DNA Learning Center Nigeria

BATOSCIN 2022 FINAL REPORT

FINAL REPORT OF THE BACK TO SCIENCE INITIATIVE, FUNDED BY THE US CONSULATE, LAGOS

an innovative STEM immersion experience for secondary school students in Nigeria

Prepared for:

DNA Learning Center Nigeria &

United States Consulate, Lagos, Nigeria

Prepared by External Evaluator:

Politeuma Group Insights

Dr. Chimdimnma Esimai, Lead Evaluator

Program Details

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Acknowledgements

BATOSCIN Program Acknowledgements

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We cannot forget to thank BATOSCIN's biggest cheerleader, Vice Chancellor of Godfrey Okoye University, Rev. Fr. Professor Christian Anieke for his benevolence and support to ensure that the DNA Learning Center Nigeria remains fully functional, always.

To the secondary school teachers and students that sacrificed much to champion STEM excellence at your institutions through participation in BATOSCIN, we say thank you for being with us. Finally, we thank the amazing staff of DNALC Nigeria for the work they have done to make BATOSCIN a highly successful and impactful program. We look forward to expanding the BATOSCIN project to other secondary schools in Enugu State and other states in Nigeria.

Mr. Michael Okoro (M.Sc.)
BATOSCIN Program Coordinator

on behalf of
the entire BATOSCIN Project Team

Executive Summary

BATOSCIN Overview

The Back-to-Science Initiative, BATOSCIN, is an innovative capacity-building project in STEM research through inquiry based learning and hands-on laboratory experiments for secondary school students in Nigeria, funded by the United States Consulate, hosted by the DNA Learning Center in Nigeria, and in partnership with Godfrey Okoye University (GOU) in Enugu State. The program was funded in August 2021 for DNALC Nigeria to train an initial 160 senior secondary students and 16 Science teachers from eight (8) schools in Enugu State in DNA Barcoding.

BATOSCIN targets specific students from selected educational zones in Enugu State for training in DNA Barcoding research to ensure skillset acquisition at the end of a curated three-day workshop. In addition, these students contributed to an ongoing global collaborating research project in three separate research streams, namely the barcoding of ants, the barcoding of medicinal plants, and the barcoding of invasive plant species. By the end of this rigorous workshop, student outcomes and mastery in the following skills related to DNA Science and Genomics include:

- Sample Collection and Metadata Annotation
- Sample documentation and In-Situ photography (annotation of metadata)
- DNA Extraction and Isolation
- Polymerase Chain Reaction
- Gel Electrophoresis
- Next Generation Sequencing
- Data analysis through DNA Subway
- Sequence Alignment and BLAST Searches through global biodiversity databases
- Basic Bioinformatics analyses
- Phylogenetic Studies

BATOSCIN commenced in November 2021 with the 'Train the Teachers' program, a one- week training for 28 secondary school teachers from 6 educational zones in Enugu State on DNA Barcoding techniques. By the conclusion of BATOSCIN, DNA Learning Center Nigeria trained and certified 200 students from 10 schools, reporting gains in their perceptions of science and in hands-on research skills learned through the program.

Executive Summary

Data

As part of DNALC's commitment to science education in Nigeria, the BATOSCIN program supports equity in science, technology, engineering, and mathematics (STEM) by offering secondary school students an opportunity to gain experience about emerging technologies in the field of molecular biology and bioinformatics.

DNALC Nigeria contracted with Politeuma Group Insights and lead evaluator Dr. Chimdimnma Esimai to evaluate the program with three major purposes:

- Provide descriptive information related to BATOSCIN's goals on the demographics, STEM background, STEM preparedness, and career interests of BATOSCIN trainees.
- Provide rigorous evidence of the impact of the BATOSCIN Program on trainees' educational aspirations, career preparations, and hands-on skills acquisition.
- Provide recommendations for the future framework of how BATOSCIN can accelerate the acquisition of hands-on skills acquisition, enhance STEM preparedness for the future workforce, catalyze the implementation of STEM initiatives in Nigerian secondary schools in Nigeria, and provide additional critical support for STEM learning.

Politeuma Group Insights designed a multifaceted and comprehensive evaluation of the BATOSCIN program from trainees, teachers, and provided exhaustive recommendations for the effective implementation of each cycle. Politeuma Group Insights provided oversight during all phases of the program planning and implementation. The BATOSCIN Program Planning Committee consulted with the government's secondary schools regulatory board – the Post Primary Schools Management Board – to streamline the selection guidelines. DNALC Nigeria then conducted in-person and telephone interviews with institutional representatives to identify candidate schools, conducted site visits to several schools in Enugu State, and collaborated with appointed secondary school teachers to identify program participants. At each stage of the process, careful design criteria helped streamline the selection criteria.

This evaluation team organized this performance progress report around the following research questions that were designed to address the three purposes of the study:

1. What is the impact of BATOSCIN on student attitudes to STEM and science?

2. What is the impact of BATOSCIN on the understanding of molecular biology techniques and hands-on research skills acquisition?
3. What is the potential impact of the BATOSCIN Program on the current framework for science education in Nigerian secondary schools?

Estimates of impact for these research questions derive from student and teacher surveys, interviews, videos, social media, and personal narratives. This report presents student data with respect to their attitudes towards science and STEM, perceptions of the research modules, skills gained from participation in the program, future career/educational trajectories, and the importance of STEM participation based on student backgrounds. These research questions address BATOSCIN Program goals as well as the strategic goals of the United States of America to influence the local economy and workforce in positive and tangible ways and to enhance educational access and equity in the region.

Telephone Interviews with Institutional Representatives

Initial evaluation of candidate schools began with a survey analysis of the 292 government secondary schools Enugu State under authority of the state-mandated Post Primary Schools Management Board (PPSMB), and from the six educational zones in Enugu State. Eight (8) schools were identified after an aggressive marketing and publicity campaign (radio spots, flier publicity, and more). The BATOSCIN team called the principals from several schools in Agbani, Awgwu, Enugu, Nsukka, Obollo-Afor, and Udi and extended the invitation for their schools to participate. A requirement for participation was the commitment of institutional support for the expansion of STEM initiatives to build on the skills acquired by the STEM teachers and trainees following the completion of the BATOSCIN Program.

Site Visits to Institutions

The BATOSCIN team weighed institutional interest against several factors, with high priority given to the school's commitment of support to STEM programming after the end of the BATOSCIN Program. Additional institutional factors included the gender distribution of students, current capacity for laboratory research, quality of teachers, and proximity to the DNALC Nigeria facility. The BATOSCIN team conducted multiple site visits to candidate schools

to explain the goals and priorities of the BATOSCIN Program, to highlight the partnership and support of the United States Consulate, and to evaluate the viability of each institution's participation in the program. Emphasis was given to selecting the right teachers from the schools to spearhead the trainee selection and to champion student engagement and skills acquisition during the program. Faculty were selected on the strength of their STEM background, their willingness to engage in STEM research, professional development, and future career plans. Two faculty per school were selected for BATOSCIN.

Selection of Student Trainees

Faculty participants and school principals provided evidence of performance of the students. The BATOSCIN Planning Team asked teachers to identify promising students who showed promise for additional instructional activities. BATOSCIN paid careful attention to the distribution of female students and male students in the selected cohort, socioeconomic background, family background and STEM preparedness, ensuring equity and access for all students. Twenty students per school from among eight schools (6 public schools and 2 private schools as standards for comparative analysis) completed the initial cohort. BATOSCIN included two additional adjunct schools to elucidate possible differences in learning curves.

Methods

The evaluation team employed different analytical methods to address the research questions.

Pre- and Post-Surveys. To address research question 1 and research question 2, teachers and students were told upon selection that they would participate in surveys to gauge the impact of the BATOSCIN program. Upon arrival at the DNALC Nigeria facility and after a brief introduction to the goals and objectives of the program, the BATOSCIN team administered a pre-survey asking questions about their prior STEM experiences, their level of expertise in the specific hands-on skills utilized in molecular biology research, and general understanding of the research process (Lopato 2008). At the end of BATOSCIN, the evaluation team administered a post-survey with comparable questions, to gauge any changes or gains in attitudes to STEM and hands-on skills acquisition. BATOSCIN program also asked students what their favorite part of the day was and what was most difficult for them, conceptually

and in practice. The daily feedback was used to guide instruction the next day and to make sure each person received adequate attention from the Teaching Team leads and interns. As additional process control, each survey participant was given a unique identifier generated from a random number generator to track individual pre- and post-survey responses.

Impact Analysis and Benchmarking. Though the study did not compare attitudes in STEM against a control non-BATOSCIN group, a large majority (~ 94%) report no prior STEM experience such as the BATOSCIN program, making the cohort of trainees chosen an important data set for future benchmarking. National data and regional data, however, can provide appropriate benchmarks to highlight the important gains of participation in STEM activities such as BATOSCIN. The strength of BATOSCIN lies in its immersive experience, where students undertake a top-notch research project in the span of days, engaging in the entire research process and analyzing study results. It will be important to track the trainees of the program to contextualize the impact of the skills they acquired, and the impact their changed STEM perceptions have on their future career trajectories and self-actualization.

Qualitative Analysis. The BATOSCIN team and the evaluation team employed several mixed methods to gain a true understanding of the program's impact, including teacher interviews, student interviews, video recordings of the teaching session, Opening Ceremony and Closing Ceremony videos, and feedback from BATOSCIN instructors, partners, and sponsors. Taken together, these additional qualitative measures highlight the impact of BATOSCIN in providing a framework for building capacity for STEM research for secondary school students in Nigeria.

Summary of Main Findings

The main questions that guided program evaluation provide organization for the key findings.

1. What is the impact of the BATOSCIN Program on student attitudes to STEM?

   Participation in the BATOSCIN program affected student attitudes in several ways. Trainees reported large gains in understanding science better, in understanding how scientists work on real problems, and in their self-confidence. The impact analysis showed that students enjoyed the program thoroughly and wanted a repetition of a

similar program. Teachers were grateful for the program and thought that skills building enhanced their capacity for impact in teaching and learning.

2. What is the impact of the BATOSCIN Program on the understanding of molecular biology techniques and hands-on research skills acquisition?

   Participation in the BATOSCIN program improved the research skills acquisition of the students and teachers in several ways. In addition to the positive gains in attitudes towards STEM, trainees reported large gains in understanding laboratory techniques, in understanding how scientists think, working independently, and interpreting results. Gains in understanding ethical conduct in research was a critical metric demonstrated by the research study. Overall, trainees reported a greater understanding of the research process and molecular biology and basic bioinformatics analysis techniques.

3. What is the potential impact of the BATOSCIN Program on the current framework for science education in Nigerian secondary schools?

   The greatest gain reported through participation in the BATOSCIN program was the clarification of future careers and the belonging to a learning community. Students reported changes in their choice of career path, focusing more on STEM careers and towards research-intensive programs of study. Overall, all stakeholders report consensus opinion that BATOSCIN provides a viable framework for increasing STEM research capacity and accelerates hands-on skills acquisition for teachers and student trainees alike. BATOSCIN is a critical model for enhancing proficiency in novel molecular biology techniques and concepts to the educational system in Nigeria.

Recommendations

Recommendations for maximizing BATOSCIN's impact for future cohorts include:

Create a BATOSCIN network and strengthen the link between BATOSCIN's programs and secondary school curriculum innovation. Survey results evidence corroborate the undisputed impact of BATOSCIN for student/faculty trainees and institutions. All stakeholders requested

Executive Summary

BATOSCIN camps be held throughout the year. Faculty members cited BATOSCIN for renewed inspiration and the need for additional training to meet the 21st-centudy demands of STEM education. Results show similar trends among student trainees, with more students leaning towards STEM careers and research-intensive careers after participation in BATOSCIN. One area for future innovation is BATOSCIN's potential in informing STEM curriculum and incorporating research competencies within Nigerian secondary school science curriculum development. At the very least, the potential for regional impact in STEM distinction is clear through institutional partnerships with BATOSCIN and with the DNALC Nigeria.

Provide additional institutional and teacher support throughout the academic year. Many participants undertook BATOSCIN as their first STEM experience. Many faculty members as learned the innovative techniques featured in the program for the first time. Continuous research support is needed to reinforce the concepts and the skills that trainees and teachers acquired. This additional support can be passive, such as monthly virtual calls, or more active such as refresher trainings and continuous analysis and skills-learning.

Amend the BATOSCIN research immersion experience model to address infrastructure concerns. The current resource model for transporting trainees to and from schools limits the maximum impact for BATOSCIN. An optimal solution would be to house program participants close to DNALC or improve DNALC Nigeria's infrastructure to purchase buses, rather than moving participants daily and relying on the limited and expensive bus system currently used.

Consider how the BATOSCIN program can reach truly underserved populations to the greatest degree possible. Most trainees who completed the BATOSCIN program were female secondary school students with little or no prior STEM experience. One critical goal of the BATOSCIN program was equity and access for students who would not typically have avenues to undertake STEM research. The BATOSCIN team paid careful attention to the socioeconomic status of the students as well as the demographics of the school within the educational zone. For future iterations of the BATOSCIN, a systematic approach to continue to ensure that students of all backgrounds can benefit from the program. Additional considerations are secondary school grades (pick students who are doing well and not doing well), and students who may feel unqualified to undertake a STEM immersion experience.

Chapter 1

Chapter 1: Introduction and Project Aims

Established in 2011 from the high-impact collaborations between the DNA Learning Center New York, a subsidiary of Cold Spring Harbor Laboratory, and Bowie State University in Maryland, USA, and in partnership with Godfrey Okoye University, the DNA Learning Center was created to build capacity for STEM education and research by promoting inquiry-based learning and hands-on laboratory experiences. The overarching priority of the DNA Learning Center Nigeria is to prepare high school and university students, teachers, and families to benefit from modern genomics and biotechnology innovations in agricultural and medical research. DNALC Nigeria aims to prepare a new generation of highly skilled scientists as the future STEM workforce to support agricultural, medical, and scientific advancement.

This task of enhancing the capacity of Nigerian schools by building student interest in molecular biology techniques was at the core of the BATOSCIN vision. Recent studies show continued decline in STEM student enrollment in Nigerian colleges, and resource deprivation is a major contributing factor (Aina and Ayodele, 2018). Lack of teacher training, lack of laboratory equipment, and limited educational resources have led to high attrition and loss of interest among students in STEM fields/careers. BATOSCIN aimed to address this crisis directly by providing a highly hands-on platform for educational engagement.

Born from a need to galvanize STEM teaching and learning in the secondary school system, BATOSCIN recruited secondary school students and teachers from selected schools in Enugu State's educational zones and trained them on cutting-edge molecular biology techniques. Financial burden for families (most of whom come from civil service or small business backgrounds) means that most can barely afford tuition and fees, and certainly cannot afford advanced science workshops such as those offered by the DNA Learning Center Nigeria. During regular school site visits as well through prior workshops, BATOSCIN identified a key opportunity to remove barriers to STEM research by giving students a platform to learn.

Specifically, all BATOSCIN trainees engaged in one of three unique DNA Barcoding projects to ensure skillset acquisition at the end of the three-day training. Of note, each of these research projects are active, global research studies to which Nigerian students contributed.

Chapter 1

Exhibit 1.1 Specific Outcomes of BATOSCIN's Molecular Biology Immersion

Program Outcomes from BATOSCIN Molecular Biology Immersion Program		
Skills Outcomes	***Development Outcomes***	***Research Outcomes***
Sample Collection, Metadata Annotation, Field Biology	Understanding what it means to be a future STEM professional	Identifying local habitats of species (plants, ants, etc.)
DNA Extraction/ Isolation	Gaining Research Experience	Barcoding of plants
Polymerase Chain Reaction	Gaining Research Confidence	Barcoding of ants
Gel Electrophoresis	Understanding Collaboration	Barcoding of invasive plants
Next Generation Sequencing	Improved STEM identity	Phylogenetic Analysis
Sequence Alignment and BLAST searches	Understanding STEM Career Options and Requirements	Identifying novel sequences and uploading to GenBank

The scientific objectives of the BATOSCIN Program are for selected students (and their teachers) to participate in and contribute to the following longitudinal research projects:

DNA Barcoding of Medicinal Plants. Medicinal plants are among Nigeria's richest bio-resources, collected from the wild by locals and becoming an important source of medicines as well as income for rural communities. However, not all species are clearly identified or cataloged, and there is a risk of overuse and possible extinction for rare species. DNA barcoding allows for fast and accurate identification of these medicinal plant species.

DNA Barcoding of Exotic & Invasive Plants. Invasive plants have aroused global attention for causing ecological damage and for impacting human health and national economies negatively. This research effort seeks to harness the power of DNA barcoding (a rapid, specific, and targeted approach for identifying unknown and known species) to map invasive species in selected regional sites. Long-term, this project hopes to inform farmers and government entities of best practices and to improve the efficiency of grazing land by reducing the invasion of non-native species.

DNA Barcoding of Ants in Nigeria. Despite their ubiquity, very little is known about ants. Almost none of Nigeria's ant species are represented in global species databases nor have published DNA barcodes. This research effort is a global collaboration between DNA Learning Centers to barcode/catalog ant species from around the world. This project is also significant because it showcases the feasibility of recruiting and training citizen scientists (such as secondary school students and teachers) to contribute to important scientific research.

Chapter 1

Review of the Previous Work by the DNA Learning Center

Like its parent organization (DNA Learning Center, New York), DNA Learning Center Nigeria aims to be the premiere center that trains the next generation of biological scientists to meet the growing demands for a technological workforce. To this end, DNALC Nigeria has hosted five signature professional courses, namely the World of DNA, DNA Science, Genome Science, DNA Barcoding, and DNA Barcoding. Upon request, it also hosts school lab field trips, science education outreaches, workshops and conferences for undergraduate students and professionals. Recently, DNALC has offered research opportunities to undergraduate students at Godfrey Okoye University (UREx) program, a framework championed by Dr. George Ude and Dr. Dave Micklos. Most of these opportunities have distinct focus on trainees who wish to gain greater mastery of concepts/skills, with great results. BATOSCIN is the first program of its kind that dedicates unique attention to building the STEM pipeline by targeting secondary school students. BATOSCIN is also unique because of its potential for implementation/scale.

Contributions of the Present Study

This present evaluation offers three main contributions to the current body of work for STEM research skills building. First, it seeks to provide evidence of the impact of BATOSCIN and its potential for changing student attitudes to STEM and in influencing future career pathways. Second, it provides tangible data on the gains in research skills acquisition for early STEM pipeline trainees. Lastly, this curated study provides validity of the BATOSCIN model in teaching hands-on skills for molecular biology to those who may not have had prior research knowledge or who may not have been advantaged to enroll in such programs. Thus, it is useful as a future framework for building capacity in STEM education in Enugu State.

Study Limitations

The BATOSCIN project aims have great scientific merit. Due to the defined scope of the project, trainees only experienced the immersive BATOSCIN program for 3 days before departure. Long-term monitoring of the future success of trainees, as well as their persistence in STEM would be ideal, as would comparing BATOSCIN outcomes against national and regional student success and retention outcomes.

Chapter 2

Chapter 2: Impact of BATOSCIN

Demographic Statistics

Previous educational research has emphasized that students must be engaged in the process of science at all stages to remain excited about and committed to pursuing STEM careers. This includes asking questions, formulating hypotheses, designing experiments, collecting data, analyzing results, drawing conclusions, and interpreting data. The proposed BATOSCIN Program is significant because it will not only immerse students in all stages of the science process, but it will also challenge them to contribute to a larger ongoing scientific study for analyzing the biodiversity of regional plants/animal species in Nigeria's unique ecosystems.

BATOSCIN's immersive model targeted students from specific regional schools early in their educational careers to focus on investigating pertinent research questions of biodiversity and conservation through specific molecular biology laboratory techniques.

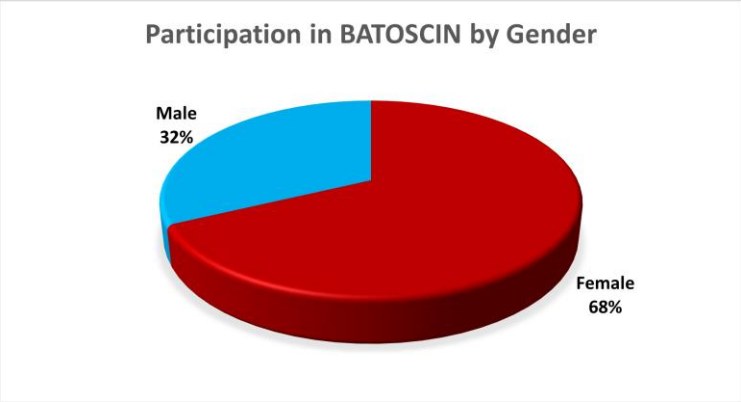
Exhibit 2.1 Overview of Program Schedule and Specific Project Designation

Timeline (Modules)	Zone	Capacity	Students	Project designation
Week One	Zone 1	One School	20 Students	DNA Barcoding of Medicinal Plants
Week Two	Zone 2	One School	20 Students	DNA Barcoding of Medicinal Plants
Week Three	Zone 3	One School	20 Students	DNA Barcoding of Medicinal Plants
Week Four	Zone 4	One School	20 Students	DNA Barcoding of Nigerian Ants
Week Five	Zone 5	One School	20 Students	DNA Barcoding of Nigerian Ants
Week Six	Zone 6	One School	20 Students	DNA Barcoding of Nigerian Ants
Week Seven	Priority 1	One School	20 Students	DNA Barcoding of Invasive Plants
Week Eight	Priority 2	One School	20 Students	DNA Barcoding of Invasive Plants
Week Nine	Priority 2	One School	20 Students	DNA Barcoding of Invasive Plants
	Total:	**Nine Schools**	**180 Students**	

One of the biggest priorities for DNALC Nigeria is to promote equity and access to quality instruction in molecular biology techniques for trainees at all educational levels. One important consideration for trainee selection was gender distribution. Using the Enugu State Post Primary Schools Management Board Schools Population Publication, candidate schools were invited to participate in the study, followed by telephone interviews with school principals, site visits, and teacher interviews (PPSMB). After careful selection and invitation to participate, approximately 68% of BATOSCIN's trainees were female and 32% were male.

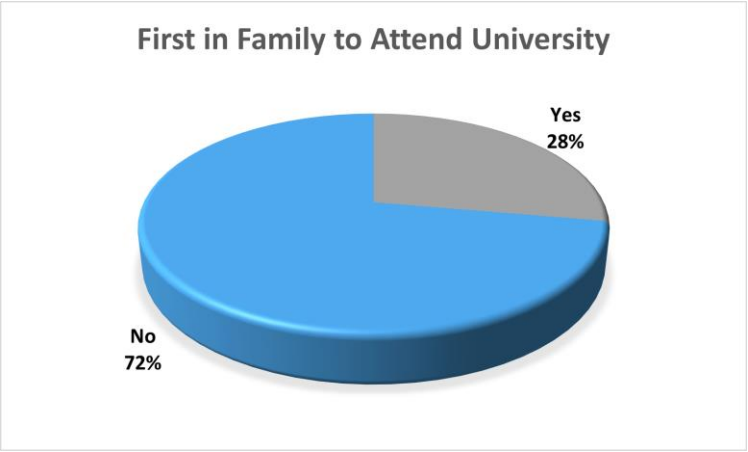
Chapter 2

Exhibit 2.2 Participation in BATOSCIN, Distributed by Gender



This is an important statistic given the wealth of research data showing a disproportionate amount of attrition in STEM for women. Interestingly, many mixed gender schools in Enugu State evidence an increased enrollment ratio of young women. To accommodate regional differences in Enugu, and to increase the strength of this study, future BATOSCIN iterations should include cohorts with a distribution ratio with more men than women, as comparison for this pilot study. It would be an important result to note whether men or women persist more in STEM programs of study given similar access to STEM learning/research.

Exhibit 2.3 Participation in BATOSCIN, Distributed by Family Background



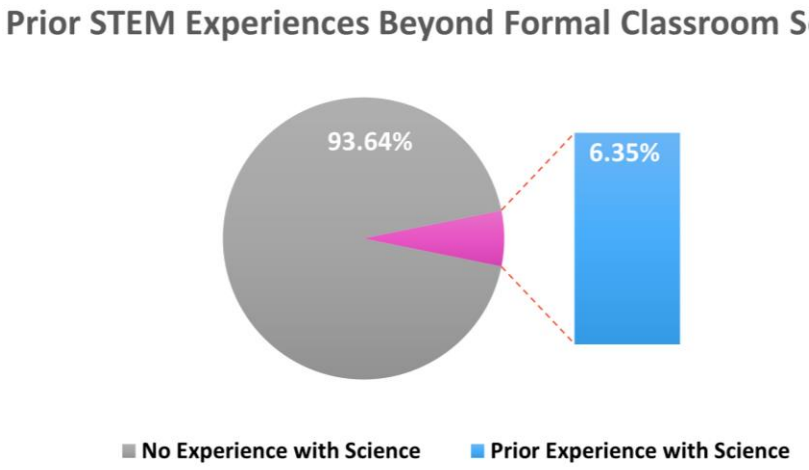
Similarly, family background is an important consideration. Twenty-eight percent (28%) of BATOSCIN participants self-reported as first-generation college students. The importance of a significant STEM immersion experience for these students cannot be overstated.

Chapter 2

Perceptions of Science and STEM Careers

To establish a proper baseline for impact reporting, the evaluation team asked participants to describe their prior STEM experiences beyond secondary school classroom settings. Ninety-four percent (94%) of BATOSCIN participants reported having no prior STEM experiences.

Exhibit 2.4 Prior STEM Experiences Beyond the Formal Classroom Setting



Of the 6% percent of trainees who reported a prior STEM experience, the survey asked them to report what kind of STEM experiences they had. The responses indicated below reveal that the prior STEM experiences involved little to no research experience or advanced methods.

Exhibit 2.5 Prior STEM Experiences (freeform survey responses)

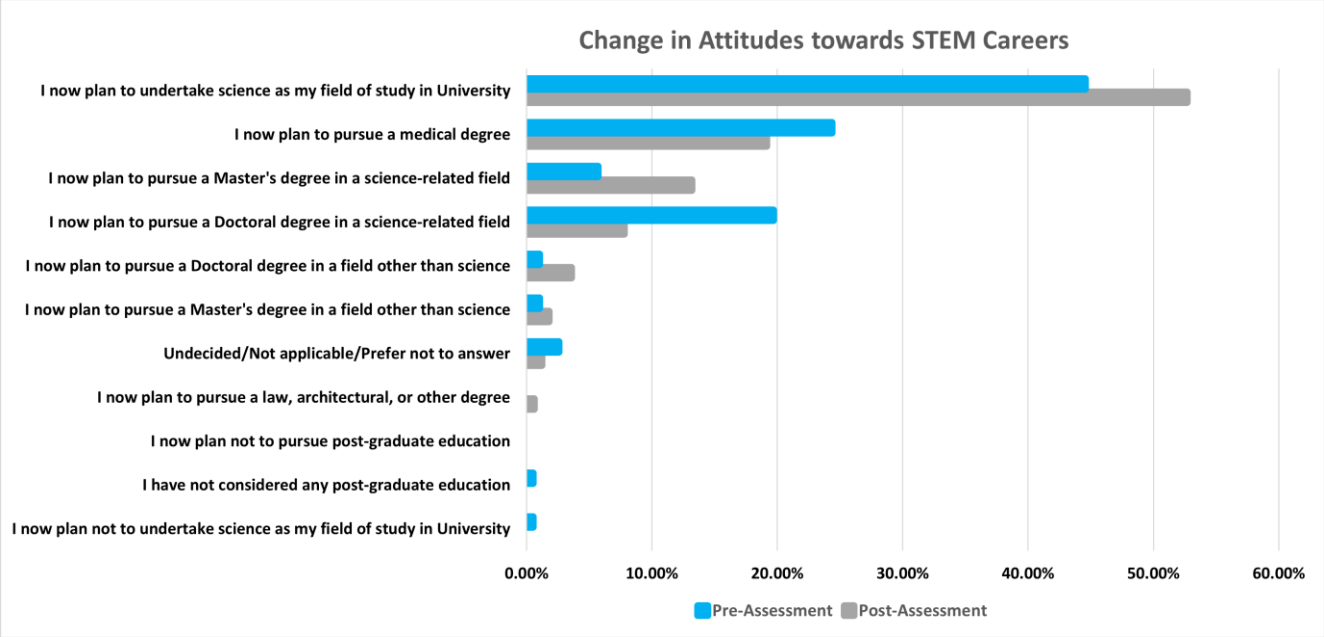
- "My mum is a medical laboratory scientist; I went with her to work a lot"
- "Following my dad to the hospital"
- "Hospital visit and laboratory visit"
- "SEDI Enugu"
- "Internship Training
- "Science Club and conventions"
- "TAFMUN"
- "Science Fair and STEM competitions"
- "Science and math competitions"

This meant that BATOSCIN was the first meaningful STEM experience trainees had beyond the limited, traditional laboratory experience. BATOSCIN represents a significant contribution to science education in that the molecular biology techniques taught represent an ***authentic*** research experience in which results are not known or understood ahead of time. Thus, BATOSCIN created an immersive experience in which they were forced to engage the scientific process like true professionals in the field.

Chapter 2

Impact on Career Aspirations and Future Programs of Study

Exhibit 2.6 Changes in perceptions/attitudes towards STEM Careers post-BATOSCIN

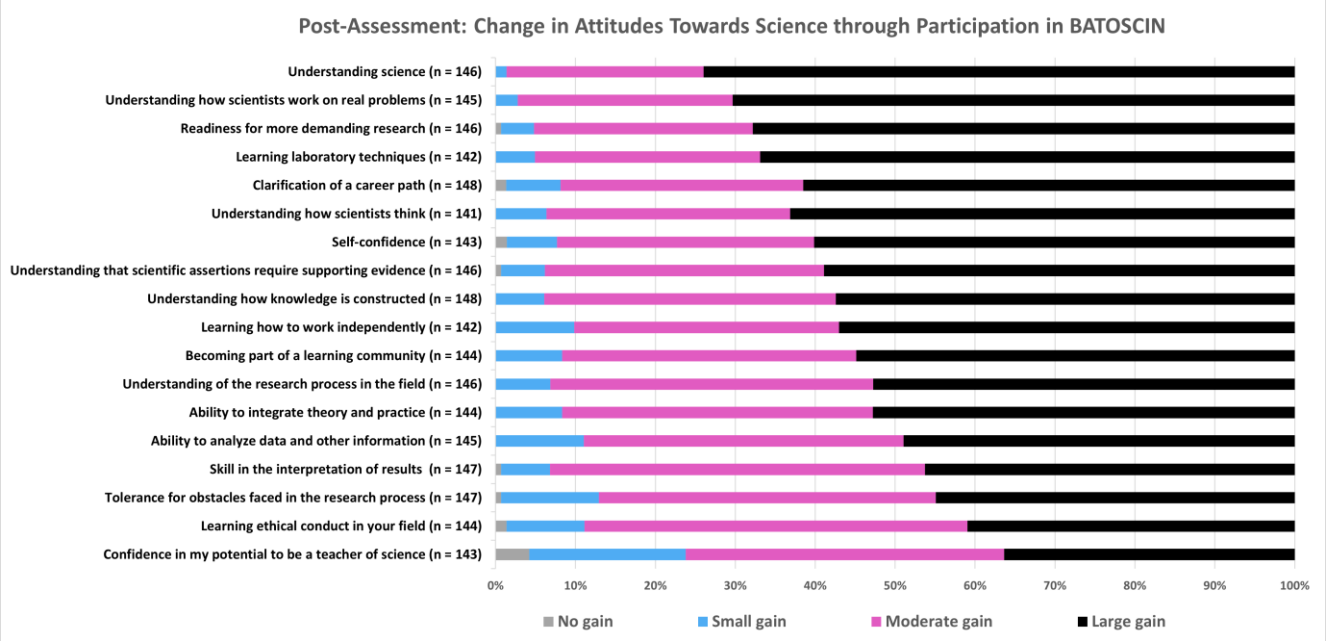


We asked BATOSCIN participants to rate their agreements with specific statements both before and after the program to gauge their attitudes to STEM careers before. Interestingly, post-BATOSCIN, a greater percentage had shifted their desire to undertake science as their field of study in university in the post-survey (52.69% vs. 44.56%). Of note, many shifted from pursuing medical degrees (19.16%, post-survey vs. 24.35%, pre-survey). This is important, as medical professionals are esteemed as the pinnacle of educational potential. Pre-BATOSCIN, many wanted to pursue STEM doctoral degrees directly (19.69%), but after BATOSCIN, that number greatly reduced (7.78%). Instead, BATOSCIN trainees reported that they now wanted to undertake a master's degree in a science-related field first (13.17%, post-survey vs. 5.17%, pre-survey), citing the need for additional training upon their first immersive STEM program. Overall, BATOSCIN was valuable in highlighting the diversity of STEM careers, which provided students an authentic evaluation of the true rigor and potential for impact in undertaking STEM careers. Additional support is needed to guide students along their STEM journeys and to provide mentorship for these trainees who are new to the world of STEM research. Longitudinal tracking would be ideal to show how BATOSCIN informed their career choices.

Chapter 2

STEM Skills Acquisition and Impact on Attitudes towards Research

Exhibit 2.7 Changes in perceptions/attitudes towards STEM/Research post-BATOSCIN



We asked BATOSCIN participants to report the gains in specific attributes of the STEM research process and their attitudes towards the STEM process before and after the program. The exhibit above is a comparative analysis of gains post-BATOSCIN, arranged in descending order. The metrics with largest gains (in black color) for participants are ranked on top, with other metrics of decreasing gains ranked lower from the top. with specific statements both before and after the program to gauge their attitudes to STEM careers before. The scale is of weighted averages, with assigned weights of 1 (No Gain), 2 (Small Gain), 3 (Moderate Gain), and 4 (Large Gains). The highest-ranking metric, “Understanding Science,” had weighted rank of 3.78, while the lowest-ranking metric, “Confidence in my potential to be a teacher of science,” had weighted rank of 3.08, which still demonstrates moderate gains in acquiring a STEM mindset through participation in BATOSCIN. On average, trainees reported moderate to large gains in all metrics, including learning laboratory techniques, real-world immersion into authentic research, and learning how to tolerate obstacles faced in the research process when techniques must be repeated, or data re-analyzed. Overall, trainees benefitted greatly from participation in the BATOSCIN program.

Chapter 3

Chapter 3: Conclusion and Recommendations

The data and metrics presented here by the evaluation team represent a comprehensive and careful analysis of the impact of the BATOCIN program. Though global transformations in the 21st century continue to change the ways in which nations practice diplomacy, programs such as BATOSCIN represent the generosity of the United States Consulate. Indeed, the success of the BATOSCIN program highlights the commitment of the United States Consulate and the Department of State to impacting the region for good. BATOSCIN has increased the diplomatic footprint of the United States Consulate and represents outstanding collaborative potential for national, state, and local governments. The tangible impact from these efforts is earmarked as a legacy of the US Consulate's initiative and investment in the region.

The goals of the BATOSCIN program were to:
1. Enhance existing curricula taught at secondary schools through a strong, yet complementary foundation of molecular biology education,
2. Provide opportunity for students to gain hands-on research skills through integrated research experiences, and
3. Provide additional research infrastructure by engaging a network of secondary schools in international research projects of organisms in their native environment.

Secondary school teachers and student trainees alike provided overwhelmingly positive feedback, with many expressing immense gratitude for being chosen for the opportunity. More importantly, all trainees reported moderate to large gains in molecular biology skills acquired and an understanding of the STEM research process, which research has shown is invaluable in persistence in STEM pathways and clarification of future career pathways. The data corroborate this finding, with many students expressing a greater sense of belonging to a scientific community while reporting specific laboratory skills gained through the program. This study was organized around three main research questions, and the main findings of the study are reported below:

1. What was the impact of the BATOSCIN Program on student attitudes to STEM?

Apart from specific laboratory skills gained through BATOSCIN, trainees reported moderate to large gains in all metrics, with the highest gains in understanding science and in authentic research, in their self-confidence, and in their sense of belonging.

2. What was the impact of the BATOSCIN Program on the understanding of molecular biology techniques and hands-on research skills acquisition?

   Participation in the BATOSCIN program improved the research skills acquisition of the students and teachers in several metrics including in understanding how scientists think, working independently, interpreting results, and ethical conduct in research.

3. What is the potential impact of the BATOSCIN Program on the current framework for science education in secondary schools in Nigeria?

   One of the intended consequences of the BATOSCIN program was the clarification of future careers for trainees. Through an authentic immersion experience, students changed their desires for specific career paths, focusing more on STEM careers and towards research-intensive programs of study. BATOSCIN can provide a strong framework for increasing STEM research capacity in the region.

Several recommendations emerge after careful analysis of the outcomes of BATOSCIN's impact. Firstly, the BATOSCIN program provides an elegant model for an authentic research experience for students and teachers. The evaluation team recommends that the BATOSCIN program be repeated, and the study cohort increased as much as possible. Additional recommendations for maximizing BATOSCIN's impact for future cohorts include:

Create a BATOSCIN network and strengthen the link between BATOSCIN's programs and secondary school curriculum innovation. All stakeholders requested that BATOSCIN be held throughout the year. Local governments should match funding given by the United States Consulate to institutionalize BATOSCIN, thereby formalizing the partnership between DNALC Nigeria and the existing educational infrastructure in the region for maximal impact. BATOSCIN can inform and enhance STEM curriculum development in the region.

Provide additional institutional and teacher support throughout the academic year. BATOSCIN participants reported that the program was their first STEM experience. DNALC Nigeria can provide additional touch points throughout the year to reinforce the concepts and the skills that trainees and teachers acquired. These additional touch points require financial support and personnel but will be invaluable in yielding maximal impact for trainees.

Amend the BATOSCIN research immersion experience model to address infrastructure concerns. To account for transportation limitations, the BATOSCIN team had to restrict institutional participation to partners who could travel to and from the DNALC Nigeria facility within specific durations, to be able to allow participants to arrive home safely at the end of each day. Thus, the current resource model for transporting trainees to and from schools limits the maximum impact for BATOSCIN. Future iterations of BATOSCIN should plan to accommodate lodging for program participants close to DNALC, where possible, or improve DNALC Nigeria's infrastructure by purchasing buses, rather than moving participants daily and relying on the limited and expensive bus system currently used.

Consider how the BATOSCIN program can reach truly underserved populations to the greatest degree possible. BATOSCIN's commitment to equity and access mandated a fair and stringent method for trainee selection. Students who would not typically have avenues to undertake STEM research attended the program. For future iterations of the BATOSCIN and with larger cohorts, a systematic approach will ensure that students of all backgrounds can benefit from the program.

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Appendix A: Important BATOSCIN Personnel

Enugu State Science & Educational Leadership Team

	Name of State Executive	Position
1.	Rt. Hon. Dr. Ifeanyi Ugwuanyi	Executive Governor, Enugu State
2.	Lolo Cecilia Ezeilo	Deputy Governor, Enugu State
3.	Professor Uche Eze	Honorable Commissioner of Education
4.	Mr. Obi Carl Kama	Honorable Commissioner of Science & Technology
5.	Dr. Mrs. Favour Ugwuanyi, *mni*	Permanent Secretary (PPSMB), Enugu State
6.	Dr. Onah Eziekiel	Professional Vocational Counselor, PPSMB

Program Sponsors, Collaborators, and Institutional Representatives

	Institutional Representative	Institution
1.	Mr. Steven Ibelli	Program Sponsor, United States Consulate of Lagos
2.	Ms. Aikulola Idowu	Grants Officer, United States Consulate General Lagos
3.	Mr. Clemson Ayegbusi	Grants Officer, United States Consulate General Lagos
4.	Prof. Christian Anieke	Host Institution, Godfrey Okoye University
5.	Dr. Dave Micklos	Global Parent Institution, DNA Learning Center New York

BATOSCIN Program Administration

S/No.	Team Lead	BATOSCIN Role
1.	Professor George Ude	Director, DNALC Nigeria and BATOSCIN Activity Director
2.	Mr. Michael Okoro	BATOSCIN Program Coordinator, DNALC Nigeria Manager
3.	Dr. Chimdimnma Esimai	BATOSCIN Program Evaluator, Politeuma Group Insights
4.	Mrs. Chidera Obih	BATOSCIN Instructional Team Lead, Project Manager
5.	Mr. John-Paul Chidili	BATOSCIN Research Team Lead
6.	Mrs. Nnenna Itodo	BATOSCIN Service Team Lead
7.	Ms. Paschaleen Onyemaechi	BATOSCIN Post-Graduate Intern
8.	Mr. Ebuka Ekeogbede	BATOSCIN Undergraduate Intern
9.	Ms. Olivia Nzerem	BATOSCIN Undergraduate Intern
10.	Mr. Ikechukwu Ozo-Osiedo	BATOSCIN Undergraduate Intern
11.	Ms. Ebubechi Okechukwu	BATOSCIN Post-Graduate Intern

Appendix B: List of Teacher Cohorts

Appendix B: BATOSCIN Teacher Cohort Trainees

	NAMES OF TEACHERS.	PHONE NO(s)	ZONES	SCHOOLS
1.	Mr. Ani, Odinaka Martin	09069208979	**Enugu Zone**	Godfrey Okoye University Secondary School
	Mr. Nnagbo, Chidera Paulinus	09059991216		
2.	Eji, Basil	08084789103	**Agbani Zone**	Holy Rosary College, Uwani.
	Ngene, Chinyere. N.	08036732811		
3.	Justina Ezeh	07034558473	**Udi zone**	St Paul's Secondary School, Eke
	Ochi, Jovita. N.	08032719899		
4.	Mrs. Ekwueme, Scholastica	08065512519	**Enugu zone**	Queens School, Enugu.
	Mrs. Obasi, Victoria. N.	07030769310		
5.	Ugwu, Bernadette. O.	08134273754	**Nsukka Zone**	Queen of the Rosary Secondary School (QRSS), Nsukka.
	Ogbuanya, Tobias. C.	08037767001		
6.	Odo, Francisca Nkechi	07053593910	**Obollo-Afor Zone**	Girls' Secondary School, Owerre-Eze Orba.
	Onah, Caroline I.	09035027459		
7.	Augustina Ogude	08038502344	**Agwu Zone**	Corpus Christi College, Achi.
	Okechukwu Onuigbo	07035349893		
8.	Mr. Simeon Chukwu	08137346622	**Private School**	Pine Crest College, Enugu
9.	Alor Ogochukwu Elizabeth	08172650657	**Udi Zone**	Aguobu-Owa High School, Aguobu-Owa
10.	Eze Edith Ugokananwa	08036760701	**PPSMB**	Post Primary Schools Management Board
	Ogbodo, Stella Ebere	08037949749		
	Edeh, Rose Cynthia	09099225525		
	Eze, Oluchi	08065115609		

Appendix C: List of Student Cohorts

Appendix C: BATOSCIN Student Cohorts

SCHOOL 1: GODFREY OKOYE UNIVERSITY SECONDARY SCHOOL, ENUGU (ENUGU ZONE)		SCHOOL 2: HOLY ROSARY COLLEGE UWANI, ENUGU (AGBANI ZONE)	
S/N	NAME (s) and Unique Codes	S/N	NAMES and Unique Codes
1.	AGU, CHIAMAKA R. – AC1084GOU	1.	CHIDOZIE, MMESOMA – CM3467HRC
2.	UCHELUE, WISDOM C. – UW1312GOU	2.	GEOFFERY, PRECIOUS – GP3705HRC
3.	ONYEMA, TOCHUKWU E. – OT1465GOU	3.	OJOBO, UCHECHI – OU3813HRC
4.	AGBOR, AMARACHI M. -AA1524GOU	4.	IKECHUKWU-ODO, ELEANOR – IE4080HRC
5.	IFEKWEM, NANCY C. – IN1953GOU	5.	EZE, CHUKWUAGOZIEM – EC4353HRC
6.	ENIGWE, VICTOR C. – EV2105GOU	6.	AKUBUE, OGONNA – AO4463HRC
7.	ALBERT BENEDICT C. – AB2556GOU	7.	IKE, PRISCA – IP4491HRC
8.	EGWUATU, EJIKE – EE3454GOU	8.	PETEREKERE, MMESOMA – PM4865HRC
9.	OBIOGBOLU, CHIMEREMEZE – OC4222GOU	9.	UZOANEKE, MITCHELLE -UM5265HRC
10.	OKAFOR, BENEDICT E. – OB5695GOU	10.	NNADI, SOMTO -NS5465HRC
11.	AGU, UCHECHUKWU T. – AU5834GOU	11.	EZE, GOODNESS -EG5867HRC
12.	MGBECHETA, TIAGO U. – MT6010GOU	12.	ANEKEOLE, FAVOUR -AF5870HRC
13.	UWOH, MAXMILLIAN C. – UM6162GOU	13.	UGWU, AMARACHI -UA6090HRC
14.	EKEANYAWU, NELSON N. – EN6205GOU	14.	CHIGBATA, CHINAZA -CC6105HRC
15.	IFENATUORAH, CHIMDI C. – IC6366GOU	15.	ALIGWEKWE, CHISOM -AC6493HRC
16.	NNAGBO, DAVID C. – ND6617GOU	16.	ONUH, CHINAZA -OC6708HRC
17.	EZEAH, CHINWEOKE – EC6646GOU	17.	NGWU, SOLUMTO -NS6832HRC
18.	ONUORAH, ANGEL I. – OA7901GOU	18.	NWORIE, MARY -NM6902HRC
19.	ANIH, IFUNNAYA C. – AI8565GOU	19.	OKOYE, KOSI -OK7230HRC
20.	CHIJIOKE, GOD'S FAVOUR C. – CGF9947GOU	20.	OGBU, SOPHIA -OS7530HRC
SCHOOL 3: ST PAUL'S COLLEGE, EKE (UDI ZONE)			SCHOOL 4: QUEEN'S SCHOOL, ENUGU (ENUGU ZONE)
S/N	NAMES and Unique Codes	S/N	NAMES and Unique Codes
1.	CHUKWUEMEKA, CHINEMEREM – CC1093SPCE	1.	EZE, MMESOMA – EM1538QSE
2.	NGWU, JUSTIN - NJ1168SPCE	2.	OKOYE, ONYINYECHI – OO2149QSE
3.	AGANIGBO, HENRY -AH1492SPCE	3.	EKWUEME, ANTHONIA – EA3221QSE
4.	OGBU, VINCENT - OV1528SPCE	4.	EZINWA, CHIAMAKA – EC3305QSE
5.	OLU, NNABUEZE - ON1677SPCE	5.	JULIET IKWUEZE – JI3421QSE
6.	OZOUDE, MELVIS - OM2290SPCE	6.	EZE, CYNTHIA – EC3582QSE
7.	ENEH, CHIJOKE - EN2395SPCE	7.	SOPHIA AUSTIN – SA3839QSE
8.	NNADI, PRAISE GOD - NPG3731SPCE	8.	ENEH, CHIAMAKA – EC4003QSE
9.	FRANCIS REJOICE - FR4219SPCE	9.	NWAFOR, SOMTOCHUKWU – NS4211QSE
10.	OKWESILI, PRECIOUS - OP4274SPCE	10.	OBASI, MARYANN – OM5629QSE
11.	AGU, EMMANUEL - AM4292SPCE	11.	ACHAZIE, VIVIAN – AV6188QSE
12.	EZECHUKWU, CATHERINE - EC4685SPCE	12.	LASBORN CHIBATA – LC6834QSE
13.	IWUAGWU, CHINEDU - IC6060SPCE	13.	ELEKWACHI, CHIDUMEBI – EC6858QSE

14.	ABONYI, KENECHUKWU - AK6622SPCE	14.	CHIMEREMEZE, ADAORA – CA7055QSE
15.	OKPA, COLLINS - OC7484SPCE	15.	OKPALUGO, FAVOUR – OF7649QSE
16.	UGWUOKOLO, DONALD - UD7692SPCE	16.	OKWUNWEZE, BENEDICTHA – OB8282QSE
17.	EZE, PRECIOUS - EP8097SPCE	17.	UFEH, CHIDIMMA – UC9081QSE
18.	OLU, SAMSON - OS8266SPCE	18.	OKENWA, MMESOMA – OM9440QSE
19.	AMALU, PAUL - AM8503SPCE	19.	OKEKE, FAVOUR – OF9582QSE
20.	ONOH, CHUKWUMA - OC8727SPCE	20.	OKPARAEZE, CHINAZA – OC9807QSE
SCHOOL 5: QUEEN OF THE ROSARY SECONDARY SCHOOL (QRSS), (NSUKKA ZONE)			SCHOOL 6: GIRLS SECONDARY SCHOOL, OWERRE-EZE ORBA (OBOLLOR-AFOR ZONE)
S/N	NAMES and Unique Codes	S/N	NAMES and Unique Codes
1.	ODOH, JANE IFUNANYA – OJ1584QRSS	1.	ALUMONA, PATIENCE – AP1214GSSOE
2.	UGWU, BLESSING ADA – UB1734QRSS	2.	OLOKO, BLESSING – OB1842GSSOE
3.	ALI, HILDA – AH2004QRSS	3.	EZE, FAVOR – EF2525GSSOE
4.	UDEKWE, JENNIFER – UJ2481QRSS	4.	MAMA, INNOCENTIA – MI2709GSSOE
5.	OTI, CHINORA - 2648QRSS	5.	UGWUONAH, JUDITH – UJ4247GSSOE
6.	NWALI, CHARITY NKIRUKA - NC2920QRSS	6.	EZE, PRECIOUS IFEANYI – EPI4591GSSOE
7.	ENYI, GLORIA - EG3059QRSS	7.	EZE, PRECIOUS UKA – EPU4640GSSOE
8.	UGWUANYI, JANE - UJ3368QRSS	8.	ASOGWA, ABIGAIL – AA5019GSSOE
9.	ONAH, JOY - OJ4228QRSS	9.	UGWUOKE, DELIGHT – UD5118GSSOE
10.	ODO, JANE - OJ4913QRSS	10.	EZE, JULIET – EJ5732GSSOE
11.	ODO, EUSTESIA - OE5121QRSS	11.	EZE, ANASTASIA – EA6296GSSOE
12.	IKEODO, JOVIAL - IJ5333QRSS	12.	UGWU, MABEL – UM6393GSSOE
13.	OGBOBE, EMMANUELLA - OE5678QRSS	13.	EZE, CYNTHIA – EC6520GSSOE
14.	ARUMA, NORA - AN6105QRSS	14.	UGWUONAH, EDITH – UE6834GSSOE
15.	OZOMBA, GINIKA - OG6162QRSS	15.	EZUGWU, DORATHY NDIDI – EDN7021GSSOE
16.	OKOLO, JANET - OJ6228QRSS	16.	ABONYI, PEACE – AP7376GSSOE
17.	ERUKA, DIVINE C. - ED6625QRSS	17.	EZE, EMMANUELA – EE8074GSSOE
18.	MBA, CHIBUGO - MC7253QRSS	18.	AGBO, JACINTA – AJ8561GSSOE
19.	OBINNA, JOY - OJ7886QRSS	19.	EZUGWU, SANDRA – ES9035GSSOE
20.	CHUKWUEBUKA, BLESSING - CB8166QRSS	20.	OZIOKO, LOVETH – OL9681GSSOE
SCHOOL 7: CORPUS CHRISTI COLLEGE, ACHI (AGWU ZONE)			SCHOOL 8: PINE CREST COLLEGE (PCC), ENUGU (ENUGU ZONE)
S/N	NAMES and Unique Codes	S/N	NAMES and Unique Codes
1.	AHAEGBU, JOHN - AJ1056CCCA	1.	CHIDI-AJA, UCHENNA – CU1527PCC
2.	ANAYO-EZE, CHIAGOZIE - AEC2254CCCA	2.	UKPABI, GRACE – UG1531PCC
3.	OKENNA, COLLINS - OC2282CCCA	3.	OKEREKE, KAITO – OK2218PCC
4.	ONONIKE, COLLINS - ONC3364CCCA	4.	AGU-NNAMANI, EMMANUEL – AE2979PCC
5.	MADU, LEONARD - ML3501CCCA	5.	MAMAH, JOEL – MJ3085PCC
6.	MADUKWE, JOHNPAUL - MJP4541CCCA	6.	ETOLUE, RACHAEL – ER3135PCC
7.	NWACHUKWU, ANTHONY - NA4864CCCA	7.	AKOGHASI, CHINEDU – AC3743PCC
8.	ONYEKACHI, PASCHAL - OP4914CCCA	8.	AJERO, CHUKWUEMEKA – AJC4343PCC
9.	OZOUGWU, FRANCIS - OF5099CCCA	9.	EZINWA, ANGEL – EA4621PCC
10.	OYEKEZIE, EMMANUEL - OE5673CCCA	10.	OKEKE, CHINONSO – OC4847PCC
11.	IFEANYIEKWE, ELOKA - IE5846CCCA	11.	ENUKA, ASSUMPTA – ENA5148PCC

12.	NNEBEDUM, EMMANUEL - NE6145CCCA	12.	MAX ALEX – MA5198PCC
13.	OKECHUKWU, SAMUEL - OS6810CCCA	13.	UZOIJE, CHISOM – UC5444PCC
14.	OKEH, FRANKLIN - OF6845CCCA	14.	ONYEISHI, SAMUEL – OS5500PCC
15.	OGBONNA, HENRY - OH7333CCCA	15.	ANI, TESTIMONY – AT6308PCC
16.	ONYEJEKWU, COLLINS - OC7523CCCA	16.	OBI-OKOYE OLAEDO – OO6343PCC
17.	UDEWEMA, CHIDUBEM - UC8328CCCA	17.	EZINWA, CHIEMERIE – EZC6709PCC
18.	CHUKWUBIKE, DESTINY - CD8435CCCA	18.	ANEKE, CHIKA – ANC7017PCC
19.	OLUNNA, JOSEPH - OJ8619CCCA	19.	EZE, OGONNA – EO7204PCC
20.	NNADI, JOSEPH - NJ9765CCCA	20.	AGUOCHA, CHIEMERIE – AGC7882PCC
SCHOOL 9: AGUOBU-OWA HIGH SCHOOL AGUOBU-OWA, ENUGU (AHS) (UDI ZONE) – ADJUNCT SCHOOL			SCHOOL 10: REGINA PACIS COLLEGE, GARKI, ABUJA (RPC) – ADJUNCT SCHOOL
S/N	NAMES and Unique Codes	S/N	NAMES and Unique Codes
1.	ALAOBI EBUBE - AE1215AHS	1.	UGWU, JOAN EBUBECHUKWU – UJB1215RPC
2.	IGBOANU AMARA - IA1356AHS	2.	UCHE CHIDERA VERA – UCV1356RPC
3.	OKORO CHIDIMMA - OC1454AHS	3.	AMAECHINA, CHIMBUSONMA NWADIUTO – ACM1674RPC
4.	OZOIBI MOSES - OM1674AHS	4.	DANIELLA OBIORA – DO1814RPC
5.	CALLISTUS MIRACLE - CM1814AHS	5.	ATU, DEBORAH EHI – ADE1814RPC
6.	EJIUCHE JOY - EJ3087AHS	6.	ALUKO-OLONAI, JANE CAROLINE – AOJC3087RPC
7.	ORJI FAVOUR - OF3767AHS	7.	CHIDI, CHRISTABEL MUNACHIMSO – CCM3412RPC
8.	CHIAWA CHINECHEREM - CC4108AHS	8.	AGOOM, DOOWUESE VERONICA - ADV3767RPC
9.	NWANCHOR EBUBE - NE4123AHS	9.	EKWUEME, ONYINYE MARY – EOM4108RPC
10.	NWAEKE KENECHI - NK4288AHS	10.	AMOKE, KAMSIYOCHUKWU SHEILA – AKS4123RPC
11.	ONUKA STANLEY - OS4797AHS	11.	KOWE, FAVOUR – KF4288RPC
12.	OKECHUKWU JUDE - OJ4830AHS	12.	ATU, ESTHER OCHANYA – AEO4797RPC
13.	OZOONWU EMMANUEL - OE5157AHS	13.	NNAJI, JOAN OKWUDILI – NJO4830RPC
14.	OBIEZE CHIOMA - OC5536AHS	14.	AGBOGO, PERPETUA CHISOM – APC5157RPC
15.	EZE CHINECHEREM - EC7741AHS	15.	OBIORA, CHINMEREM DIVINE-MERCY – OCDM5536RPC
16.	URUMA SOPURU - US8030AHS	16.	ONYEMA, AMARACHI EDITH – OAE6621RPC
17.	ILOABUCHI CHIDIMMA - IC8616AHS	17.	ADOLE, ENE MARY – AEM7257RPC
18.	OBU LUCY - OL8882AHS	18.	CHIDERA UGHAMMADU – CU7741RPC
19.	ANICHEBE CHINENYE - AC9476AHS	19.	CHRISTABEL ONOGU – OC8030RPC
20.	NWANDU EMMANUEL - NE9737AHS	20.	OMONOKHUA, FAITH – OF8616RPC