as a methodology (processes) of acquiring scientific knowledge for practical application. Science learning is associated with laboratory activities which provide opportunities for students to perform various kinds of hands-on experiments (Demircioglu &Yadigaroglu, 2011). Indeed, laboratory activities are expected to help pre-service teachers in teacher training institutions to acquire science process skills through experimentation.

Pre-service teachers are students of Faculties of Education in Universities, Institutes of Education, and Colleges of Education in Nigeria. Pre-service teachers in this study refer to students of Federal Colleges of Education in North-East Nigeria. Colleges of education are teacher training institutions saddled with the responsibility of training teachers for primary and secondary school education (Oritsebemigho, 2014). These colleges are very crucial to the Nigerian educational system because, the certificates those institutions award is regarded as the minimum qualification a teacher can possess to teach in the country (Akindutire & Ekundayo, 2012). Moreover, a nation`s success depends greatly on the quality of education she provides for her citizens which also depends upon how inspired, satisfied, and dedicated her teachers are. This agrees with the statement that no nation can rise above the quality of its educational system and no educational system can rise above the quality of its teachers (Egwu, 2015). Therefore, teacher training institutions in Nigeria are integral to the development of the country.

Despite the fundamental role of colleges of education in national development, they are facing myriads of challenges. According to Omorogbe and Ewansiha (2013); Ikechukwu and Akeem (2015), these challenges include;

inadequate science laboratories and equipment, large student enrolment, inappropriate and non-effective teaching methodology, among others. The effects of these problems are pronounced not only in the academic achievement of those pre-service teachers but also in the achievement of Nigerian secondary school students who are taught science subjects by the product of these colleges. To buttress the point, the achievement of students particularly in biology in the West African Senior Secondary Certificate Examination (WASSCE) has not been encouraging at all (Zalmon & Wonu, 2017). The percentage of students that passed Biology at credit level and above was consistently less than 50% for the past three years in Nigeria (WAEC Chief Examiners' Report, 2016, 2017, 2018 & 2019). However, West African Examination Council (WAEC, 2016; 2017; 2018 & 2019) reported the observed weaknesses of candidates in practical related topics. For instance, inability to state the aim of experiment and illustrate relationships between organisms was reported in 2017. Again, poor biological drawings, inability to compare biological processes, drawing urinary system instead of reproductive system were reported in 2018. Also, Failure to identify biological systems and organs and inability to state the structural differences was reported in 2019. Therefore, challenges encountered by students in practical related topics seem to be consistent in Nigerian schools across years. The trend in NECO SSCE students' results is also similar. Studies on students' achievement especially in biology indicate that students are underachievers despite all inputs by concerned bodies in education (Ugwuadu, 2017). Therefore, the poor achievement of students in biology, in particular, might not be unconnected to the inadequate science laboratories, equipment and cost, the abstract nature of some biological concepts that require a practical approach, overcrowded classes, inadequate time, safety and non-effective teaching methodology in colleges of education in Nigeria (Aina, 2018). As a result, this study provide an alternative teaching and learning strategy using a virtual biology laboratory for conducting virtual experiments as a good option for ameliorating the identified problems in Nigerian colleges of education.

Virtual Laboratory is an interactive environment for creating and conducting simulated experiments. According to Karacop and Doymus (2013), a virtual laboratory is a three-dimensional computer-generated environment with appropriate equipment that can be explored and interacted with by a user in manipulating objects and performing a series of experiments. In consonant with this view, El-Sabagh and Kohler, (2010) assert that virtual laboratories simulate real laboratory environments and processes as learning environments in which students convert their theoretical knowledge into practical knowledge by conducting experiments. Society for Virtual Reality (SVR) elucidated that where it is too dangerous, expensive, or impracticable to do something, in reality, the virtual laboratory is the answer. It serves as an alternative learning environment that helps to make biology practical available to students (Jeschke et al, 2010). Virtual laboratories provide students with an opportunity of repeating incorrect experiment or deepen the intended experiences. Moreover, the interactive nature of such teaching strategy offers a clear and enjoyable learning environment and it is expected to improve student`s achievement and interest in biology (Jeschke et al, 2010).

Academic achievement is the extent to which a student attained their short or long-term educational goals. Completion of educational benchmarks such as secondary school, diplomas National certificates, and bachelor's degrees represent academic achievement. Academic achievement is commonly measured through examinations or continuous assessments but there is no general agreement on how it is best evaluated or which aspect is the most important in determining procedural knowledge between skills or declarative and knowledge such as facts (Alhassan, 2017). Furthermore, there are inconclusive results over which individual factors successfully predict academic achievement. Academic achievement continues to be a focus of educators, teachers, psychologists, policymakers, parents and guardians, social workers, etc. Aremu and Jokan (2003) in their attempts to investigate what determines the academic achievement of learners, they have come up with more questions than answers. Recently, literature has shown that learning outcomes (academic achievement) have been determined by the application of individualized and collaborative learning strategies.

Individualized learning Strategy is a learning strategy in which an individual student works alone based on his/her ability using a variety of learning activities to improve his/her understanding of a subject (John et al, 2013). This strategy requires each individual to present his/her solution to the problem without the cooperation or assistance of other classmates (Aluko & Olorundare, 2011). The essence of this learning strategy is; each student is unique and learns differently therefore, the use of a one-size-fits-all approach to teaching is not always the best. Individual learners have different abilities and learning styles; some learns better kinaesthetically, while others learns best visually. Likewise, some students are analytical learners interpersonal learners, or use up all of their senses to understand a concept better. Furthermore, reflective learners learn best by thinking or working alone while active learners learn best by working in groups. Therefore, to meet the needs of all learners, individualized learning strategy is essential (Felder & Brent, 2005). Teacher Training institutions in Nigeria are facing the challenge of overcrowded classes and fewer resources, employing an individualized learning model supported by technology in which content, instructional strategy, and pace of learning are based upon the abilities and interests of each learner will be a good option. Supplementing individualized learning with students' collaborative groupings had been highlighted in the literature as a significant option for

ameliorating scarce resources in school science laboratories (Udu, 2017).

A collaborative learning is a strategy of teaching and learning in which student's team together in small groups to explore a significant question or create a meaningful project towards achieving a common instructional goal (Hafner & Ellis, 2004). In collaborative learning, the teacher acts as a coach, mentor, or facilitator of the learning process. The achievement of the common goal is shared among all group members. Therefore, Collaborative learning is a situation in which two or more students learn material together. This is based on the model that knowledge can be created within a population where members actively interact by sharing experiences. The assumptions of collaborative learning according to Smith and MacGregor (2016) learners are challenged both socially and emotionally as they listen to different perspectives, and they are also required to articulate and defend their ideas. In so doing, the learners begin to create their unique conceptual frameworks and not rely solely on an expert's framework. Thus, in a collaborative learning setting, learners have the opportunity to converse with peers, present and defend ideas, exchange diverse beliefs, question other conceptual frameworks, and are actively engaged. This provides an opportunity to combine the special abilities of everyone to achieve a common goal collaboratively. Its however, not known whether the two learning strategies (individualized and collaborative) are gender responsive or otherwise.

Gender which plays a mediating role in this study refers to the characteristics of women, men, girls, and boys that include norms, behaviours, and roles as well as relationships with each other. Gender has been described as one of the factors influencing students' achievement in science. While some studies have proven that female students perform better than their male counterparts in the learning process, others have shown that male students perform better (Anyawu et al, 2015). The issue of gender is very relevant especially nowadays, with the increasing emphasis on ways of boosting manpower for teaching science as well as increasing the population of females in science and technology fields (Olum, 2013).

However, the attitude of females towards studying Science and Technology remains a challenge in the Northern Nigeria because of some misperception in cultures and religion. This is affecting progress in science and technology in the region. This discrepancy between male and female science achievements continues in post-secondary education where women are less likely to major in science disciplines (Demet et al, 2013). Again, studies need to be conducted to examine whether these achievements will still vary in biology (dissection) based on virtual laboratory practical. This, therefore, necessitates the researcher to explore individualized and collaborative virtual biology laboratory to see if it will enhance both male and female students' achievement in biology practical in federal colleges of education in North-East Nigeria.

**Purpose of the Study**

The purpose of this study is to investigate the effects of individualized and collaborative virtual biology laboratory on pre-service teachers' achievement in animal dissection. Specifically, this study seeks to determine the;

1. effects of individualized and collaborative virtual biology laboratory on pre-service teachers' achievement in dissection.
2. influence of gender on pre-service teachers achievement in dissection.
3. interaction effect of individualized and collaborative virtual biology laboratory and gender on pre-service teachers achievement in dissection.

**Research Questions**

The following research questions will guide the study;

1. what are the mean achievement scores of pre-service teachers' taught dissection using individualized and collaborative virtual biology laboratory?
2. what are the mean achievement scores of male and female pre-service teachers taught dissection with virtual biology laboratory?
3. what are the interaction effects of individualized and collaborative virtual biology laboratory and gender on pre-service teachers' achievement in dissection?

**Hypotheses**

The following null hypotheses are formulated for the study and were tested at a 0.05 level of significance.

**$H_{O1}$:** There is no significant difference in the mean achievement scores of pre-service teachers taught dissection using individualized and collaborative virtual biology laboratory.

**$H_{O2}$:** There is no significant difference in the mean achievement scores of male and female pre-service teachers taught dissection using virtual biology laboratory.

**$H_{O3}$:** There is no significant interaction effect of individualized and collaborative virtual biology laboratory and gender on pre-service teacher's achievement in dissection.

**METHODOLOGY**

This study adopted a pre-test post-test quasi experimental and 2X2 factorial research design using non-equivalent groups. This design is chosen because, the study has two independent variables and each variable has two levels. This design allows for the examination of the main effect and the interaction effect (Edmonds & Kennedy, 2017). The aspect of pre-test and post-test control the internal validity threats of the initial group equivalence and researcher`s

selection bias that can emanate as a result of non-perfect randomisation of the subject.

The population of the study comprised of all the 2,372 NCE II biology students from Federal Colleges of Education in the North-East zone of Nigeria. Federal College of Education Technical Potiskum have 739 NCE II biology students of which 326 are male students and 413 are female students. Federal College of Education Technical Gombe have 918 NCE II biology students of which 391 are male students and 527 are female students. Lastly, Federal College of Education Yola have 715 NCE II biology students of which 371 are male students and 344 are female students.

The sample for this study comprised of 80 NCE II biology Students selected randomly from the two colleges of education in the study area using simple random sampling. The researcher with the help of the research assistants count five students in the class and draw one male student as a sample until he got 20 male students. The researcher repeated the process to draw female students up to 20. The selected students were merged and divided in to two groups of 20 students with 10 male and 10 female students per group. The whole process was repeated in the other colleges of education. In consequence, two groups of 20 students were used in each college of education because the functional computer systems in laboratories are not more than 20. The use of this sample size of 40 NCE two in each colleges is inconsonant with the NCE minimum standard (FGN, 2012) which says that science laboratory space should be large enough to accommodate about 40 students. The document also made provision of forty equipment/consumables in each laboratory as a standard. Therefore, by implication, the practical class should not be more than forty students for a particular period. One college of education was randomly selected using a hat drawn method from the two colleges and assigned as experimental group I while the remaining one was assigned as experimental group II.

Biology students were exposed to Virtual Biology Laboratory (VBL) in both individualized and collaborative learning strategies. Thereafter, an instrument called Virtual Dissection Achievement Test (VIDAT) was developed by the researcher from the four topics in the current NCE II Minimum Standard for Biology that form the contents scope for this study. The VIDAT consists of 40 multiple-choice items with four options A-D. Only one option is the correct answer and carries one mark making a total of 40 marks for the 40 items. The test was administered to NCE II biology students as a pre-test before the treatment and shuffled and administered as a post-test after the treatment to measure students` academic achievement.

The instrument was subjected to face and content validity experts and trial tested on NCEII biology students in Federal College of Education Yola, Adamawa State which is not part of the colleges of education where the experiments was carried out but have similar demography with the study area. A single test administration of VIDAT was done to determine the internal consistency reliability of the instrument using Kuder Richardson 21 formula and it was found to be 0.84 which indicates a high internal consistency correlation, giving credence that the instrument is reliable (Nworgu, 2015). Mean and standard deviation were used to answer the research questions posed for the study and Analysis of Covariance (ANCOVA) was used to test the hypotheses at a 0.05 level of significance.

**Results**

**Research Question One**

What are the mean achievement scores of pre-service teachers' taught dissection using individualized and collaborative virtual biology laboratory?

***Table 1: Pretest and posttest mean achievement scores and standard deviations of pre-service teachers taught dissection with IVBL and CVBL***

| | Pre-test | | | Post-test | | | |
|---|---|---|---|---|---|---|---|
| **Variables** | **N** | **Mean** | **S D** | **N** | **Mean** | **S D** | **Adjusted Mean** |
| *IVBL* | 40 | 30.625 | 9.018 | 40 | 74.237 | 6.589 | 74.731 |
| *CVBL* | 40 | 31.313 | 9.887 | 40 | 70.75 | 9.841 | 70.700 |

Results in Table 1 show that the group that was taught dissection using individualized virtual biology laboratory package had a pre-test mean achievement score of 30.625 with a standard deviation of 9.018 and a post-test mean achievement score of 74.237 with a standard deviation of 6.589 and adjusted mean of 74.731. The results also show that the group that was taught dissection using collaborative virtual biology laboratory package had a pre-test mean score of 31.313 with a standard deviation of 9.887 and a post-test mean score of 70.750 with a standard deviation of 9.841and adjusted mean of 70.700. Table 1 show that the adjusted mean score of experimental group I is higher than that of experimental group II by 4.031 than the experimental group II. However, for each of the groups, the post-test mean scores were higher than the pre-test mean scores with the group that was taught dissection using individualized virtual biology laboratory package having a higher adjusted mean score. This result therefore, shows that pre-service teachers taught dissection using individualized virtual biology laboratory package achieved higher than the group taught dissection with collaborative virtual biology laboratory package. Nevertheless, the experimental group I had a posttest standard deviation score of 6.589 and that of experimental group II was 9.841. This shows that the individual score of those in experimental group I clustered around the group mean more than those in experimental group II.

**Research Question two**

What are the mean achievement scores of male and female pre-service teachers taught dissection with virtual biology laboratory?

***Table 2: Pre-test and post-test mean achievement scores and standard deviations of male and female pre-service teachers taught dissection with virtual biology laboratory***

| | Pre-Test | | | Post-Test | | | |
|---|---|---|---|---|---|---|---|
| **Gender** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** | **Adjusted Mean** |
| Male | 40 | 32.812 | 10.937 | 40 | 72.900 | 8.657 | 72.248 |
| Female | 40 | 29.125 | 7.262 | 40 | 72.087 | 8.439 | 73.183 |

Table 2 shows that the male students taught dissection with virtual biology laboratory package had a pre-test mean achievement score of 32.812 with a standard deviation of 10.937and a post-test mean achievement score of 72.900 with a standard deviation of 8.6574. Table 2 shows the female students taught dissection with virtual biology laboratory package had a pre-test mean score of 29.125 with a standard deviation of 7.262 and a post-test mean score of 72.087 with a standard deviation of 8.4397. Table 2 also shows the adjusted mean achievement scores of male students to be 72.248 and adjusted mean achievement score of 73.183 for female students. There is a difference of 0.935 in the adjusted mean score of female students against the male students. The difference in the adjusted mean score shows that female students achieved more than the male students in the post-test. However, the post-test standard deviation of 8.4397 for female and 8.6574 for male shows that the female students' individual scores clustered around the group mean more than those of the male students. This result therefore, shows that female pre-service teachers taught dissection with virtual biology laboratory package achieved higher than their male counterparts.

**Research Question Three**

What are the interaction effects of individualized and collaborative virtual biology laboratory and gender on pre-service teachers' achievement in dissection?

***Table 3: Interaction effects of individualized and collaborative virtual biology laboratory and gender on pre-service teachers' mean achievement and standard deviation.***

| | IVBL | | | CVBL | | |
|---|---|---|---|---|---|---|
| **Group** | **N** | **Mean** | **Std. Deviation** | **N** | **Mean** | **Std. Deviation** |
| **Male Students** | 20 | 74.8 | 7.112 | 20 | 71 | 9.78 |
| **Female students** | 20 | 73.68 | 6.154 | 20 | 70.5 | 10.15 |

Table 3 shows that the male students taught dissection using IVBL had post-test mean score of 74.800 and standard deviation of 7.112 while their female counterparts had post-test mean score of 73.675 and standard deviation of 6.154. Male students who taught using CVBL on the other hand had 71.000 post-test mean score with a standard deviation of 9.780 whereas female students achieved a post-test mean score of 70.500 and standard deviation of 10.150. The data on table 3 shows the interaction effect that is not ordinal between the type of virtual biology laboratory and gender on pre-service teachers' achievement in dissection. This is because at all level of gender, the post-test mean achievement of the group taught using IVBL is higher than the group taught using CVBL. The higher achievement recorded in the experimental group I could be as a result of the main effect of IVBL to the group not interaction effect of type of virtual biology laboratory and gender. Going by the standard deviation of the experimental group I and experimental group II, table 13 shows that individual scores in the experimental group I for both male and female clustered at the group mean score while that of the experimental group II was extreme to the group mean.

**Hypothesis One**

$H_{o1}$: there is no significant difference in the mean achievement scores of pre-service teachers taught dissection using individualized and collaborative virtual biology laboratory.

***Table 4: Analysis of covariance of the for the mean achievement scores of students taught dissection with IVBL and CVBL***

| **Source** | **Type III Sum of Squares** | **df** | **Mean Square** | **F-ratio** | **P-value** | **Partial Eta Squared** |
|---|---|---|---|---|---|---|
| Corrected Model | 970.318[a] | 2 | 485.159 | 7.875 | .001 | .170 |
| Intercept | 26074.670 | 1 | 26074.670 | 423.225 | .000 | .846 |
| Pretest | 727.065 | 1 | 727.065 | 11.801 | .001 | .133 |
| Method | 274.809 | 1 | 274.809 | 4.461 | .038 | .055 |
| Error | 4743.929 | 77 | 61.609 | | | |
| Total | 426141.750 | 80 | | | | |
| Corrected Total | 5714.247 | 79 | | | | |

**F-ratio (4.461), P-value (.038) P < 0.05 *: Significant**

Table 4 shows an F-ratio of 4.461 with an associated probability value of 0,038. Since the associated probability value of 0,038 was less than 0.05 set as level of significance, the null hypothesis one ($H_{o1}$) which stated that there is no significant difference in the mean achievement scores of pre-service teachers taught dissection using individualized and collaborative virtual biology laboratory is rejected. Therefore, the inference drawn is that there was a significant difference in the mean achievement scores of pre-service teachers taught dissection using individualized and collaborative virtual

biology laboratory with those taught using IVBL having a higher adjusted mean. This shows that IVBL has more effect on students' achievement in dissection than the CVBL.

**Hypothesis Two**

$H_{o2}$: There is no significant difference in the mean achievement scores of male and female pre-service teachers taught dissection using virtual biology laboratory.

***Table 5: Analysis of covariance for the mean achievement scores of male and female students taught dissection using VBL***

| Source | Type III Sum of Squares | df | Mean Square | F-ratio | P-value. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 698.063[a] | 2 | 349.032 | 5.358 | .007 | .122 |
| Intercept | 25259.703 | 1 | 25259.703 | 387.744 | .000 | .834 |
| Pretest | 684.860 | 1 | 684.860 | 10.513 | .002 | .120 |
| Gender | 2.555 | 1 | 2.555 | .039 | .844 | .001 |
| Error | 5016.183 | 77 | 65.145 | | | |
| Total | 426141.750 | 80 | | | | |
| Corrected Total | 5714.247 | 79 | | | | |

**F-ratio (.039), P-value (.844P > 0.05 *: Not significant**

Table 5 shows an F-ratio of 0.039 with an associated probability value of 0.844. Since the associated probability value of 0.844 was higher than 0.05 set as level of significance, the null hypothesis three ($H_{o3}$) which stated that there is no significant difference in the mean achievement scores of male and female pre-service teachers taught dissection using virtual biology laboratory is retained. Thus, the inference drawn is that there was no significant difference in the mean achievement scores of male and female pre-service teachers taught dissection using virtual biology laboratory and therefore, any observed difference in the adjusted mean could be as a result of sampling error and it is immaterial. This shows that gender has no influence on pre-service teachers` achievement in dissection when taught VBL.

**Hypothesis Three**

$H_{o3}$: There is no significant interaction effect of individualized and collaborative virtual biology laboratory and gender on pre-service teacher's achievement in dissection.

***Table 6: Analysis of covariance for the interaction effect in the post-test mean achievement scores of pre-service teachers in dissection by type virtual biology laboratory and gender***

| Source | Type III Sum of Squares | df | Mean Square | F-ratio | P-value |
|---|---|---|---|---|---|
| Corrected Model | 1169.737[a] | 8 | 146.217 | 2.284 | .031 |
| Intercept | 13268.590 | 1 | 13268.590 | 207.298 | .000 |
| Pretest | 452.655 | 1 | 452.655 | 7.072 | .010 |
| Method * Gender | 68.950 | 1 | 68.950 | 1.077 | .303 |
| Error | 4544.510 | 71 | 64.007 | | |
| Total | 426141.750 | 80 | | | |
| Corrected Total | 5714.247 | 79 | | | |

**F-ratio (1.077), P-value (0.303) P > 0.05 *: Not Significant**

Table 6 shows an F-ratio of 1.077 with an associated probability value of 0.303. Since the associated probability value of 0.303 was higher than 0.05 set as level of significance, the result shows that, the interaction effect of type of virtual biology laboratory and gender on pre-service teachers' achievement in dissection is not significant. Therefore, null hypothesis seven ($H_{o7}$) which states that there is no significant interaction effect of individualized and collaborative virtual biology laboratory and gender on pre-service teacher's achievement in dissection is upheld.

**Discussion**

The findings of this study show that students taught dissection using individualized virtual biology laboratory package (IVBL) performed significantly better than the experimental group II taught using collaborative virtual biology package (CVBL). The result of testing the corresponding hypothesis further revealed that the difference in the mean achievement of experimental group I and II was statistically significant. Thus, the null hypothesis one which stated that, there is no significant difference in the mean achievement scores of pre-service teachers taught dissection using individualized and collaborative virtual biology laboratory was rejected. The implication is that, IVBL has an enhancing effect on the learning of dissection more than CVBL. The higher achievement score by the experimental group I could be as a result of the hand-on-deck activity each and every pre-service teacher performed individually in the IVBL. This predisposing factor may have helped in capturing attention and made them ready for learning. It could also be as a result of opportunity IVBL provided to students to think and construct knowledge themselves by extrapolation.

The finding is consistent with the basic tenet of Jerome Seymour Bruner's theory of psychological/cognitive constructivism which held that: learning is an active process in which learners construct active ideas based on their experience and participation, that learners have innate affection to make sense of their environment. Therefore, learners can use different techniques to explore their environment and build personal interpretations based on their prior learning experiences. Similarly, it is evident that the developed IVBL on animal dissection stands to satisfy the demands of constructivism theory which suggests that learners learnt better by doing.

This finding is also in agreement with the studies of Faur and Ayuobi (2018) who's study in on the effect of using virtual laboratory on grade 10 students conceptual understanding and their attitude toward physics and found that the mean score of the experimental group was significantly higher than the mean score of the control group. Ferhat and Mehmet (2016) conducted a study on the effect of individualized instructional system on the academic achievement scores of students and found that individualized learning portal has positive effect on the students learning. Alhassan (2017) who carried out an empirical study on the impact of virtual laboratory on academic achievement and learning motivation in chemistry in the students of Sudanese secondary schools and found that that student's taught with virtual chemistry laboratory exhibited high achievement and motivation level compared to those students taught chemistry with conventional laboratory method. This study also supported the studies of Cengis (2010), Tatli and Aayas (2013), and Thisgaard and Makransky (2017), who`s studies are on different virtual laboratory packages on students' achievement and noted that virtual laboratory packages increase students' achievement in science. The finding also did not agree with the studies of Gambari, Obielodara and Kawu (2017), Udu (2017), and Aluko and Olurundare (2005), who noted that collaborative virtual laboratory was found to be more effective than individualised virtual laboratories in enhancing students` performance. This disagreement may be as a result of the difference in the students' level of education because those studies were carried out in secondary schools while the present one is carried out on animal dissection in federal colleges of education in Nigeria.

The findings on the influence of gender on the mean achievement scores of pre-service teachers taught dissection using VBL indicated that male pre-service teachers performed slightly better than female students when VBL is used. The outcome of testing the corresponding hypothesis further revealed that there was no statistically significant difference in the achievement of male and female pre-service teachers. Thus, the null hypothesis two which stated that, there is no significant difference in the mean achievement scores of male and female pre-service teachers taught dissection using virtual biology laboratory was accepted. This implies that gender does not significantly influence pre-service teachers achievement when taught dissection with VBL package.

This finding is in agreement with that of Chukwu (2012) who examined the influence of gender on students` achievement and interest and found that influence of gender on achievement is insignificant. The finding also is in support of the findings of Ogboji (2013) who investigated effect of local resources on students` achievement and interest cultural and creative arts and found that influence of gender on achievement was insignificant. The finding also is in agreement of Afolabi and Yusuf (2010) who investigated the influence of gender on the achievement of students exposed to CAT in individualized and cooperative learning packages among senior secondary two (S.S.II) and found that there is no significant difference between the achievement of male and female students in biology when they are taught using individualised and cooperative computer assisted instruction (CAI). However, the finding of this study contradict the earlier finding of Olum (2013) who`s study is on the effect of computer simulation package and gender as predictors of students' achievements in biology in Ibadan Oyo State and found that that there was a significant main effect of gender on student's achievement in biology in favour of male students. Again, the findings of this study contradict Nwachukwu (2014) who found statistical difference in the achievement of male and female students exposed to group learning in favour of male students.

The findings on the interaction effect of the two modes of VBL and gender on pre-service teachers' achievement in dissection indicated no interaction effect between method and gender. This is because at all levels of gender, the group taught using IVBL have higher mean scores than the group that was taught with CVBL. This implies that the achievement recorded is as a result of the methods used not the interaction of methods and gender. The outcome of testing the corresponding hypothesis seven further revealed that there was no statistically significant interaction effect of VBL and gender on pre-service teachers' achievement in dissection. Thus, the null hypothesis seven was accepted and it implies that VBL does not significantly interact with gender in bringing about the achievement recorded. This finding is in agreement with Ogboji (2013), whose study found that methods and gender has no significant interaction effect on students' achievement.

**Summary**

The major findings of this study were summarised as follows:

1. The findings of this study show that pre-service teachers taught dissection using individualized virtual biology laboratory package (IVBL) performed significantly better than the pre-service teachers taught using collaborative virtual biology package (CVBL). The result of testing the corresponding hypothesis further revealed that the difference in the mean achievement of pre-service teachers who taught dissection with IVBL and those who taught dissection with CVBL was statistically significant.

2. The findings on the influence of gender on the mean achievement scores of pre-service teachers taught dissection using IVBL and CVBL indicated that male pre-service teachers performed slightly better than female students. It further revealed that there was no statistically significant difference in the achievement of male and female pre-service teachers. Thus, the null hypothesis two was accepted. This implies that gender does not

significantly influence pre-service teachers achievement when taught dissection with VBL package.

3. The findings indicated no interaction effect between method and gender. This implies that the achievement recorded is as a result of the methods used not the interaction of methods and gender. It implies that IVBL and CVBL do not significantly interact with gender. This finding is in agreement with Ogboji (2013), whose study found that methods and gender has no significant interaction on students' achievement.

**Conclusions**

Based on the findings of this study, the following conclusions were made: Individualized virtual biology laboratories package is more effective than collaborative virtual biology laboratory in enhancing pre-service teachers` achievement in dissection. Gender does not influence pre-service teachers` achievement in dissection. Lastly, there is no interaction effect of VBL and gender on pre-service teachers` achievement in dissection. In consequence, this study provide solutions to the challenges that make animal dissection infeasible and give avenues of carrying out experiments on animal dissection in federal colleges of education for meeting the requirements of the NCE Biology minimum standard in Nigeria.

**Recommendations**

The following recommendations were made based on the findings and conclusion of the study:

1. Individualized Virtual Biology Laboratory Package should be used in carrying out experiments in dissection in teacher training institutions. Because, it is ascertained to develop pre-service teachers` spirit of understanding animal dissection.
2. Lecturers and Technologist should be encouraged to be more resourceful, creative and innovative in developing, selecting, and using IVBL virtual laboratory packages for teaching and learning animal dissection.
3. Individualized and collaborative virtual biology laboratories are gender friendly; therefore, lecturers and technologist in colleges of education should adopt the packages in teaching all pre-service teachers irrespective of their gender or ability levels.
4. Curriculum designers should incorporate the use of virtual laboratories in the biology minimum standard for colleges of education in Nigeria
5. Government and other stake holders in education should make Virtual Biology Laboratories instructional packages available in colleges of education; provide more computer systems and computer accessories to Teacher Training Institutions.

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