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Enhancing Pathways to Degree Completion and Career Success for Engineering Students

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ABSTRACT

In this session, a pilot program addressing critical needs identified by the National Science Foundation (NSF) report on Building Capacity at Hispanic Serving Institutions (HSIs) is outlined. The proposed program, developed at Keiser University(KU) Flagship Campus, focuses on redesigning the curriculum to incorporate recent advances in emerging technology, attracting and retaining high-potential, low-income, and Hispanic students in engineering, and enhancing evidence-based student-centered initiatives to support degree completion and career success. Building upon successful STEM research projects, the session discusses the proposed revision of the Applied Engineering program at KU, introducing new tracks and certification programs. The proposal is under review by the academic affairs review committee. Early exposure to applied engineering majors through interventions like Introduction to Engineering aims to motivate students and provide insights into professional engineering roles.

1. INTRODUCTION

America is at a critical juncture in terms of advancing science, technology, engineering, and mathematics (STEM) education across the increasingly diverse student population in postsecondary classrooms. And, while there's a plethora of reasons for the present condition of postsecondary STEM education, the current case and advocacy for improvement have yet to factor into its systemic analysis of the incredible pace of development of those disruptive technologies that will, in and of themselves, change the focus, direction, and impact of STEM education in terms of the lives and our entire economic development, health, education, and security systems. More specifically, the explosive research and development taking place in areas such as Artificial Intelligence (AI), data analytics, cyber security supply chain, alternative energy, and biotechnology, to mention a few, are key to America advancing its positional strength in world affairs, national defense and security, educational systems across the life span, economic growth and development, and health and human welfare. Engineering focus is particularly noteworthy given its dramatic impact on all segments of society, industries, the economy, and the educational community. In addition, the growth in Information Technology (I.T.) and related computer industry is expected to increase exponentially over the next decade. Given the fact that the medical, biotech technology and health care industries will require innovative software packages to manage health care, the exponential growth of 25.6 % in engineering and computer-related industries is expected from 2018 to 2028[1]-[6]. According to the new Pew Research Center analysis [7], employment in STEM occupations has increased 79% since 1990 from 9.7 million to 17.3 million, outpacing overall U.S. job growth. Additionally, over 99 percent of STEM employment was in occupations that typically require some type of post-secondary education for entry, compared with 36 percent of overall jobs [8].

For post-secondary institutions, including Keiser University, the recent pandemic has resulted in extensive alterations in how instruction is being delivered to students and the comprehensive utilization of new virtual technologies. However, the impact on student learning and the potential impact on student's career trajectories in emerging fields are unknown. At the same time, the demand for graduates with solid engineering backgrounds has continued to grow tremendously, including among the tech giants as well as the small start-up companies. These trends require universities to accelerate their efforts to enhance their STEM programs so that they meet the nation's expanding infrastructure and security needs. A second equally critical and related challenge is to increase the number of graduates from among the nation's growing diverse populations, such as low-income and underrepresented minority (URM) students (e.g., Hispanic) in engineering [4], [9]-[10]. Thus, it is strongly believed that our focus on applied engineering curriculum revision with new certifications in emerging technologies such as alternative energy and biotechnology will move forward the required trajectory to address America's technological challenges and the need for a more diverse workforce [3]-[4].

The curriculum revision and the proposed new Engineering programs are also aligned with evidence-based research and recommendations from the National Academy of Science, Engineering, and Medicine [9], the National Research Council [11]-[14], and the National Academy of Engineering [15]-[17]. They indicate a high need to boost the nation's economic growth and competitiveness, national security, and general well-being. Therefore, we should expand the emphasis on STEM education and systemically address ways to expand the impact on the education of 'all' students, thus contributing to a growing, more diverse *talent pool* for STEM education and careers.

2. STEM PROGRAMS at KEISER UNIVERSITY

Keiser University stands out as one of the most diverse institutions of higher education in the State of Florida. According to the U.S. News and World Report, the institution boasts a "diversity index" score of 0.69 out of 1.0, positioning it as the 5th most diverse institution in the state [18]. Situated in Fort Lauderdale, the main campus serves as a hub, with additional campuses spread throughout Florida. Guided by a dedication to quality teaching, learning, and research, Keiser University is steadfast in its commitment to equipping students with the knowledge, understanding, and skills essential for successful employment. With a foundational belief in a "students first" philosophy, Keiser University prides itself on preparing graduates for careers across a spectrum of disciplines, including business, health care, engineering, information technology, education, and career-focused general studies. Central to the university's mission is a commitment to community service, realized through partnerships, engagement with diverse constituencies, and various continuing education initiatives.

As of the most recent data, KU boasts a student body of 19,567 individuals, with a substantial 87% of full-time undergraduate students receiving financial aid. The undergraduate population at Keiser University is predominantly female, comprising 68%, with male students constituting 32%. Notably, the Hispanic student population at Keiser University has shown significant growth, increasing from 28.1% in the previous year to over 29% in 2023, alongside 18% Black or African American students. Table 1 provides a snapshot of the latest statistics regarding the Keiser University student body [19].

Table 1- *Keiser University Overall Student Population*

KU	Overall	UG	Pell	FT	Black	Hispanics (UG)	Native American	Pacific Island	Total Minority
Population	19,567	16,875	10,451	15,313	3,660	5,107	133	54	9,580
Percentage	100%	86.24%	62%	78.3%	18.7%	28.1%	0.8%	0.3%	49%

Keiser University's "Students First" philosophy serves as a defining characteristic that sets the institution apart from others. This approach underscores the significance of placing students' needs and success at the forefront, tailored to their unique profiles of needs and interests. It mirrors the university's steadfast dedication to fostering a student-centered learning environment and delivering education of the highest quality. In essence, "Students First" epitomizes the institution's unwavering commitment to prioritizing its students' needs, fostering a supportive learning atmosphere, and equipping them for prosperous careers. Table 2 succinctly outlines the principal strengths and weaknesses of the institution.

Table 2. *Summary of Keiser University's Strengths and Weaknesses.*

Academic Program Strengths	Academic Program Weaknesses
• More than 113 Undergraduate Programs • Growing Hispanic enrollment due to multi-campuses • Small class size for all programs • Online and flexible learning options • Center for Academic Support and Achievement (CASA) • State-wide Distribution of Campuses • Robust growth in Applied Engineering program for the last 4 years • Dedicated STEM faculty • Student Research Symposium every Spring semester • Deep community outreach and partnership with many counties in the state of Florida	• The Applied Engineering program is not ABET Accredited • Low retention and graduation rates especially among Hispanic and low-income students • A small percentage of STEM programs compared with non-STEM programs at KU • A low number of high-impact certification programs such as cyber security and data science, networking, and six sigma • Low STEM program enrollment • Identifiable student career pathways for workforce development/high quality job attainment • Experiential learning, paid co-ops, and internships

As depicted in the preceding tables, an in-depth examination of the institution's strengths and weaknesses is warranted. Notably, the analysis of student data from the 2022-2023 academic year underscores a pressing concern regarding STEM retention and graduation rates. Alarmingly, a substantial proportion (31.9%) of STEM students did not maintain enrollment, opting instead to transfer out or withdraw due to factors such as academic performance, financial constraints, or other reasons. Furthermore, only a meager percentage (15.2%) of these STEM students ultimately attained graduation status. This disparity highlights a significant challenge that demands immediate attention and targeted intervention to enhance STEM student retention and promote successful graduation outcomes.

Table 3. *STEM Student Enrollment and Retention as a Function of Degree Program.*

STEM Degree Area	Enrollment	%Remain Active	% Graduate
Overall	2079	68.1%	15.2%
Applied Engineering	145	66.9%	11.0%
Biomedical Sciences	326	60.1%	11.3%
Data Analytics	29	72.4%	41.4%
Homeland Security	314	64.0%	14.6%
Cyber Forensics/Information Security	137	74.5%	13.9%
Information Technology	1116	71.0%	16.8%
Medical Laboratory Science	12	50.0%	0.0%

More than half of those STEM students who leave before completing their degree (55.4%) identify as underrepresented minorities. The full picture of which students began the program, graduated, or left before completing the program is shown in the table below.

Table 4. *STEM Student Enrollment and Retention as a Function of Ethnicity*

Ethnicity of STEM students	Enrollment	% Transfer Out	% Drop
American Indian or Alaska Native	19	10.53%	10.53%
Asian / Pacific Islander	41	2.44%	21.95%
Black or African American	353	5.95%	13.03%
Hispanic/Latino	611	6.1%	12.26%
Multi-Ethnic Background	3	0.00%	33.33%
Native Hawaiian or Other Pacific Islander	7	0.00%	0.00%
Nonresident Alien	41	7.32%	31.71%
Two or more races	13	0.00%	23.08%
White	466	4.51%	18.24%
Unknown	525	4.46%	11.78%
Grand Total/Average	2079	4.76%	15.25%

As indicated in the aforementioned tables, the enrollment and graduation rates of STEM students at Keiser University pale in comparison to those of non-STEM majors. This discrepancy is cause for concern, particularly in light of projections indicating an 11% increase in STEM job opportunities by 2031. However, current statistics reveal that over 60% of students who initially declare a STEM major eventually switch to non-STEM fields, while approximately 20% drop out of school altogether. Furthermore, research suggests that minority students, particularly Black and Latino individuals, are disproportionately affected, with nearly double the rate of attrition compared to their white counterparts.

Johnson et al. [21] highlight a critical period of vulnerability for STEM students, particularly within their first and sophomore years, contrasting with the broader trend among American college students, who are predominantly at risk solely during their first year. Consequently, the development of new STEM majors, particularly in emerging fields such as engineering, computer science, and information technology, emerges as imperative for fostering STEM growth at Keiser University. Addressing these challenges head-on is paramount to cultivating a more inclusive and supportive environment that empowers all students to pursue and persist in STEM disciplines.

As it is clear from tables 3 and 4, the major drawback are the retention and graduation rates for both STEM and non-STEM majors. . In order to address the issue, a comprehensive mentoring plan will be the developed in the coming year.

The proposed mentoring plan utilizes the mentors (a) To serve in an academic support role in which they will provide one-to-one or very small group learning sessions focused on helping students learn-how-to-learn by thinking mathematically rather than to be problem-solvers or assist students in doing their homework as the main outcome, (b) To establish a supportive relationship in which to progressively guide the participants in becoming more effective and independent learners through the application of self-regulated learning strategies integrated into the mentoring sessions, and (c) To serve as student role models who can highlight how they addressed academic and social issues they encounter, identify what's really necessary to complete a degree in a rigorous domain such as engineering (e.g., persistence, autonomy, active learning), along with the career potential in terms of what engineers really do, and some of the supportive benefits offered by the University. Mentor training will be guided by a series of evidence-based and student-centered framework[34]:

1. Mentor Selection: The near-peer mentors will complete an application process including a personal statement expressing commitment to provide the students the necessary academic and motivational support]. The selection process will include interviews using set criteria (e.g., maturity level, enthusiasm toward the mentoring role, communication skills). The mentors will function as student ambassadors, will assist with recruitment, and participate in professional development addressing ethics, professional obligations, and socio-psychological issues (e.g., motivation, persistence, self-efficacy, autonomy).

2. Near-Peer Mentor/Mentee Matching: Building upon student career goals, identified major, personal interests, and preference to serve as a near-peer mentor, the P.I.s will link each mentor with mentees based on shared interests, shared times, and willingness to meet as needed with the mentee

3. Mentee Development Workshop: The author has identified the challenges, including meeting time, location, frequency, and mentee attendance, as well as the mentees' perception of near-peer mentors as tutors for technical concepts and knowledge. We will conduct a workshop for all engineering students to address such potential challenges at the beginning of each semester.

4. **Virtual Platform-** We also propose to create a virtual platform for the mentors/mentee activities to provide seamless and continuous support:

a. Mentors developed digital platforms to streamline contacts with mentees.

b. Participants will have access to mentors, thus allowing them access and making it more convenient for students.

c. Mentors developed rich resources to motivate the freshman participants to stay the course and complete their program of study. Examples of resources include modules on self-learning, financial literacy, and what's trending in emerging technologies.

The mentoring plan outlined above is expected to tackle the challenges of low retention and graduation rates by aligning with a recent report on mentorship [34]. The NASEM report offers a comprehensive review of evidence-based research findings and models, showcasing the effectiveness of mentorship in promoting learning and student success.

3. APPLIED ENGINEERING

The current Applied Engineering (AE) curriculum at Keiser University follows a structured format, offering introductory courses in Electrical, Mechanical, and Computer Engineering fundamentals over the span of a four-year program. However, despite the program's growth, Keiser University is falling short in addressing the evolving needs of the local industry, particularly in critical sectors such as renewable energy, battery technology, big data, cybersecurity, biotechnology, and drone technology. Our current curriculum fails to adequately meet the demand for emerging technologies in these areas.

Analysis of available data and institutional trends strongly advocate for a significant overhaul of the existing AE curricula to better align with new ABET criteria and student learning outcomes. Consequently, there arises a pressing need to develop at least two new programs that cater to the demands of the evolving industry landscape.

Recent statistics from the U.S. Bureau underscore a substantial need for engineers and computer science professionals over the next decade, driven by both job growth and the need to replace retiring workers. Among the occupations projected to experience the most growth by 2031 are computer and information science, as well as biomedical engineering. To address this growing demand and encourage student participation in these professions, Keiser University must actively promote these fields among its student population. This strategic emphasis on aligning curriculum with industry demands and fostering interest in burgeoning fields is crucial to ensuring the university remains at the forefront of engineering and computer science education.

4. NEW ENGINEERING PROGRAMS

The Director of Applied Engineering, in collaboration with faculty members, has spearheaded the development of two new programs that align with ABET criteria: (a) Electrical Engineering, and (b) Mechanical Engineering, each featuring emerging technology tracks. These programs are poised to address industry demands for highly skilled engineers proficient in cutting-edge technologies. Additionally, plans are underway to establish a comprehensive engineering laboratory to serve as a focal point for hands-on student activities.

IV.1 Electrical Engineering: This program is designed to meet the needs of modern society, encompassing the design and analysis of systems utilizing electricity, electromagnetics, networking, satellite radio, power generation, transmission, integrated circuits, and various other applications. It is a highly sought-after major, particularly with the integration of electrical engineering with information technology, leading to numerous innovations and the establishment of new industry sectors.

IV.2 Mechanical Engineering: Renowned as one of the most popular disciplines in engineering, Mechanical Engineering applies principles of physics and materials science to analyze, design, implement, and maintain mechanical systems. As one of the oldest and broadest engineering disciplines, it has witnessed recent innovations through its integration with other majors such as Electrical Engineering and information technology, resulting in the development of various innovative devices including sensors and actuators.

Both programs have been meticulously designed to align with ABET accreditation standards. ABET accreditation involves a rigorous process encompassing five major steps, ensuring that accredited programs meet specific criteria in three key areas: Program Educational Objectives, Student Outcomes, and Continuous Improvement.

To address the workforce development needs of the industry, three emerging technology tracks have been developed for the new curriculum: 1) Alternative Energy, 2) Biotechnology, and 3) Artificial Intelligence (AI) [21]-[23]. While there are several other emerging technologies such as the Internet of Things (IoT) or Cyber Security [21]-[23], the aforementioned three tracks were chosen due to their relevance to all three programs (current Applied Engineering, and new EE and ME programs) and the availability of resources in terms of facilities and faculty expertise. Each track comprises four distinct courses in engineering or biotechnology, and students are expected to complete one of the three tracks to receive their degree along with a special certification.

IV.3.1 Alternative Energy Track: The Alternative Energy track focuses on addressing the need for "green" workforce development by providing significant exposure to solar, wind, fuel cell, biofuels, geothermal, and other clean-energy-related technologies [24]-[26]. Additionally, students will learn about the underlying foundations of designing for sustainability. This track incorporates content related to complexity and economic issues relative to energy and environmental policy, including carbon reduction targets. Students will gain awareness of the impact of human activity on the environment and how politics and business interests influence technology development and delivery to the market. Given that the transportation sector accounts for the largest source of pollution in the United States [25], efforts to combat this issue include an accelerated rollout of electric vehicles (EVs) by automotive companies with government support. The certification program aims to familiarize students with the design, testing, and implementation of alternative energy technologies, including equipment and software development [24]-[26]. Courses in this track include Introduction to Sustainable Energy, Introduction to Solar Energy, Introduction to Electrical Vehicles and Sustainability, Solar Energy and the Smart Grid, Introduction to Renewable Distributed Generation and Energy Storage, and Introduction to Fuel Cell Technology.

IV.3.2 Biotechnology Track: The Biotechnology track focuses on the integration of natural science and engineering for the utilization of biological systems and living organisms to create different products and services [26],[27]. This field has experienced exponential growth over the last two decades, driven by events such as the COVID-19 pandemic and increased financial support. Several trends dominate the biotech industry today, each with exciting developments. The proposed track and certification program offer courses related to both medical biotechnology and industrial biotechnology. Curriculum design has been developed by faculty with extensive background in this area. Courses include Introduction to Biotechnology, Genetics and Genetics Laboratory, Molecular Biology and Lab, Industrial Biotechnology, Bioinformatics, and System Biology and Biotechnology.

*IV.3.3 Artificial Intelligence (AI) Track :*The Artificial Intelligence track integrates soft computing paradigms and incorporates human expert knowledge in various emerging and complex systems [28],[29]. These paradigms have demonstrated an ability to process information, adapt to changing environmental conditions, and learn from the environment. This track includes applications-oriented and hands-on artificial intelligence simulations, covering topics such as neural networks, deep learning, fuzzy logic, and evolutionary computation [28],[29].

IV.4 Development of New Engineering Laboratory

The proposed new laboratory at Keiser University will serve to support instruction in the current Applied Engineering program and facilitate the establishment of two new undergraduate curricula in Electrical Engineering (EE) and Mechanical Engineering (ME). Presently, there is a notable absence of engineering laboratories available to any Keiser University students. Thus, the introduction of this facility will provide invaluable hands-on learning experiences for all STEM students.

The connection between theory and practice has long been recognized as one of the most challenging aspects to teach in engineering education. Hands-on experience in a laboratory environment offers a vital tool to solidify concepts covered in lecture courses. The proposed project aims to significantly enhance undergraduate instruction related to recent trends and developments in emerging technologies, including alternative energy, drone technology, and biotechnology. The laboratory will supplement various engineering courses for the new programs and support capstone design projects. Moreover, it will serve as a platform for the development of state-of-the-art projects for engineering students.

- *The proposed laboratory will achieve the following goals and objectives:*
- *Familiarize students with the design, testing, and implementation of emerging technologies desired by local industries.*
- *Evaluate the effect and efficiency of design laboratory experiments.*
- *Introduce the use of test setups emerging in industrial communities, not yet utilized in the undergraduate university environment.*
- *Create a focal point for interdisciplinary learning and present a balance between theoretical and hands-on experience in undergraduate instruction.*
- *Provide a platform for the development of undergraduate capstone projects related to emerging technologies.*

5. EVALUATION

The implementation of the new curriculum is anticipated to provide a robust and comprehensive educational experience that effectively addresses industry demands while catering to the diverse needs of students. A key aspect of this evaluation process involves the provision of certification in the selected track upon completion of academic requirements. To ensure the efficacy and continuous improvement of the curriculum, rigorous evaluation procedures will be employed, guided by the Program Evaluation Standards [30]-[33].

Central to the evaluation process will be the use of valid and reliable measures to assess the utility and effectiveness of the curriculum. This includes gathering feedback from stakeholders, analyzing student performance data, and evaluating the alignment of course content with industry standards and best practices. By leveraging these evaluation methodologies, the curriculum will be refined iteratively to optimize learning outcomes and meet the evolving needs of both students and industry.

A key metric for assessing the success of the new programs will be its ability to facilitate the transition of graduates into industry roles or further graduate studies within one semester after graduation. This outcome underscores the program's commitment to providing students with the skills, knowledge, and credentials necessary for success in their chosen field.

It is important to note that due to the recent implementation of the new curriculum, comprehensive data to validate the evolution and refinement of the curriculum are not currently available. However, ongoing evaluation efforts will be conducted to systematically assess the program's effectiveness and make data-driven adjustments as needed to ensure continuous improvement and alignment with educational and industry standards.

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