INFLUENCES OF LABORATORY SPACE AND QUALITY ON STUDENT SUCCESS IN RURAL AND URBAN SCHOOLS

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Abstract

The importance that districts have placed on the teaching of science in school systems has declined due to high-stakes testing for reading and math. Resources and science labs are few and far between especially in rural communities where money is scarce. This study provided information about the influences of science laboratories and quality science laboratory materials have on student learning and academic achievement in rural and suburban schools. The researcher provided data on the possible influence on science test scores and the schools capacity for inquiry-based science activities. Research showed that this was an indicator of a lack of interest in learning science. Research suggests that the long-term effect is fewer students will pursue careers in the science field. The hypothesis stated that there would be a negative influence on student learning due to how labs were taught and a negative influence on how teachers and students view science overall. Results of recent studies indicate a strong correlation between the use of science labs and test scores. The purpose of this research was to help guide educators and administration in finding alternative ways to teach science labs.

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Chapter I

Introduction

On the other side of the walls of the classroom in rural communities are the largest science labs available to students. Rural communities offer woods, forests, creeks, and terrain. Why are science assessment scores lower in rural school districts than suburban school districts? Could this outside living lab be incorporated into the curriculum to close that achievement gap?

Teachers' attitudes toward teaching science have changed dramatically over the years. The demand to score high on state assessments in reading and math has contributed to this change (Jones et al., 2018). When teachers are faced with the choice between, 'teaching to the test' and teaching for meaningful learning, the former is usually picked over the latter because of the pressure to succeed on the state-mandated tests (Diaconu et al., 2012). Teaching science effectively has become a concern for administrators and districts. State testing is one of many challenges that face educators and science education. Other contributing factors include lack of training for educators, lack of interest from both students and teachers, textbooks that do not match the curriculum, and insufficient funds for science experiments and science labs. The focus of this study was the influence of laboratory science labs and quality lab materials in rural and urban schools, particularly in the secondary school setting and the influence that it had on student achievement on state assessments.

Rural school districts receive less funding than suburban school districts, funding that is needed for quality textbooks and science lab materials (Avery, 2013). Quality science education is imperative to developing scientific literacy and inspiring students for future science careers. Jones et al. (2018) found that learning in science also contributed to reading literacy and being proficient in math. Long term effects of this gap in science learning are that by high school students has little interest in science resulting in students not pursuing science careers. The elementary school years are when children often make fundamental decisions that influence their career track (National Research Council [NRC], 1990). Learning from hands-on, science experiments and labs is important to student success according to the constructivist theory. The constructivist theory for learning is based on learning that occurs as learners are actively involved in a process of sense-making and knowledge construction as opposed to passively receiving information. Constructivist approaches incorporate the cognitive and social aspects of a student's environment with a student's specific interest to create a more holistic approach to learning (Jones et al., 2018). Value is placed on learning through experience and interaction.

Stamp and O'Brien (2005) collaborated with a school district to develop 5E teaching cycles that matched the state and district curriculum guidelines. However, without appropriate textbooks and lab materials, it is difficult to incorporate all aspects of the 5E cycle. Stamp and O'Brien (2005) stated that Grades K-6 have more limited science equipment, supplies, and budgets. Strategies could be put into place to help alleviate this problem. The need for teacher training contributes to the problem as well. Teachers lack the appropriate training and background to teach science effectively (Diaconu et al., 2012). As a result, many teachers are not interested or lack confidence to teach science. This also leads to not finding the time during the day to teach it. Resources and lab materials are of little use if teachers do not know how to incorporate them into the curriculum. Avery (2013) discussed one solution as having students in rural communities engage in their surroundings to explore issues that influence their community. By using the environment that students are surrounded by as a living lab, learning becomes relevant and connected to their lives. This would be a solution to the lack of resources for lab experiments as well as bringing real world experience to the students. Adeyemi (2008) found that higher scores were present in schools that had at least three science laboratories. He recommended that the government provide money for laboratories in schools that lacked funding. Advancements in technology are bringing science experiments and labs into the classroom with the use of computers. Lui et al. (2021) conducted a study to develop mobile, natural-science, learning environments and activities based on instructional needs as well as on integration of mobile technology and the 5E learning cycle. A study conducted on the effectiveness of mobile, natural-science, learning environments and activities suggested that, in general, they can effectively increase students' knowledge and improve students' learning motivation (Liu et al., 2021). A case study, in an elementary school in Taipei City, showed a significant increase in test scores when a mobile learning environment devoted to natural-science instruction on aquatic plants was implemented (Liu et al., 2021). The use of technology would help fill gaps in science from the lack of having available science labs and materials.

Statement of the Problem

The problem initiating this study centered on the perceived deficiencies in laboratory space and quality materials in rural and suburban schools. High quality working laboratories are considered an essential part of learning science. Students are given a chance to develop reasoning skills and problem-solving skills with the use of experiments and laboratories. Constructivism requires learning to be relevant and meaningful. Hands-on activities and science labs support this theory by making learning relevant to students' lives.

The purpose of the study was to compare laboratory space and materials as possible influences on student achievement on science tests and the schools' ability to provide science lab activities. This study compared possible differences in science assessment scores between students in rural schools to those in suburban schools. Archival data was investigated to identify differences in funding and, in particular, laboratory resources between rural and suburban schools. A goal of the study was to identify if the lack of science resources and science labs influenced low scores on state assessments.

The significance of the study lies in the potential to help guide educators, administrators, and districts to put strategies and training into place to close the gap on science education. At the university level, teacher education classes need to offer training for teacher candidates to prepare them for teaching in rural and urban school districts. With the implementation of the 5E model guiding science education, it is imperative to have knowledgeable teachers in the school system. Teachers need the experience, tools, and strategies to be successful. If educators have a solid background in science, they will have the confidence to teach the subject matter proficiently.

The assumption made in this study was that teachers would utilize science labs and incorporate them into daily lesson planning and teaching. The validity of the study was contingent on giving the same material and lessons to all participants. Another assumption was that the teachers would use the same amount of time for lessons, experiments, and labs. Too often teachers cut time off science lessons or skip them altogether due to the fact that they lack the background and confidence in order to teach the subject matter. Teachers also skip science because they feel pressured to teach longer lessons for reading and math.

A limitation of this study included the paucity of schools with appropriate laboratories from which to pull data. Acquiring data from schools using science laboratories was a challenge in the research. Accessing data on whether teachers were actually utilizing science laboratories and material resources was restricted for this study. The sample size was small and would not be generalizable. The convenience sample limited both population size and representation.

Therefore, the results may not have passed the external validity test. The sample used needed to be inspected to determine how well it represented the population.

Research Questions

The guiding research questions for this were as follows:

1) To what extent do science scores on standardized assessments among secondary students in Nigeria vary between schools equipped with one, two, or three laboratory spaces?
2) To what extent do science scores on standardized assessments among secondary students in Nigeria differ among schools supplied with varying stocks of quality science laboratory materials?

Hypothesis

The null hypothesis (H_0) for research question 1 in this study was: $H_{0\ 1}$ = No difference exists among secondary students in science achievement tests among those in schools with one, two, or three laboratories.

The alternative hypothesis for research question 1 in this study was: $H_{A\ 1}$ = Significant differences exist among secondary students in science achievement tests among those in schools with one, two, or three laboratories.

The null hypothesis (H_0) for research question 2 in this study was: $H_{0\ 2}$ = No difference exists among secondary students in science achievement tests among those in schools with varying stocks of quality science laboratory materials.

The alternative hypothesis for research question 2 in this study was: $H_{A\ 2}$ = Significant differences exist among secondary students in science achievement tests among those in schools with varying stocks of quality science laboratory materials.

Chapter II

Review of Literature

Science scores on the state assessments across the United States are low and have been a concern for district leaders for many years (Jones et al., 2018). Jones et al. (2018) posited that students are lacking proficiency in science skills due to lack of science laboratories. Another concern is the loss of interest in students pursuing careers in the science field. Lack of resources and science laboratories is a contributing factor to the low-test scores. Due to lack of funding, rural schools are impacted with little to no resources available for adequate labs.

Theoretical Foundation

Lev Vygotsky's social constructivist theory stated that social interactions allow students to acquire knowledge (McLeod, 2020). Science laboratories are an important aspect of cognitive development. One notion of the theory is that learning is an active process rather than a passive one. Learners construct meaning through active engagement with the world. It is believed that the environment that children grow up in influences what and how they think (McLeod, 2020).

Science experiments help students with reasoning, critical thinking, and problem-solving skills (Niazi et al., 2018). A fundamental assumption of constructivism is that learners construct understanding through interactions with the physical and/or social environment (Liang and Gabel, 2005). The goals of science laboratories are to enhance student mastery of material, develop skills, and develop scientific reasoning. According to Kubat (2018), supporting science with experiments help students understand concepts, facts, and theories more concretely. Lessons in science education include complex and abstract concepts. When students are given the opportunity to do hands-on experiments it enables them to link that knowledge with everyday life. Given this approach, many students develop a positive attitude toward science, which could lead to an interest in a science career. Using a constructivist approach to teaching make the lessons relevant and encourages questioning. The benefits of this theory encourage students to reflect and evaluate their work.

Niazi et al. (2018) stated that laboratory experience helps learners to develop important problem-solving skills necessary for success in their competitive, technological society. Simply memorizing information is not meaningful, nor does it have a lasting effect. Most memorized information has a short-term place in the memory. Previous studies focused on relationships between cognitive learning and academic achievement suggested that there is a positive relationship between laboratory environment and cognitive learning (Niazi et al., 2018).

Laboratories allow students to make a connection with what they are learning to a real-world experience that has greater meaning. Implementing science experiments entails putting students into groups that contributes to positive social skills among children as well as making learning fun. Niazi et al. (2018) conducted a study on cognitive learning of chemistry students in the rural and urban schools of Rawalpindi Division at the secondary school level. A proportionate sampling technique was used with the population of all science teachers and students. A *t*-test was used to find out the significance level between the rural and urban groups. The results showed a significant difference between mean scores of rural and urban students, in favor of the urban students (Niazi et al., 2018).

Challenges of Rural Schools

Rural areas are countryside consisting of small towns and fields. These areas have low population, density, and a large amount of undeveloped land. In contrast urban refers to a city itself and surrounding areas. The National Center for Education Statistics (NCES) defined rural "as those areas that do not lie inside an urbanized area or urban cluster" (Strange et al., 2012, p.1). Rural areas tend to be economically underdeveloped, lack government funding, and have limited technology exposure. Thus, many rural children are not exposed to the diverse ways in which STEM is practiced in the world and may not envision STEM-related educational or career pathways (Avery, 2013). The lack of funding and resources makes it difficult to get teachers who are qualified to teach science in rural areas, which also contributes to low test scores. Experienced teachers gravitate toward urban schools where the pay is higher and resources are available. Avery (2013) found that state and federal incentives often lure professionals to urban schools where they may receive monetary bonuses or graduate tuition.

The 5E Model

Kubat, (2018) revealed that classrooms were not equipped with proper laboratory equipment or resource material. Teachers stated that when they did experiments there were not enough materials so they would not be able to do the experiments or they would have to do different experiments. Although they are important to teaching and learning, a lack of science materials in the classrooms exists and leaves some students without materials for science experiments (Williams, 2010).

Growing concern for the way that science is being taught and the lack of interest in science careers brought about the implementation of the 5E Science Model. The 5E Learning Cycle, first created by Robert Karplus in the late 1950s and early 1960s, has been regarded as a general philosophy of teaching and learning with strong constructivist foundations (Lui et al., 2009). The 5E model and inquiry-based learning go hand in hand. Inquiry-based science instructions enhance students understanding and help them develop critical thinking skills (Lui et al., 2009). These are necessary skills as the students enter secondary school years (Bybee et al., 2006). The explore phase of the 5E gives students the opportunity to do hands-on learning, explore questions, and participate in an investigation (Lui et al., 2009). Stamp and O'Brien (2015) stated that repeated exposure to 5E science lessons was found to have positive effects on science knowledge. Using this model to teach science could bring about significant changes to how science is taught and possibly raise test scores (Lui et al., 2009). The 5E approach does have obstacles; it can be difficult to implement this type of learning if there are limited resources with which students are able to work. Another obstacle of the 5E approach would be the inability for students to see phenomena and participate in experiments to further understanding of the skills taught.

Technology and Labs

Science education has been positively impacted by technology (Al-Balushi et al., 2015). Students are able to see phenomena they would not be exposed to in a traditional setting. Technology allows students to see experiments that would not be available otherwise or that would be too dangerous to do in the classroom setting. Hoppe and colleagues (2003) argued that incorporating technology into lessons positively affected a student's ability to gather, organize, and display information. Use of educational technology has the potential to close the gap in learning for schools that have limited or no science labs available.

Recent literature confirms the important role of experimentation in increasing students' active participation in the learning process, as well as helping students acquire skills and positive attitudes toward science (Al-Balushi et al., 2015). E-laboratories were developed to give students an interactive, lifelike learning experience. E-laboratories offer simulation services from concept to analysis, test planning, and real experiments over the internet. The benefits of using an E-lab include substitution of traditional labs, provide students with opportunities to do experiments that they would not be able to do, and students have an advantage of seeing phenomena that they would not otherwise be able to see (Al-Balushi et al., 2015). E-labs offer implementation of difficult and dangerous experiments through simulations (Al-Balushi et al., 2016). However, there are obstacles as well. The software programs require computers with internet access. Most rural areas are not equipped with a reliable internet source or have no internet connection at all.

Mobile laboratories are another example of using technology to aid in science education. Mobile laboratories are laboratories that are fully housed within or transported by a vehicle. These laboratories are housed in a trailer, bus or RV. The Science Adventure Lab, Seattle Children's Research Institute's (SCRI) mobile laboratory program was launched in 2009 (Roden et al., 2018). The focus was on elementary and secondary students who had no access to science laboratories. The program was designed to prioritize visiting Title I-eligible schools, rural schools, and schools with high percentages of students receiving free or reduced price lunch (FRPL; Roden et al., 2018). Roden et al. (2018) described their mobile laboratory, operating model, and curriculum, as well as the positive impacts, strengths, and challenges of the approach as a resource for other groups who may wish to use a similar strategy for STEM education outreach. They determined that a mobile laboratory would best suit their needs to meeting their goals for STEM. The program was offered to qualifying schools with no charge. The mobile lab was built on a bus and designed to represent a functional laboratory. The Science Adventure Lab program has successfully enriched science education at low-resource schools by providing engaging, hands-on learning opportunities to diverse populations in both urban and rural locations (Roden et al., 2018). A laboratory of this design would solve monetary issues but money to purchase and build it would have to come from grants or from government funds.

Liu et al. (2009) explored three major purposes including designing mobile natural-science learning activities that rest on the 5E Learning Cycle, examining the effects of these learning activities on students' performance, and exploring students' perceptions toward these learning activities. A case study method was used with 46 students selected. The significance of the study lie in its collaborative efforts, from the research team and the schoolteachers, to develop mobile natural-science learning environments and activities that were based on instructional needs as well as on an integration of mobile technology and the 5E Learning Cycle (Lui et al., 2009). The results indicated that the learning activities enhanced students' scientific performances, including both knowledge and understanding levels (Liu et al., 2009). Observation and manipulation were two factors that contributed to these positive results. Although the results had positive effects, there were some limitations of using a mobile learning environment. Technical stability could have a negative influence as well as lack of material used for observations. Conclusions found that the potential of mobile computing would impact student learning in a positive way.

Solutions

The research indicated that there was a positive influence on student learning when science laboratories are implemented on a regular basis. There are solutions and strategies that can be put into place to compensate for lack of resources and laboratories to teach science. However, there are teachers who are unwilling to come up with alternative resources or have no interest in doing so. Avery (2013) stated that rural contexts could be rich environments for learning science. Teachers have access to a variety of places in the rural community that could be used for teaching science. The outdoors can become the science laboratory by using the wooded areas, creeks, streams, and fields. Rural communities face many challenges including low school funding and absence of technology. Additionally, access to educational opportunities offered by science organizations, colleges, and corporations is generally limited (Avery, 2013). Most students lacked exposure to STEM or careers related to STEM. Teachers and students in rural schools would benefit from using what they have right outside their classroom doors. By using what is available in the surrounding environment, teachers are engaging students and making a connection to their community. These types of learning would help students sustain their environment.

The available literature on the impact of science laboratories seemed to be limited to secondary and high schools. However, research depicts that in urban schools where science laboratories were comparatively better equipped and theory and practical work was being done in some schools showed better performance on the achievement test (Niazi et al., 2018). There are gaps in literature pertaining to elementary school students and the effect that labs have on their learning. This is a concern due to the fact that a significant amount of learning is done in the early years. The early years of one’s life are the time when most career choices are decided. STEM and STEM-related careers play a major role in education and decisions about college, without the interest of science, there is little chance that these students would pursue a career in science. While there has been some progress in science education in the United States, according to the 2015 National Assessment of Educational Progress (NAEP) only one-third of students have the skills they need to be adequately prepared for college-level science classes and for a career in STEM (U.S. Department of Education, 2016).

In another study, Diaconu et al. (2012) described a constructivist science lab program that provided professional development training to elementary school science teachers from high-needs urban school districts in Houston, Texas. This study examined the impact of the teacher professional development program on teachers’ science content knowledge, use of inquiry-based teaching practices and leadership skills. The program used the 5E Model as the basis for lesson plans. Teachers attended the program for a year, participated in labs, kept journals for reflections and digital portfolios. They took what they learned back to the classroom to use with their students then; they would share student work with other teachers in the program. In the four years of the program, teachers who received the training showed a significant increase in their science content knowledge between pre- and post-tests on all science topics tested, i.e. Earth Science, Physical Science and Life Sciences content tests (Diaconu, 2012). Teachers stated that they also learned the importance of the content and how to teach the standards correctly. Self-reported teacher survey data on teaching practices from several instruments consistently demonstrate significant positive changes from pre to post-intervention scores (Diaconu, 2012).

Gaps in Literature

Although most research showed that there is a negative influence on learning for students that have little or no access to science labs, the studies did not track students over a period of time. It is important to know what the trend of science learning would be over a period of years. It would be interesting to see how much of a difference would be in the data from one year to the next or from elementary school to secondary school in order to see how much learning is lost. The research did not give periods for how often or how long the science labs would be incorporated. The funding needed for resources and labs would depend on the amount of time allocated to labs as far as how much material would be needed. The formation of small groups would also be important as far as the amount of materials needed. The research was lacking in overall geographical locations. Much of the research found was from other countries. There was little research done in the United States. The research is lacking generalizable data in these areas.

Current Study

The current study was done using a meta-analysis of data collected in an investigation of the influence of limited science labs and quality materials in classrooms on student achievement. Data was gathered from a group of students from a secondary school in Nigeria and from a different group of students in another secondary school in Nigeria. The data would give significance on the long-term outcome of using science labs. This study provided data from different geographical locations, close to one another, to find out if there was a difference in learning outcomes. The study also looked at the number of science labs that were used to see if that variable affected the overall scores of students. Science education would benefit from more research especially in the area of academic achievement. Further research could possibly improve careers in science that are suffering due to the fact that students are not interested or prepared to pursue careers in the field.

Chapter III

Methods

The purpose of the study was to compare data to see if there was an influence on student achievement on science tests and the school's ability to provide science labs and materials. A meta-analysis was conducted between two studies, the first from Ondo State, Nigeria and the second from Taraba State, Nigeria. The study also examined differences in schools having more than one laboratory and the differences in learning from a school with one, two or three laboratories. According to research, there is a positive correlation between the use of science laboratories and science assessment scores. Jones et.al, (2018) stated that urban areas had higher test scores than rural areas. Limited resources for science experiments and lack of science laboratories seem to be the common factor of low-test scores in rural areas (Jones, et.al, 2018). Adeyemi (2008) research examined science laboratories from secondary schools in Ondo State, Nigeria. A descriptive survey design was utilized in this case study. The second study conducted by Jebson and Moses (2012), investigated the relationship between learning resources and student academic achievement in Taraba State Secondary Schools. An ex-post facto research design was used in the study.

Participants

The study population in Ondo State was comprised of all the 257 secondary schools that presented candidates for the year 2003 senior secondary Certificate examinations in the State (Adeyemi, 2008). The sample consisted of 168 secondary schools (65% of the population) drawn randomly from the study population (Adeyemi, 2008). The stratified random sampling technique was applied in the selection of the sample while variables such as school-location and school-sex were considered in the selection of the sample (Adeyemi, 2008).

The study population in Taraba State was comprised of all 19 secondary schools in the three geopolitical zones of Taraba State (Jebson & Moses, 2012). The sample consisted of six secondary schools, purposively sampled for use in the study (Jebson & Moses, 2012).

Instrumentation

An inventory was used to collect data for the Ondo State study. The inventory requested among other things data on enrollment figures, number of science laboratories in each school and grades obtained by students in physics, chemistry and biology in the 2003 SSC examinations in the State (Adeyemi, 2008). The validity of the inventory was made by experts who examined each item of the inventory to determine whether the instrument actually measured what it was supposed to measure (Adeyemi, 2008). The data was analyzed using a One-way (ANOVA). Semi-structured interviews were conducted with 20 principals and 20 education officers randomly sampled. Responses to their questions were analyzed with the content analyses technique.

Three sets of instruments were used in the Taraba State study, namely**;** Bio-data for Science Teachers, Science laboratory equipment inventory checklist for three science laboratories head of departments, and Student's Academic Achievement Scores (Jebson & Moses, 2012). The three instruments were vetted and validated by the researchers and experts in the three science subjects (Jebson & Moses, 2012). The researchers administered and collected the questionnaires and students' achievement scores were extracted from Education Resources center of Taraba State Ministry of Education (Jebson & Moses, 2012). The data were analyzed using the Pearson's Product Moment Correlation Coefficient and the *t*-test of independence (Jebson & Moses, 2012).

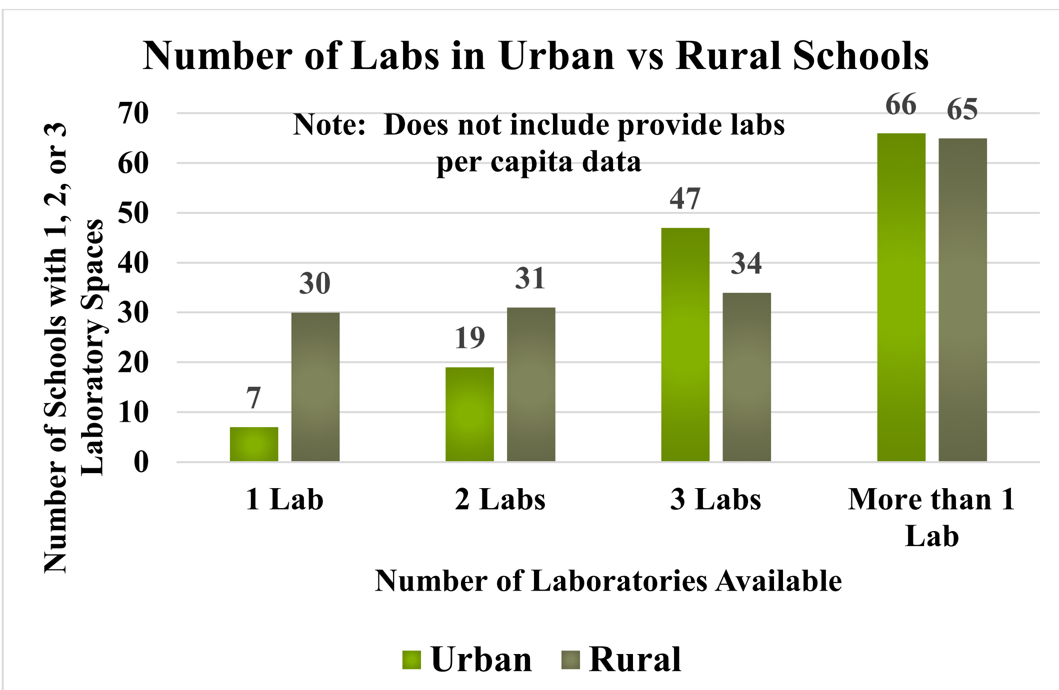
Chapter IV

Results

The first research question in the Ondo State study wanted to know to what extent science scores on standardized assessments among secondary schools in Ondo State, Nigeria varied between schools equipped with one, two or three laboratory spaces (Adeyemi, 2008). The schools were classified into three groups. Group 1 consisted of schools with one laboratory, group 2 consisted of schools with two laboratories, and group 3 consisted of three laboratories. Results concluded that schools having three science laboratories were in larger number in urban areas whereas schools having less than three science laboratories were more in the rural areas (Adeyemi, 2008). Results are shown in Figure 1.

Figure 1

Number of Labs in Urban vs Rural Schools in Ondo State, Nigeria



Note. The table shows that schools having three science laboratories were in larger number in urban areas whereas schools having less than three science laboratories were more in the rural areas.

The second research question in the Ondo State study wanted to know the performance level of students in physics, chemistry and biology in the SSC examinations in secondary schools in Ondo State, Nigeria. Performance was computed through the frequency counts of the number of students who obtained credit grades 1 to 6 in each subject in the examinations were transformed from discrete data into continuous data through secondary analysis (Adeyemi, 2008). Performance level of the schools was low. Results are shown in Table 1.

Table 1

ANOVA findings on students' performance on SSC examinations in Ondo State, Nigeria

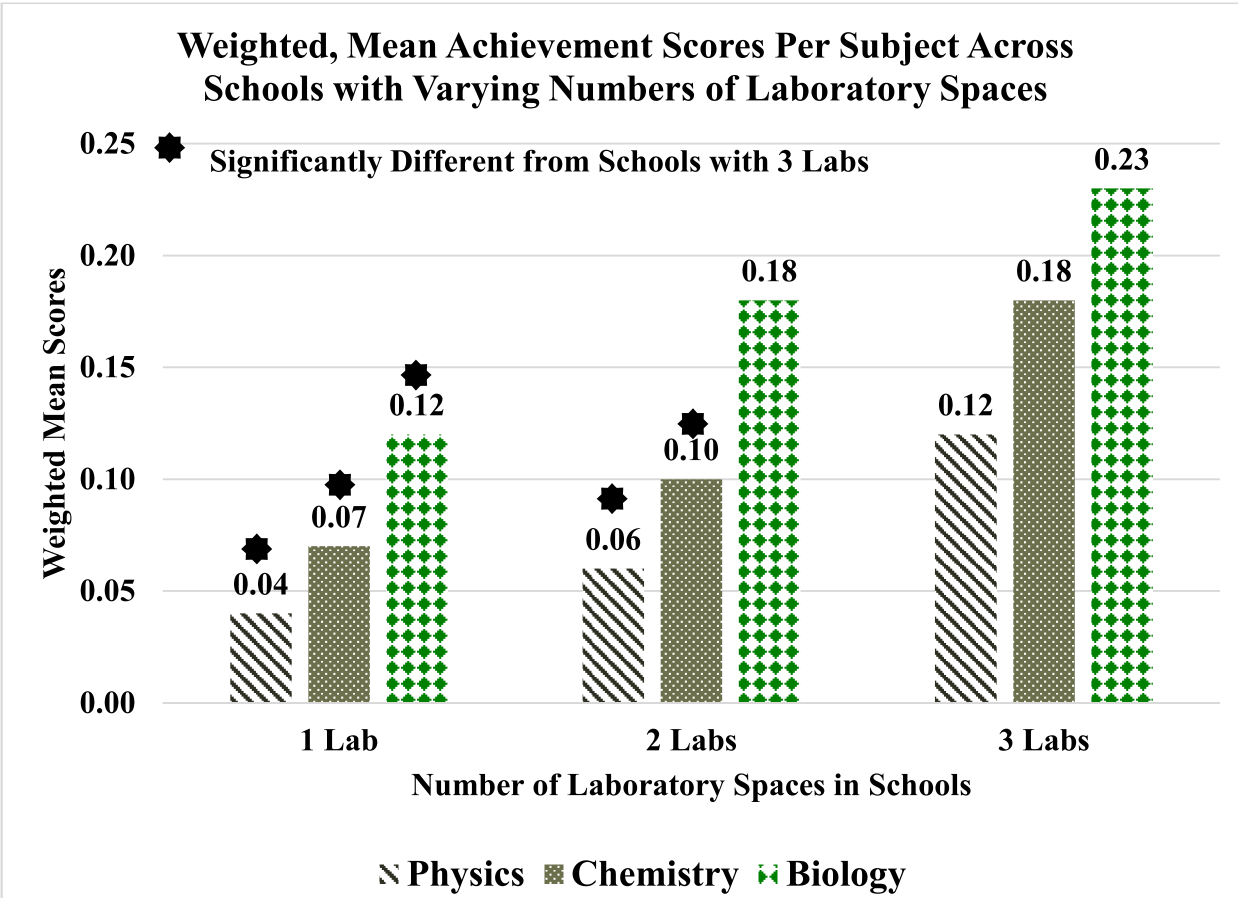
	Mean for Groups			SD for Groups			Sum of Squares		Mean Square				
							SSb	SSw	MSb	MSw	F ratio	F prob	Decision
Subjects	1	2	3	1	2	3							
Physics	0.04	0.06	0.12	0.05	0.07	0.13	0.37	7.52	0.19	0.03	8.42	0.01	Significant
Chemistry	0.07	0.10	0.18	0.08	0.11	0.19	0.69	11.8	0.31	0.03	9.51	0.01	
Biology	0.12	0.19	0.23	0.13	0.19	0.22	0.44	9.47	0.23	0.02	7.83	0.00	

*N for Group 1= 37; N for Group 2 = 50; N for Group 3 = 81 *df = 2
Note. Performance levels were low and almost the same in all subjects.

The third research question in the Ondo State study wanted to know if there was an influence on the number of science laboratories on the quality of output in the secondary schools. The hypothesis raised: There was no significance in the quality of output between schools having laboratories in the subject areas and between schools having less than three laboratories in the subject areas. To test the hypothesis the quality of output was measured by exam performance. Results showed a significant difference in the quality of output based on the three groups with different numbers of labs, although the *F*-test did not show where the differences were located among the groups (Adeyemi, 2008). Results showed a significant difference in the quality of output based on the number of labs as shown in Figure 2.

Figure 2

Weighted, Mean Achievement Scores per Subject across Schools with Varying Numbers of Laboratory Spaces



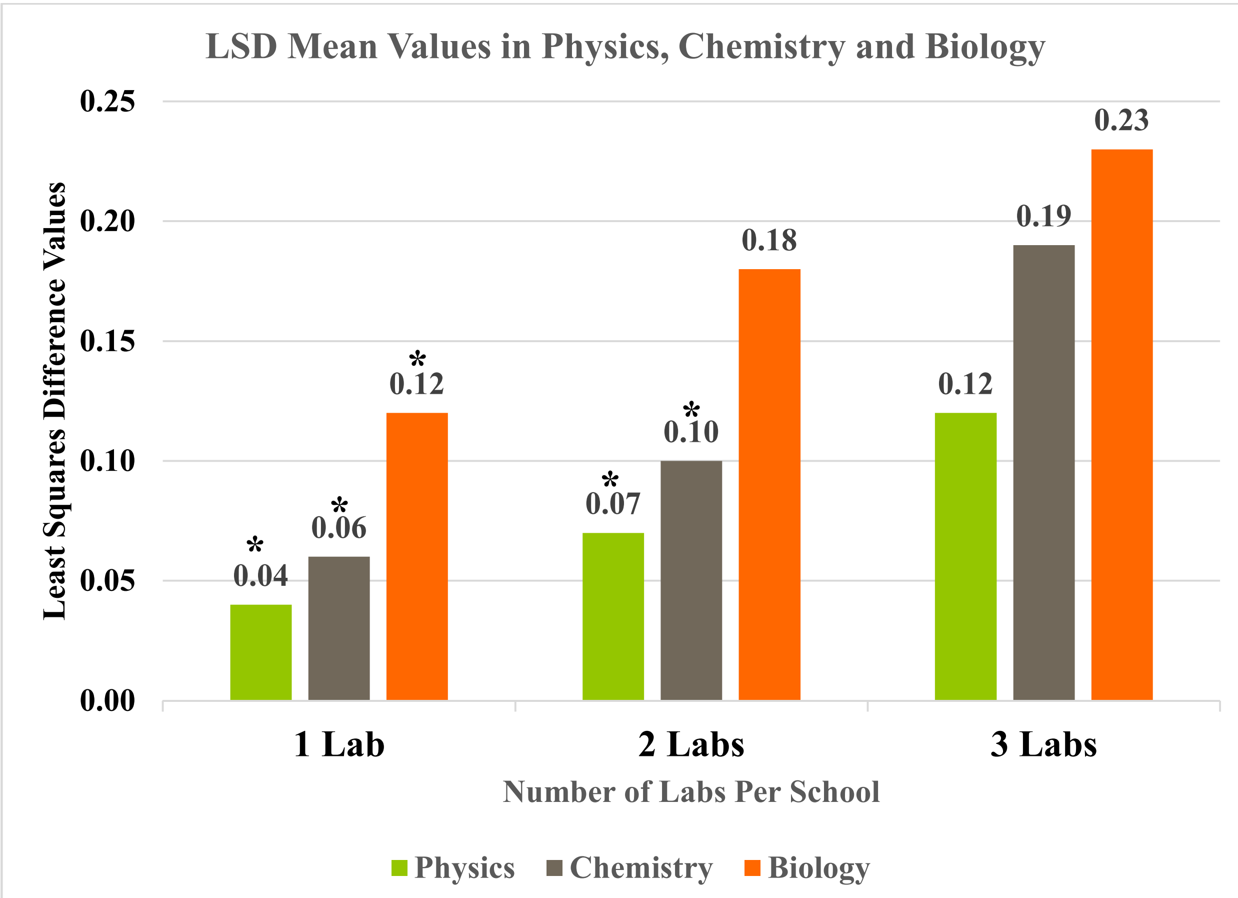
Note. *Significantly different from schools with 3 labs.

In order to identify the between-group difference, the Least Significant Difference (LSD) test, which is a post hoc test, was conducted (Adeyemi, 2008). In Figure 3, the mean value for each group increased uniformly for each subject as the mean values increased in the group (Adeyemi, 2008). The difference between the groups was statistically significant. Thus, students of schools in-group 3 with three science laboratories had better performance than students of schools in-group 2 with two laboratories and students of schools in-group 1 with one science laboratory (Adeyemi, 2008). The findings also showed that quality of output in schools in-group

2 with two science laboratories was not significantly better than the quality of output in schools in-group 1 with one science laboratory in any of the subjects. Results are shown in Figure 3.

Figure 3

LSD findings indicating mean values in physics, chemistry and biology



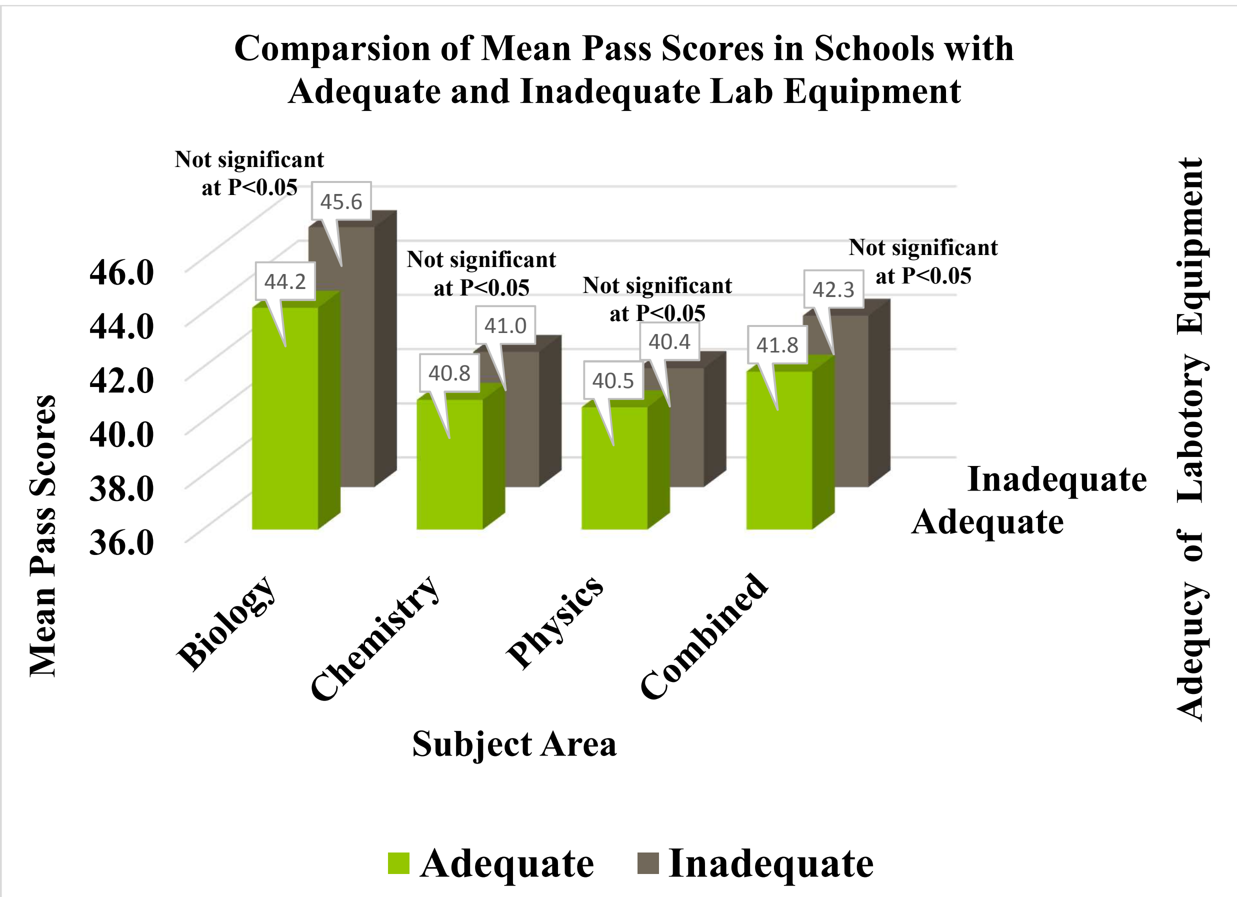
* Indicates significant differences.

The first question in the Taraba State research wanted to know the relationship of qualified teachers to student's academic achievement. Results concluded that there was no significant relationship between the availability of qualified biology and qualified physics teachers and students' academic achievement in biology and physics (Jebson & Moses, 2012). There was a significant relationship between availability of qualified chemistry teachers and students' academic achievement in chemistry (Jebson & Moses, 2012).

The second question in the Taraba State research wanted to know the relationship between adequacy of laboratory equipment and student's academic achievement. Results concluded that there was not a significant relationship between adequacy of biology and chemistry laboratory equipment's and students' academic achievement in biology and chemistry (Jebson & Moses, 2012). There was no significant relationship between adequacy of physics laboratory equipment and students' academic achievement in physics (Jebson & Moses, 2012).

Figure 4

Comparison of Scores in Schools with Adequate and Inadequate Lab Equipment



Note. Not significant at the P<0.05.

Chapter V

Discussion

The Ondo State study tested the hypothesis on what differences exist among secondary students in science achievement tests in schools with one or more science labs. Based on the findings from data collected from the research, the hypothesis was supported. It was concluded there was a significant difference in the quality of output based on the number of labs. The study made no mention of the differences in population of students at each school and whether this was a contributing factor as to why a particular school had more than one lab. Socioeconomic status could have also been a contributing factor to the number of labs in a school; however, there was no mention of this in the study either. Adeyemi (2008) suggested that many of the students might not have been exposed to the science labs. The study does suggest, as stated by the principals, that much of the lab equipment was unserviceable (Adeyemi, 2008). No information was given as to the reasoning in the number of laboratories in each of the schools or to what extent they were used in the study. Population, socioeconomic status, and the extent to which the labs were used would be variables that could possibly influence the results in the study.

The Taraba State study tested the hypothesis in what differences exist among secondary students in science achievement tests among those schools with varying stocks of quality laboratory materials. The research stated the adequacy of science laboratory equipment did not have any significant effect on students' performance in science. However, the Taraba State study found that most of the schools lacked qualified science teachers. The study concluded that the availability of qualified teachers had no effect on student achievement. Future research is needed to determine if the labs in question were utilized with students that were being taught by qualified teachers or teachers that were not qualified. This could influence the performance of students on science assessments.

The results from the studies contradict each other as well as the Federal Government of Nigeria. This is interesting since they were conducted in the same country. Jebson and Moses (2012) stated the Federal Government of Nigeria had taken measures in the previous years to improve and promote the study of science, technology, and mathematics in the country. However, science educations at all levels in Nigeria were almost at a deplorable state, especially in Taraba State (Jebson and Moses, 2012). A key question would be the measures that the Government had taken to improve science and why it is not working.

The present study started with the premise that student achievement is low in rural areas that lack adequate science laboratories and resources. After consideration of the meta-analysis, the studies suggest that a lack of laboratories and resources are not the primary contributing factors to low student achievement. The unexpected result can be interpreted in several ways. It may be that there is no link between science achievement scores and laboratories. Alternately, it may be that the focus on secondary schools limited the generalizability of the results. Another possible factor is the amount of time dedicated to science lab activities. Students do not benefit from the labs if they are not exposed to them on a regular basis. Lastly, the lack of good textbooks and teacher training could also be a contributing factor. Textbooks are not sequenced with lessons that align with standards and curriculum maps. Science textbooks are aimed at a mass market and so try to cover a little bit of everything in each grade, they are neither conceptually nor developmentally appropriate in terms of covering the concepts, relative to the National Science Education Standards (NAS 1995) recommendations and research (Stamp & O'Brien, 2005). Lack of teacher training and professional development were factors in student success. A background in science could be a factor in students' success on test scores. Teachers are not confident teaching the curriculum due to lack of appropriate training. Some may feel the stress to score high on assessments in reading and math so they may tend to spend less time teaching science. Stamp and O'Brien (2005) suggested graduate teaching fellows can provide up-to-date scientific information and engaging activities to develop concepts, habits, and skills necessary for future work in science. Graduate teaching fellows are graduate students who are training as research scientists. The National Science Foundation (NSF) Graduate Teaching Fellows in K-12 Education (GK-12) program was designed to strengthen ties between K-12 and postsecondary education (Stamp & O'Brien, 2005). The graduate students were provided training and paired with teachers to help them with updated science information and strategies. In turn, the graduate students would be able to work on their communication skills. The teaching fellows would help teachers with the implementation of the 5E Learning Cycle and during the summer the fellows would work on putting materials together for hands-on activities. However, both teachers and teaching fellows felt that their experience in science courses was heavily biased toward "knowing facts" but that the ideal would have been "understanding concepts" (Stamp & O'Brien, 2005, p. 73). This could be a solution in helping teachers with their confidence in teaching science.

There are alternative methods to implementing experiments where science labs are not readily available in rural communities. Rural communities have access to the biggest science laboratory outside the back door of the school. Creeks, ponds, forests, and fields can offer an abundance of scientific information and ability to incorporate experiments for students. A bucket of water from the local pond has an abundance of possibilities for learning. A forest could be used as a living lab for learning about habitats. These methods could help close the gap in learning with regard to the lack of science labs. However, in order for these methods to be successful, they have to be incorporated into science lessons. Research suggests that teachers lack the background and knowledge to teach science successfully. Without training, teachers may not be able to use these alternative methods.

The Federal Government could assist in funding for science laboratories and supplies. E-laboratories and the outside environment could be implemented to compensate for the lack of proper laboratories if funding could not be procured. However, E-laboratories pose a challenge in rural areas where technology is not readily available or is unstable. A solution for adequate internet access in rural communities would need to be attained in order to have accessible and reliable technology.

Chapter VI

Conclusion

Based on the findings of this study, science laboratories were one variable for student success, however, there were other variables as well in determining the quality of output from secondary schools (Ademeyi, 2008). Laboratories are of no use if they are not utilized and implemented correctly. Without appropriate training, teachers may not know how to teach science with the absence of labs and materials.

Suggestions for Future Research

More research on the use of science labs and materials is needed to determine if they are a factor for low test scores. There is little research done on the long-term effects from a lack of science laboratories in the elementary schools. It is recommended that future research include schools within the United States as well. According to research, low student achievement in science is a problem all over the world. Research expanding over several years on the same students would also be beneficial to finding out if there is a positive or negative influence between laboratory use and student achievement.

Studies are needed to test the effect of teacher willingness to teach science and use laboratories to further advance student learning. Research could have a significantly different outcome with regard to student achievement if teachers are not willing, or do not have the knowledge to implement labs efficiently and consistently.

It is recommended that the following be included in future meta-analyses: (a) United States studies; (b) elementary school studies; (c) studies dealing with motivation in science students and teachers; and (d) studies dealing with science teacher professional development.

Test scores are low in the United States and further research could possibly help find the variables that are contributing to the low scores. Education would benefit from further research not only in the United States but also at the elementary grade level. This study used information from secondary schools in Nigeria that have low test scores. The United States also has low test scores which suggest that there is a similar problem throughout the world. Low test scores are a concern but the lack of student's interest in pursuing careers in science careers is also a cause for concern. Could the low test scores be a contributing factor for the lack of interest in science careers? Future research could help fill the gap in learning and raise test scores which could in turn raise interest in students pursuing careers in science, particularly STEM related careers.

Research suggests that students start deciding on future careers in the elementary grades. Future research at the elementary level could give insight as to why students are not interested in the science careers. What is the reason and could something be done to raise students' interest? Could science labs motivate students' and engage them in learning? Research suggests that hands-on activities and experiments play a crucial role in learning.

Finally, teachers are an important part of the learning process. Without qualified science teachers, are students learning what they need to with regard to science? What solutions are needed to make sure that science is not only being taught but being taught correctly?

The topic of this research was the influences of laboratory space and quality on student success in rural and suburban schools. Through analysis and reflection, it has been determined that laboratories and materials are one possible influence on student achievement. However, there are other factors that have more significance. Teacher effectiveness seems to be one important contributing factor. Why are teachers unwilling to teach science? Why is science not being taught efficiently? There are many unanswered questions that warrant future research to help fill the gap in science learning.

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