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EFFECTS OF VIRTUAL LABORATORY TECHNIQUE ON SENIOR SECONDARY TWO STUDENTS' MOTIVATION IN BIOLOGY IN AKWANGA, NASARAWA STATE, NIGERIA

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ABSTRACT

The study investigate the effects of virtual laboratory technique on senior secondary two students' motivation in biology in Akwanga, Nasarawa State, Nigeria. Two research questions and two hypotheses were formulated. This study adopted a quasi-experimental design, specifically the pretest posttest non-equivalent control group design where intact groups was assigned to the experimental and control groups. Intact classes was used in all the groups without randomization to avoid disruption of normal class lessons. Two groups were used: one was assigned the experimental groups while the second group was assigned the control group. The experimental group was exposed to the virtual laboratory (E) and the control group was exposed to closed door laboratory (C). The total of 109 males and 120 females students from two schools were sampled using purposive sampling technique from the total population of 229 SS two students that offered Biology during the 2023/2024 session from 4 public co-educational secondary schools. The instruments that was used for data collection in this study were Biology Motivation Questionnaire (BMQ) and Biology Performance Test (BPT). The validity of Biology Motivation Questionnaire (BMQ) was sought using Kendall's coefficient of concordance and coefficient of 0.75 was obtained. Equally, the reliability of Biology Performance Test (BPT) items was sought using Cronbach alpha method and a coefficient of 0.92 was obtained. Research questions were answered using mean and standard deviation and Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The result shows that there is improvement in the motivation mean scores of both the male and female students using virtual laboratory technique; however female students perform better than their male counterparts. Also, there is significant difference between the pre-test and post-test motivation mean scores of SS2 students in the experimental and control groups.

Key words: Virtual Laboratory Technique, Students' Motivation.

INTRODUCTION

Education is an indispensable tool for the growth and development of every nation. It is viable and characterized by constant changes, innovations and creativity that are brought about by the changing environment. These characteristics bring dynamism in education that exposes teachers to suitable ways to facilitate, improve and increase students' learning experiences in the changing world. The learners acquire practical and manipulative skills to interact with the environment for better productivity in this ever-changing world. This also makes knowledge of science education important for meeting societal needs and serve as the bedrock for ensuring sustainable economic and national development. The field of Science comprises of branches that include Biology, Chemistry and Physics.

Biology as a branch of science is a field of knowledge that focuses on the study of life and human activities that contribute to a large extent to sustainable economic growth and productivity of the nation. The knowledge of Biology according to Ahmad, Abubakar and Yau (2018), serves as bedrock to disciplines such as medicine, pharmacy, biochemistry, biotechnology, microbiology, agriculture, botany (plant science), zoology (animal science), anatomy and physiology, genetics, ethnobotany and other related fields. The exposure to Biology offers the learners a wide range of relevance to all aspects of life and has gone a long way to improve the social and economic prospect of mankind. However, the knowledge of Biology can be efficient if adequate attention is focused on the application of laboratory by ensuring the provisions of equipped and functional laboratory. The teaching and learning of Biology cannot be effective when it is only taught theoretically, but will be much more effective when complimented practically in the laboratory.

Laboratory method of teaching and learning is regarded as a method that makes teaching and learning more real to students as opposed to abstract or theoretical presentation of facts, principles and concepts of the subject matter. Akani (2015) defined laboratory as a room, building or a special period of practical or experimental studies that provides opportunity for students to develop experimental skills.

Laboratory is therefore, an equipped and conducive environment that can be motivating for better performance and will further equip the learners with practical experiences that will enable them face challenges before and after graduation.

The biology laboratory in most of the secondary schools involves the use of closed-door laboratory. Closed door laboratory is the type of laboratory design that takes place mainly inside or in an enclosed rooms and it is a resource intensive, both in terms of acquiring and maintaining the equipment and staffing requirements. This poses a great challenge in spite of the importance of laboratory in the teaching and learning of Biology as most secondary schools lack laboratory facilities due to the challenge of cost and maintenance. This is in line with the finding of Ahmad (2022) that biology laboratories in Nigeria Senior Secondary Schools are poorly and inadequately equipped and resulted in poor academic performance by students. Study by Ugwuadu (2017) revealed that performance of students in Senior School Certificate Examination (SSCE) as presented by both WAEC & NECO Chief Examiners' are persistently poor. Recently, Onu, Anyaegbunam and Uzoigwe (2020) revealed the 2017 and 2018 WAEC Chief Examiner's report which revealed that the mean performance score of students were 31 (with a standard deviation of 11.92) and 30 (with a standard deviation of 9.00) respectively in the May/June WASCE. According to Ojekwu and Ogunleye (2020) students' performance in the West Africa Examinations Council showed that 50.02% and 35.82% failed Biology in 2018 and 2019 respectively.

This shows that poor laboratory facilities and application have a huge set back on students' performance and thereby have negative effect on the nation economic growth. A paradigm shift on the application of laboratory on the teaching and learning of Biology is therefore needed that will enable learners conduct practical that will help them construct their own knowledge, make meanings of tasks, set out to perform better (Ojo & Owolabi, 2020). The application of virtual laboratory as a digital method is a shift that can ameliorate the challenge and compliment the inadequate laboratory facilities in the education system, particularly, biology and help learners blend with the global technology changes.

A Virtual Laboratory is a website or software for interactive learning based on simulation of real phenomena. It allows students to explore topics and to get practical experience over the internet. Achuthan, Nair and Nedungadi (2022) defined Virtual laboratories as computer simulation-based environments used to interactively design and conduct controlled experiments. As observed by Estriegana, Medina-Merodio and Barchino (2019), it is electronically programmed in computer in order to simulate the real experiments inside the real laboratories. It therefore mean that virtual laboratory is an educational environment website or software that is electronically programmed in computer or other digital devices for interactive learning based on simulation of real phenomena that allows students to explore topics and get practical experiences. It serve as a good alternative for schools that cannot build laboratories and provide tools and equipment.

In contrast to the closed-door (traditional) laboratory, virtual laboratory technique allow students to have unlimited opportunities to re-do the simulations that can aid in further conceptual development and understanding (Daineko, Dmitriyev, & Ipalakova, 2017). Although, virtual laboratory have the disadvantages of lack of real interactions with practical apparatus, students' social interactive skills, need computers and tolls with special standard, specialized working staff, instructors and curriculum experts for designing and production. However, Ali and Ullah (2020) and Raman, Achuthan, Nair and Nedungadi (2022) in separate studies, compared virtual laboratory to closed-door laboratory, indicated that virtual laboratory offers reduced cost, greater accessibility, time-saving, safe environments, and flexibility for self-regulated learning. Virtual laboratory can provide simulated versions of closed-door laboratories where students are provided with virtual representations of the real objects used in closed-door laboratory and can significantly improve both motivation and performance outcomes.

Motivation is one of the important influential variable and predictor in education that enhanced learning and performance outcomes and has been linked to better academic performance and greater conceptual understanding of subject matter (Ardura & Pérez-Bitrián, 2018) and is vital to improving students learning outcome. According to the definition by Jonathan, Michael and Yevgeniya (2021), motivation is the desire to study, the drive towards educational goals and a persuasive feeling that always helps students to accomplish task or activity no matter how hard and tough. Motivation enhances initiation, determination and drives students to be committed to learning task and is fundamental in achieving educational objectives. Students who are most motivated tend to learn better and excel in class activities and become higher achievers. Motivation plays a major role in students' academic work and in their performance. Therefore, Students' academic performance is a feature in every education enterprise. Also,

students often have different motivation levels in terms of gender differences. According to research by Naz, Shah and Qayum (2020) indicate that female students often set higher motivation than male students while in another research by Ardura and Pérez-Bitrián (2018) male show higher motivation than female students. However, study by Jonathan, Michael and Yevgeniya (2021) showed that there is no gender difference in terms of motivation towards academic performance. This is why students gender is a fundamental variable in this study that the researcher will like to investigate.

It was against these background that the researcher sought to find out effective laboratory technique for teaching and learning Biology that will enhance meaningful learning and application in real life situation considering the digital and technological era. Hence, the topic: effects of virtual laboratory technique on secondary school two students' motivation and performance in Biology in Akwanga, Nasarawa State.

AIM AND OBJECTIVES OF THE STUDY

The aim of the study was to investigate the effects of virtual laboratory technique on Senior Secondary School two students' motivation in Biology in Akwanga, Nasarawa State. Specifically, the study sought to:

1. ascertain the pre-test and post-test motivation scores of the SS2 students in experimental and control groups
2. determine the pre-test and post-test motivation scores of SS2 male and female students in the experimental group

RESEARCH QUESTIONS

The following research questions will guide the study:

1. What are the pre-test and post-test motivation mean scores of SS2 students in the experimental and control groups?
2. What are the pre-test and post-test motivation mean scores of SS2 male and female students in the experimental group?

HYPOTHESES

The following hypotheses will be tested at 0.05 level of significance:

1. There is no significant difference between the pre-test and post-test motivation mean scores of SS2 students in the experimental and control groups
2. There is no significant difference between the pre-test and post-test motivation mean scores of SS2 male and female students in the experimental group

METHOD AND PROCEDURE

This study adopted a quasi-experimental design, specifically the pretest posttest non-equivalent control group design where intact groups was assigned to the experimental and control groups. Quasi-experimental design was considered appropriate for the study because it was not possible to randomly assign the students in either of the groups. The researcher made use of the normal school period to administer the treatments. Therefore, intact classes was used in all the groups without randomization to avoid disruption of normal class lessons. The research used two groups: one was assigned the experimental groups while the second group was assigned the control group. The experimental group was exposed to the virtual laboratory (E) and the control group was exposed to closed door laboratory (C). The Quasi-experimental design served as a blue print that guided the structuring, collection, analysis and interpretation of the data that was collected.

The population of the study consisted of all the senior secondary two Biology students in public co-educational schools in Akwanga Metropolis of Nasarawa State with a total of 229 SS two students that offered Biology during the 2023/2024 session from 4 public co-educational secondary schools. Out of the 229 population of senior secondary school students during the 2023/2024 session in Akwanga metropolis, 109 were males and 120 were females. The sample for the study consisted of two schools. One school was assigned to experimental group and one to control group respectively. The total of 112 Biology students were sampled from the 229 Biology students from the 2023/2024 academic session as intact classes. From the sample, 27 male students and 26 female student totally 53 students were used for the experimental group. While, 28 male students and 31 female students totally 59 students were used for control group. The

study adopted purposive sampling technique. The purposive sampling technique was used to sample one school with virtual facilities (computer lab, projector, and internet facility) and one school without virtual facilities but have physical laboratory facilities. The instruments that was used for data collection in this study were Biology Motivation Questionnaire (BMQ) and Biology Performance Test (BPT). The validity of Biology Motivation Questionnaire was established using Factor Analysis and instrument was considered valid. Equally, the reliability of Biology Performance Test (BPT) items was sought using Cronbach alpha method and a coefficient of 0.92 was obtained. All the research questions were answered using mean and standard deviation and Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

RESULTS

Answering Research Questions

Research Question One : What are the pre-test and post-test motivation mean scores of SS2 students in the experimental and control groups?

Table 3:Pre-test and Post-test Motivation Mean Scores of Experimental and Control Groups

Groups	N	Pre-test Mean	SD	Post-test Mean	SD	Mean Gain	Mean Difference
Experimental	53	58.283	6.602	65.076	6.997	6.793	4.200
Control	59	60.271	8..339	57.678	9.978	2.593	

Table 3 reveals the pre-test and post-test motivation mean score of SS2 students in the experimental and control groups. In the experimental group the post-test motivation mean score was 65.076 and standard deviation of 6.997, higher than the pre-test mean score of 58.283 and standard deviation of 6.602 with a mean gain of 6.793., indicating that there was improvement in the students motivation to Biology after main treatment. Also, for the control group the mean score was 60.271 and a standard deviation of 8.339 in the pre-test. The post-test mean score of students decrease to 57.678 and a standard deviation of 9.978. The findings show that students in the experimental group had a higher motivation mean score to Biology (65.076) after treatment using virtual laboratory technique than those in the control group (57.678) who were not given treatment with a mean difference of 4 .200. At the pre-test, the experimental group had poor motivation, but after the intervention the experimental group were motivated better than the control group. It can be deduced that virtual laboratory technique motivate students in Biology.

Research Question Two: What are the pre-test and post-test motivation mean scores of SS2 male and female students in the experimental group?

Table 4: Pre-test and Post-test Motivation Mean scores of Male and Female Students in the Experimental group

Gender	N	Pre-test Mean	SD	Post-test Mean	SD	Mean Gain	Mean Difference
Males	27	59.963	5.840	63.741	6.249	3.778	6.145
Females	26	56.539	6.872	66.462	7.569	9.923	

Table 4 reveals the pre-test and post-test motivation mean scores of SS2 male and female students in the experimental group. The post-test mean score of males is 63.741 and standard deviation of 6.249, while pre-test is 59.963 with standard deviation of 5.840. The post-test is higher than the pre-test mean score with the mean gain of 3.778. The pre-test of the female motivation mean score is 56.539 and standard deviation of 6.872, the post-test mean score rouse to 66.462 with the standard deviation of 7.569. The mean gain of the female students is higher than the mean gain of the male students. The finding shows that there is improvement in the motivation mean scores of both the male and female students after treatment, however, female students perform better than their male counterparts.

Hypotheses

Hypothesis One: There is no significant difference between the pre-test and post-test motivation mean scores of SS2 students in the experimental and control groups

Table 7: **ANCOVA Result on Pre-test and Post-test Motivation Mean Scores of Students in Answering Motivational Scale Questionnaire**

Source	Type 111 Sums of Squared	Df	Mean Square	F	Sig	Partial Eta Squared
Corrected model	1547.073a	2	773.536	10.157	.000	.157
Intercept	5957.524	1	5957.524	78.285	.000	.418
Covariate	19.224	1	19.224	.252	.616	.002
Group	1546.462	1	1546.462	20.306	.000	.157
Error	8301.356	109	76.159			
Total	429044.000	112				
Corrected Total	9848.429	111				

a. R Squared = .492 (Adjusted R Squared = .483)

Analysis of Covariance (ANCOVA) was conducted to determine if a significant difference exists in the pre-test and post-test motivation mean score of students in answering motivational scale questionnaire. The table shows that $F(1,51) = 14.99$, $p < 0.05$, since the p-value of 0.000 is less than 0.05 level of significance, the null hypothesis was rejected, indicating that there was a significant effect of motivation of the students. The result further reveals an adjusted R squared value of 673 which means that 67.3 percent of the variation in the dependent variable which is achievement in answering literal questions is explained by variation in the treatment of metacognitive strategies, while the remaining is due to other factors not included in this study. Hence, we can say that metacognitive strategies can help improve students' achievement in

Hypothesis Two: There is no significant difference between the pre-test and post-test motivation mean scores of male and female students in the experimental group.

Table 8: ANCOVA Result on Pre-test and Post-test Motivation Mean Scores of Male and Female Students in the Experimental Group

a. R Squared = .0.30(Adjusted R Squared = .008)

Analysis of covariance (ANCOVA) was conducted to determine if there is a significant effect of gender on

Source	Type 111 Sums of Squared	Df	Mean Square	F	Sig	Partial Eta Squared
Corrected model	75.380a	2	37.690	.785	.462	.030
Intercept	2671.680	1	2671.680	55.662	.000	.527
Covariate	19.879	1	19.879	.414	.523	.008
Gender	32.841	1	32.841	.684	.412	.013
Error	2399.903	56	47.998			
Total	238787.000	53				
Corrected Total	2475.283	52				

motivation of SS2 students taught Biology using the package motivation. Table 8 shows that the main effect of gender shows that F (1) .414, $p > 0.05$. Since the p-value 412 is greater than 0.05, the null hypothesis was retained, indicating there was no significant difference in the post-test motivation mean scores of male and female students toward Biology in the experimental group. The result further reveals an adjusted R squared value of 008 which means that 0.8 percent of the variation in the dependent variable which is motivation in Biology was explained by variation in the treatment of virtual laboratory technique, while the remaining was due to other factors not included in this study. Hence virtual laboratory technique can help improve motivation of both male and female students in Biology.

Discussion of Findings

The aim of the study is to investigate the effects of virtual laboratory technique on Senior Secondary School two students' motivation and performance in Biology in Akwanga, Nasarawa State. All the research questions were answered using mean and standard deviation and analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

Research question one that state that what are the pre-test and post-test motivation mean scores of SS2 students in the experimental and control groups was answered based on the pre-test and post-test mean score of students in the experimental and control groups in motivation to Biology. The experimental group post-test motivation mean score obtained was 65.076 and the standard deviation was 6.997, which is higher than the pre-test mean score of 58.283 and standard deviation of 6.602 with a mean gain of 6.793. This indicated that there was improvement in the students' motivation to Biology after main treatment. Also, for the control group the mean score obtained was 60.271 and the standard deviation obtained was 8.339 in the pre-test. The post-test mean score of students decrease to 57.678 and a standard deviation of 9.978. The findings shows that students in the experimental group had a higher motivation mean score to Biology (65.076) after treatment using virtual laboratory technique than those in the control group (57.678) who were not given treatment with a mean difference of 4 .200. At the pre-test, the experimental group had poor motivation, but after the intervention the experimental group were motivated better than the control group. It can be deduced that virtual laboratory technique improve students' motivation. The result of the finding is in line with Dareen and Alnaser (2024) who revealed that using virtual laboratories positively affects students' motivation. It is also in agreement with the findings by Ernita, Muin, Verawati and Prayogi (2021); Koehler, (2021), who all reported a positive effect of virtual laboratories on students' motivation. However, the finding is in disagreement with Puntambekar, Gnesdilow, Dornfeld, Narayanan and Rebello (2021) who revealed that students exhibit higher motivation when engaging in physical laboratory activities.

Research question two that state that what are the pre-test and post-test motivation mean scores of SS2 male and female students in the experimental group was answered based on the pre-test and post-test motivation mean scores of male and female students in the experimental group. The males obtained post-test mean score of 63.741 and standard deviation of 6.249, while pre-test mean score of 59.963 with standard deviation of 5.840. The post-test is higher than the pre-test mean score with the mean gain of 3.778. The females obtained pre-test motivation mean score of 56.539 and standard deviation of 6.872, the post-test mean score rouse to 66.462 with the standard deviation of 7.569. The mean gain of the female students is higher than the mean gain of the male students. There is improvement in the motivation mean scores of both the male and female students after treatment; however female students perform better than their male counterparts. The result coincides with the study conducted by Cheruiyot, Njagi and Mburugu (2023) that females were significantly motivated in biology compared to the male students. The researchers further discovered that substantial gender difference favored females across a variety of motivational factors in their study. In contrast, the finding of this study is in variance with the study by Radulović, Županec, Stojanović and Budić (2022) that male students were more motivated towards Physics than female students and they had greater confidence in their knowledge.

Hypothesis one that state that there is no significant difference between the pre-test and post-test motivation mean scores of SS2 students in the experimental and control groups was tested using Analysis of Covariance (ANCOVA) to determine if a significant difference exists in the pre-test and post-test motivation mean score of students in answering motivational scale questionnaire. The result shows that $F(1,51) = 14.99$, $p < 0.05$, since the p-value of 0.000 is less than 0.05 level of significance, the null hypothesis was rejected, indicating that there was a significant effect of motivation of the students. The result further reveals an adjusted R squared value of 673 which means that 67.3 percent of the variation in the dependent variable which is motivation is explained by variation in the treatment of virtual laboratory technique, while the remaining is due to other factors not included in this study. Hence, we can say that there is significant difference between the pre-test and post-test motivation mean scores of SS2 students in the experimental and control groups. This conclusion is in harmony with Dareen and Alnaser (2024) finding that there is a significant difference in the mean score of students' motivation for control group and experimental group was significant. This result is also in line with Ahmad and Ismail (2023) who revealed that there was a significant difference between the total students mean scores of motivation before and after the activities.

Hypothesis two that state that there is no significant difference between the pre-test and post-test motivation mean scores of SS2 male and female students in the experimental group was analyzed using Analysis of covariance (ANCOVA) to determine if there is a significant effect of gender on motivation of SS2 students taught Biology using the package motivation. The analysis shows that the main effect of gender shows that F (1) .414, $p > 0.05$. Since the p-value 412 is greater than 0.05, the null hypothesis was

retained, indicating there was no significant difference in the post-test motivation mean scores of male and female students toward Biology in the experimental group. The result further reveals an adjusted R squared value of 008 which means that 0.8 percent of the variation in the dependent variable which is motivation in Biology was explained by variation in the treatment of virtual laboratory technique, while the remaining was due to other factors not included in this study. This shows that virtual laboratory can help improve motivation of both male and female students in Biology. Hence, there is no significant difference between the pre-test and post-test motivation mean scores of male and female students in the experimental group. This result concord with Hagos and Andargie (2022) who indicated that there was no statistically significant difference in the mean between males and females students on the motivation to study chemistry. While it disagreed with the conclusion of Cheruiyot, Njagi and Mburugu (2023) that indicates there was statistically significant difference in student motivation in biology depending on gender when taught utilizing a computer-assisted teaching technique.

CONCLUSION

It is concluded from this study that students in the experimental group had a higher motivation mean score to Biology after treatment using virtual laboratory technique than those in the control group who were not given treatment using virtual laboratory technique. Also, virtual laboratory technique improve the motivation of both the male and female students after treatment; however, female students perform better than their male counterparts. This therefore mean that female girls students are more academically motivated than male boys students using virtual laboratory technique. It therefore mean that virtual laboratory technique is a good educational electronically programmed environment for learning based on simulation of real phenomena that allows students to explore topics and get practical experiences and provides tools and visualizations that motivate the students to participate in learning within and outside the class.

RECOMMENDATION

In view the findings drawn from this study, the following recommendations are made

1. Workshops and seminars should be organized for biology teacher to be train on the use of virtual laboratory technique for laboratory activities
2. Virtual laboratory technique should be integrated in the biology laboratory curriculum for the training of biology pre-service teachers.
3. Biology teachers should be encourage to use it in their laboratories to help motivate their students.

REFERENCES

Ahmad, S. I., Abubakar, B. B., & Yau, S. (2018). Biology education a panacea for sustainable national development. *Frontiers in Environmental Microbiology, 4*(2), 71-74.

Ahmad, A., & Ismail, J. (2023). Effects of Biology 21st Century Teaching Strategies on Students' Motivation. *Indonesian Journal of Educational Science and Technology (Nurture), 2*(1), 15-28.

Ahmad, A. (2022).Problems of teaching practical biology in senior secondary schools. *ASEAN Journal of Science and Engineering Education, 2*(3), 199-206.

Akani, O. (2015). Laboratory teaching: Implication on students' achievement in chemistry in secondary schools in Ebonyi State of Nigeria. *Journal of Education and Practice, 6*(30), 206-213.

Ali, N., & Ullah, S. (2020). Review to analyze and compare virtual chemistry laboratories for their use in education. *Journal of Chemical Education, 97*(10), 3563-3574.

Ardura, D., & Pérez-Bitrián, O. (2018). The effect of motivation on the choice of chemistry in secondary schools: Adaptation and validation of the science motivation questionnaire II to Spanish students. *Chemistry Education Research and Practice, 19*(3), 905-918.

Cheruiyot, G. L., Njagi, M. W., & Mburugu, B. M. (2023). Gender-related differences in using computer assisted teaching strategy on student motivation in biology based in public secondary schools in Baringo County, Kenya. *Journal of Advanced Education and Sciences, 3*(2), 15-19.

Daineko, Y., Dmitriyev, V. & Ipalakova, M. (2017). Using virtual laboratories in teaching natural sciences: An example of physics courses in university, *Comput. Appl. Eng. Educ.*, 25(1), 39-47.

Dareen, S. A., & Alnaser, S. F. (2024). Investigating the effects of virtual laboratories on students' motivation and attitudes toward science. *Science Education International 35*(2), 154-162.

Ernita, N., Muin, A., Verawati, N.N.S.P., & Prayogi, S. (2021). The effect of inquiry learning model based on laboratory and achievement motivation toward students' physics learning outcomes. *Journal of Physics: Conference Series*, 1816(1), 12-19.

Estriegana, R., Medina-Merodio, J. A., & Barchino, R. (2019). Student acceptance of virtual laboratory and practical work: An extension of the technology acceptance model, *Computer Education, 95*(1), 309-32.

Hagos, T., & Andargie, D. (2022). Gender Differences in Students' Motivation and Conceptual Knowledge in Chemistry Using Technology-Integrated Formative Assessment. *Asian Journal of Assessment in Teaching and Learning*, *12*(1), 10-22.

Jonathan, D. S., Michael, D. G., & Yevgeniya, V. Z. (2021). Motivation, pedagogy, and gender: examining the multifaceted and dynamic situational responses of women and men in college STEM courses. *International Journal of STEM Education, 1*(1), 1-19.

Koehler, E. (2021). The effect of virtual labs on high school student attitudes towards chemistry. Retrieved on 7/8/2024 from: https://red.mnstate.edu/thesis/540

Naz, S., Shah, S. A., & Qayum, A. (2020). Gender differences in motivation and academic achievement: A Study of the university students of KP, Pakistan. *Global Regional Review, 5*(1), 67-75.

Ojekwu, I. N., & Ogunleye, B. O. (2020). Effects of jigsaw learning strategy on science students" performance and interest in biology in selected schools in Rivers State, Nigeria. *Sapientia Foundation Journal of Education, Sciences and* Gender *Studies, 2*(3), 325-334.

Ojo, O. M., & Owolabi, O. T. (2020). Effects of predict-observe-explain and virtual laboratory instructional strategies on secondary school students' performance in physics practical. *European International Journal of Science and Technology, 9*(1), 1-11.

Onu, W. O., Anyaegbunam, N. J., & Uzoigwe, A. U. (2020). Improving biology students' interest and achievement through collaborative instructional strategy. *Journal of Education, Society and Behavioural Science, 33*(2), 9-20.

Puntambekar, S., Gnesdilow, D., Dornfeld Tissenbaum, C., Narayanan, N. H., & Rebello, N. S. (2021). Supporting middle school students' science talk: A comparison of physical and virtual labs. *Journal of Research in Science Teaching*, 58(3), 392-419.

Radulović, B., Županec, V., Stojanović, M., & Budić, S. (2022). Gender motivational gap and contribution of different teaching approaches to female students' motivation to learn physics. *Scientific reports, 12*(1), 1-9.

Raman, R., Achuthan, K., Nair, V. K., & Nedungadi, P. (2022). Virtual laboratories- A historical review and bibliometric analysis of the past three decades. *Education and Information Technologies, 27*(1), 1055-11087.

Ugwuadu, O. R. (2017). Peers and students' assessments of biology teacher effectiveness in secondary schools in Adamawa State. *International Journal of Innovative Social & Science Education Research, 5*(2), 16-24.