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Case Study: How Langston University's LINC Program Contributed to Diversity in the Next Generation of Chemists, Medical Personnel and other Highly Trained STEM Professionals

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Why this Matters

The U.S. Bureau of Labor Statistics, which measures labor market activity, predicts that STEM occupations are projected to grow 1.4 times faster than non-STEM occupations (10.5% STEM vs. 7.5% non-STEM) between 2020 and 2030 [1]. The STEM subset of Materials chemistry is projected to grow 6 percent from 2020 to 2030 [2].

According to *Materials Today Chemistry*, a multi-disciplinary journal focused on all aspects of materials chemistry, this area of chemistry is one of the fastest developing areas of science, covering the application of chemistry-based techniques to the study of materials-including materials synthesis and behavior, and the relationships between material structure and properties at the atomic and molecular scale.

A diverse and capable workforce is vital to maintaining the nation's standard of excellence in STEM, according to the National Science Foundation (NSF) [3]. Despite the acknowledged criticality of participation by a diverse workforce, Black and Hispanic workers remain underrepresented in the STEM workforce, according to a Pew Research Center study [4].

Langston University's demonstrated commitment and capability in this area

Bottom line, there is a real need to increase the number of highly qualified STEM professionals, and specifically to increase the diversity of these professionals, in all areas including Materials Chemistry. Langston University (LU) , the only Historically Black University in Oklahoma, has demonstrated a process that makes a substantial contribution to qualified STEM professionals.

Langston University's LINC (Langston Integrated Network College for STEM) program was in full effect from 2003 through 2017, and to this day continues to yield results. LINC was a linked, managed network of STEM program support. Its managed, multifaceted, and networked collaboration became the foundation for LINC. It was comprised of over 20 existing LU pre-college and college programs, institutions of higher learning, and research organizations throughout the U.S. Together, these organizations created a sense of community and common purpose. Support for this network began at LU's office of the President and included all department heads.

Figure 1: Langston University. Langston OK

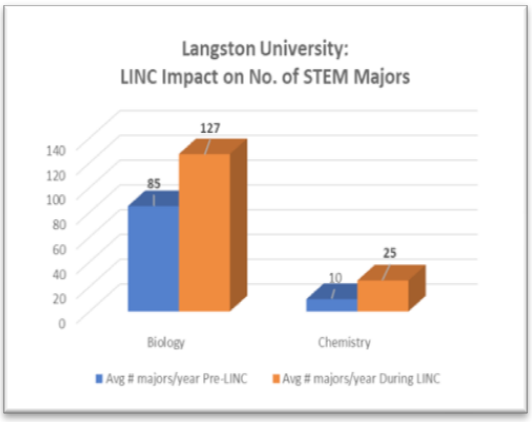

Figure 2: STEM Major Increase

The aforementioned Langston University (LU), is a regional, public, open admissions historically Black University in Langston, Oklahoma. 85% of its students are on financial aid (DataUsa)[5]. The average ACT score for entering freshmen is 17 [7].

In 2003 LU applied for and was awarded an HBCU-UP grant. A continuation grant was awarded in 2008. The 10-year program, funded by the National Science Foundation, produced a 50% increase in Biology majors and a 150% increase in Chemistry majors compared to a pre-program period of similar duration. 92.5% of program participants received a STEM undergraduate degree; of those almost half went on to earn an advanced STEM or professional degree, and now hold prominent positions in industry and medicine. Comparatively the 6-year STEM graduation rate for U.S. public institutions is 59% (NCES). 23% of STEM graduates earn a Masters degree, and 4.9% earn a doctorate or professional degree [6].

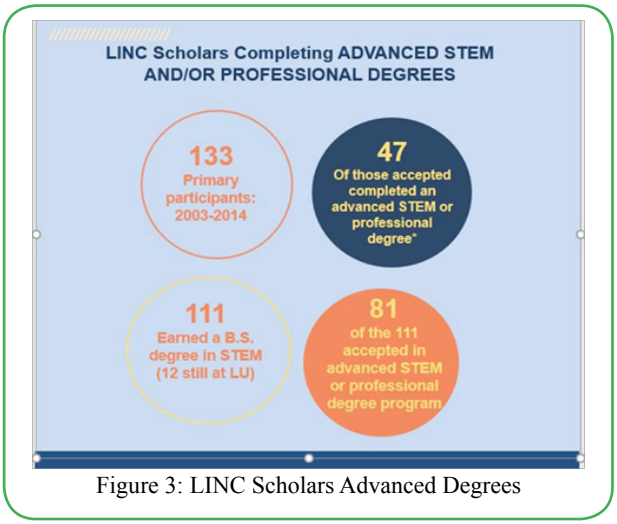

Figure 3: LINC Scholars Advanced Degrees

LU's approach to launching its LINC program began with creating a Network of support that included participation and support of the entire institution.

Langston University's LINC Project Primary Elements

Although there were many moving parts to the LINC process, 7 stand out as critical to success:

1. Financial Support
2. STEM Summer Bridge
3. Developmental Academic Mentoring for Intentional Outcomes
4. Other Academic Support
5. Enrichment Experiences
6. Competency Performance Recording for Learning. (CPR-L
7. STEM Digital Village (SDV).

LU's LINC team had over a half century of successful experiences working with primarily African American students in STEM. Historically, its STEM majors were self-selected. They chose science, and persisted through graduation. Many achieved advanced degrees, and have high-level positions in the STEM industry. The HBCU-UP grant provided a pathway for the team to expand the number of STEM majors. They recruited non-STEM majors at LU, as well as at local high schools. The expanded reach included some students who were brilliant but had never considered STEM as a college major or career choice. These had their choice of LU merit scholarships. Awareness of possibilities, and the challenge the program presented moved them to join. It also included students who would not normally select a STEM discipline; they were among students identified by ACT as not adequately prepared for success in college-level STEM courses [7]. They met the program's GPA requirements but did not qualify for LU's academic scholarships. They had to earn money to support themselves, and sometimes their family. The full scholarship was sufficiently attractive to convince this group to join the program. If LU was to succeed in increasing STEM majors, it had to consider both groups as a potential pool for the LINC program. LU's LINC team did exactly that. The process that was already producing stellar STEM professionals was adapted to the realities of the expanded group, including intense and intentional counseling, mentoring, tutoring, and performance monitoring. The LINC team pledged to increase LUs STEM graduates 15% over baseline. It wildly exceeded this objective, as shown in Figure 2. In addition to the program's construct that included pledged support throughout LU, it also had an environment that had faculty and staff role models who mirrored the institution's demographics. Excellence was expected. These program features were similar to those that are yielding success at other minority serving institutions. Other elements included STEM Summer Bridge, Supplemental Instruction, course Colloquiums, mentoring and tutoring, and research internships [8]. LINC's model followed many of the best practices cited by literature; however, numerous innovative and "tried and true" processes were also integrated to adapt these practices to the LINC scholar population.

Financial Support

The HBCU-UP program provided two critical elements for success – full scholarships for students and minimal additional support staff for coordination and monitoring all program related activities, along with scholar support. Scholarship availability got the attention of students with good academic performance; however, students had little knowledge of the potential value of receiving a STEM degree. Few high schools had prepared them for academic success in STEM disciplines, but most believed it would be hard work. Program participants had to understand and trust that they would have the full support of the institution.

STEM Summer Bridge

LU built on its history of successful Summer Math and Science academies to create a 4-week STEM Summer Bridge program with collaborations with other entities. Participants were up to 32 high school graduates scheduled to enter LU the following Fall term in a STEM curriculum. The LINC faculty taught Chemistry, Biology, and Pre-Calculus courses, along with laboratory research opportunities. The program helped students to become acclimated to university culture and college level STEM courses. Participants served as a pool from which LINC scholarships were offered for the Fall semester.

Developmental Academic Mentoring for Intentional Outcomes

Mentoring, as traditionally defined, does not adequately describe the support the LINC team provided for program scholars. The team recognized that, at its core, the broader student group from which LINC scholars were tapped required information and experiences that bridged a large chasm. The chasm was populated with 1) inadequate academic cultural awareness, 2) improper readiness for success in advanced college STEM academics, 3) low-level personal expectations of achieving excellence, coupled with lack of clarity about what excellence might look like and how to accomplish it, 4) lack of appreciation for academic success among family and peers, and 5) lack of STEM role models with whom they could identify. The group was being introduced to a different world; a world unfamiliar to many. The LINC team was familiar with both worlds – the world from which scholars came, and the world that held great potential for STEM professionals. The Faculty Mentoring program was designed to address all these issues. It incorporated a holistic approach capable of bridging the gaps. The *intentional* Mentoring became a composite of role-modeling, developmental academic advising (behavioral awareness, environmental interactions, personal growth and development, decision-making capabilities, problem-solving skills [9] and mentoring/tutoring for academic prowess). Academic advisors also served as mentors; their approach more closely followed the developmental model [10] than the typical prescriptive model of academic advising.

Other Academic Support (SI, Colloquiums, peer mentoring and tutoring)

Supplemental Instruction (SI) classes that addressed areas of weakness in core courses were held weekly, facilitated by advanced LINC scholars. The focus was understanding of basic STEM concepts. Pre/post SI test scores measured improvement, with detailed records of participation and results. Course enhancing **Colloquium** classes were developed and implemented for gatekeeping courses and are now part of the LU Course Catalogue. These courses present opportunities for open discussion and dialogue that support an enhanced understanding of subject matter. Each LINC scholar was assigned a **peer mentor** who helped in assimilation into the college

environment, serve as role model, and assist with academics and goal attainment [11]. Advanced STEM scholars served as **tutors**, assisting those in need of assistance in STEM courses.

Enrichment Experiences (Research Internships)

Collaborations with internal and external partners provided access to meaningful research experiences for LINC scholars during the course of LU's initial project. Literature indicates that students most active in research internship programs are most likely going to attend grad school [12]. During the pre-LINC period, LU STEM students earned research internships throughout the U.S. However, the number expanded 600% with the larger number of STEM majors. Participation was required; it was part of the LINC experience. Awards for research presentations at regional and national events increased 450%. Although some scholars were reluctant participants initially, they embraced participation in research internships and presentation at venues more fully as their colleagues garnered awards and recognition for their stellar presentations.

Innovative Teaching and Learning Tool: Competency Performance Recording for Learning. (CPR-L).

Operationalizing LINC'S Developmental Academic Mentoring for Intentional Outcomes process demanded an innovative solution for improving student's academic prowess, particularly in foundational STEM courses. True academic prowess needed a thorough understanding of a course's foundational concepts. To this end, a member of the LINC team who was already incorporating novel approaches in teaching chemistry developed and incorporated CPR-L. CPR-L is a teaching and learning methodology enabled by authenticated, broadly accepted learning protocols and 21st century technologies. It is aimed at "resuscitating" a student's learning of the analytical process of problem solving, thus enhancing their problem-solving skills as well as their understanding of core course concepts. Although it utilizes modern technologies to involve larger groups of students more rapidly than could be possible without technological support, the processes it adheres to have been effective for learning throughout the ages [13-16]. The CPR-L process, guided by Rubrics, delivers a recording of students' homework that enables the instructor to determine, with great precision, the student's grasp of concepts and ability to use those concepts to solve problems. Its contribution is to strengthen the problem-solving techniques of students, and to engage students in more in-depth science curricula. It was instrumental in improving students' grasp and retention of core course concepts and grades.

Innovative Information Gathering and Sharing: STEM Digital Village (SDV)

SDV was developed as a tool to make relevant information available to LINC scholars 24/7, and to connect program participants through displaying their achievements. It is an online community and information "warehouse" that served all STEM majors during the LINC program, and it continues through the present. It is available 24/7 and supports remote communications and information dissemination. The site is devoted to providing relevant information regarding STEM activities, programs, and items of interest to those interested in STEM-related topics.

Results Recap

During LINC, **STEM majors increased** as follows: Biology majors - 49% (avg. of 85/year to avg. of 127/year) and Chemistry majors experienced a 150% increase, from an average of 10/year to 25/year.

Of the 111 that received a STEM undergraduate degree as of early 2017, 81 or 73% matriculated to an advanced STEM or professional degree program. 56 (69%) have received an advanced STEM or professional degree or are still in school pursuing an advanced STEM or professional degree. 27 of the 50 (54%) have earned a STEM PhD or a medical degree (MD, DO, DDS, DPT). 18 of the 27 are the aforementioned medical degrees.

Conclusion

LU's NSF sponsored LINC program demonstrated that a regional HBCU university with the student profile (as outlined on page 2) can compete with top producing organizations in supporting persistence through graduation for its STEM students. These students, properly nurtured and otherwise supported, can achieve academic excellence and personal development that enable them to receive advanced or professional degrees at a rate that exceeds national norms. One of the major factors, and one not easily overcome, is adequate funding for this kind of program. The urgency of this kind of support is articulated in numerous writings [8,17]. LU's results are not an anomaly; A quarter of Black graduates with Science, Technology, Engineering and Mathematics (STEM) degrees come from Historically Black Colleges and Universities (HBCUs), according to a report from the United Negro College Fund. Twenty five percent of African American graduates with STEM degrees come from HBCUs. HBCUs are the institution of origin among almost 30% of black graduates of science and engineering doctorate programs [18].

Conflict of interest: The authors declare no conflict of interest.

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